**3GPP TSG-RAN WG1 Meeting #104b-e R1-210xxxx**

**e-Meeting, April 12th – 20th, 2021**

**Agenda Item: 5.2**

**Source: Moderator (ZTE)**

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

**Document for: Discussion**

# Introduction

[104b-e-NR-R17-SDT-01] Email discussion/approval for RAN1 aspects for NR small data transmissions in INACTIVE state – Li (ZTE)

* 1st check point: 4/15
* 2nd check point: 4/19
* Last check point: 4/20

In RAN1#104-e meeting, there were some discussion on the CORESET/SS configurations for RA-SDT and SSB to PUSCH mapping for CG-SDT regarding the LS triggered by RAN2 (R1-2100025). A reply LS containing the agreements on part of issues was sent to RAN2 (R1-2102125). In this meeting, it is necessary to continue the discussion on the remaining physical layer issues.

In addition, there is another LS received from RAN2 (R1-2102286) asking about the timing alignment (TA) validation mechanism. It is expected that a reply LS is needed based on RAN1 discussions.

This document contains the summary of issues related to the physical layer aspects of small data transmission in RAN1#104b-e meeting.

# Identified issues

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| --- | --- | --- |
| Issue # | Description | Related TDoc # |
| 1 | TA validation for CG-SDT | R1-2102312, R1-2102578, R1-2102647, R1-2102837, R1-2102932, R1-2103013, R1-2103139, R1-2103211, R1-2103380, R1-2103494, R1-2103678 |
| 2 | SSB to PUSCH mapping for CG-SDT (including the issues related to repetition and PUSCH validation) | R1-2102312, R1-2102578, R1-2102647, R1-2102837, R1-2102932, R1-2103013, R1-2103075, R1-2103334, R1-2103380, R1-2103380, R1-2103494, R1-2103678 |
| 3 | CORESET/SS for RA-SDT | R1-2102578, R1-2103286, R1-2103380 |
| 4 | Beam correspondence in RRC\_INACTIVE | R1-2102647 |
| 5 | BWP related issues | R1-2103334, R1-2103494 |

# TA validation for CG-SDT

To be handled by email thread [104b-e-NR-R17-SDT-LS-01].

# SSB to PUSCH mapping for CG-SDT

Conclusions from the last meeting:

* One or multiple SSBs can be associated with each CG configuration for CG-SDT.
* From RAN1 perspective, the following options can be considered for the association between the SSBs and the CG resources (including transmission occasions and DMRS) per CG configuration for CG-SDT.
	+ Opt. 1: Define the SSB-to-CG-PUSCH mapping rule
		- Reuse the SSB-to-RO mapping as the baseline
		- FFS the potential RAN1 impact, e.g. mapping ratio and association period
	+ Opt. 2: CG resources per CG configuration are associated with a set of SSB(s) by explicit signalling.
		- FFS the potential RAN1 impact
	+ Other solutions are not precluded
* FFS whether repetition is supported for CG-SDT or not, and if supported how to handle the mapping between the SSBs and repetitions
* FFS TA validation and PUSCH validation for CG-SDT.

## Clarifications on the resource configuration of CG-SDT

Before we do the down-selection for the association between SSBs and CG resources, it seems that some clarifications regarding the configuration of CG-SDT resources need to be aligned firstly.

1. In R1-2102932, vivo mentioned that it should be first clarified that which option should be adopted regarding the configuration of CG-SDT resource.
* Option 1: reuse the configuration mechanism for CG configuration in licensed band
* Option 2: reuse the configuration mechanism for msgA PUSCH configuration of 2-step RACH

In vivo’s contribution option 2 was proposed, however it is the moderator’s view that option 1 should be the baseline understanding unless more information is provided by RAN2.

1. In R1-2103334, LGE propose to clarify whether a CG PUCCH occasion is dedicated to one UE or common to all UEs capable of SDT at a cell, and whether a CG PUSCH transmission in Option 1 requires contention resolution.

If the Rel-16 CG configuration is reused, it is the moderator’s understanding that the configuration is UE-specific, but the CG resources for different UEs could be possibly overlapped or non-overlapped, and thus whether contention resolution is needed or not can be up to gNB’s implementation.

### First round comments

Any comments on the above issues for the resource configuration of CG-SDT?

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| --- | --- |
| Company | Comment |
| Samsung | Based on our understanding, the option 1 is used for CG-PUSCH configuration in CG-SDT, which should not have dependence on RACH resource. However, whether directly reuse every configurations as exactly same as in CG-PUSCH should be discussed, e.g., we could re-interpret the repetition number as the number of PUSCH occasions in one period.  |
| CATT |  We are fine with Option 1. |
| ZTE | Agree that option 1 should be applied for CG-SDT |
| Ericsson | CG PUSCH resource allocation could be similar to CG type-1 PUSCH allocation, which should be UE specific in our view. To support one to one mapping between SSB and CG PUSCH, multiple CG PUSCH occasions/DMRS resources may be needed. Furthermore, the CG PUSCH configuration period may need to be revisited for CG SDT in RRC inactive state, which now should be similar to PRACH configuration period for UEs in RRC inactive state to save the resource overhead. |
| vivo | We are either fine with option 1 or option 2. We think the key question is whether multiple PUSCH resources within a CG period are allowed, e.g. multiple PUSCH occasions and/or multiple DRMS ports/sequences. For CG configuration in licensed band, only one CG PUSCH resource can be configured within a period. If SSB is one-to-one mapped to CG PUSCH resource within a period, it will increase the latency for CG-SDT when selecting the appropriate SSB.Therefore, multiple CG PUSCH resources, e.g. multiple CG PUSCH occasions or a PUSCH occasion with multiple DMRS resources, can be adopted, to reduce the latency. The configuration method of 2-step RACH PUSCH can be a possible way, or it can up to RAN2 to decide how to configure the CG PUSCH resources.  |
| Huawei | Agree with moderator view and understanding.About vivo question, we think RAN2 has already agreed to support multiple CG configurations for CG SDT which in Rel-16 was designed to reduce latency as vivo considered. |
| Spreadtrum | We are fine with Option 1. |
| LG | Regarding R1-2102932, we think that Option 1 should be the baseline understanding. We are not sure if we really need flexibility provided by msgA PUSCH configuration for CG SDT.Regarding R1-2103334, during this meeting, RAN1 could clarify that the CG configuration is dedicated to a UE and specification impact on contention resolution is not expected for CG-SDT.  |
| Apple | According to RAN2 agreements and LS, the CG-SDT is based on Option 1, but for the detailed configuration for CG-SDT configuration needs to be discussed further on top of type 1 CG configuration.For the second question, RAN2 agreed no contention resolution procedure is assumed for CG-SDT. |
| Intel | We support Option 1, i.e., reusing configuration mechanism for CG configuration. The detailed signalling mechanism can be discussed further.  |
| Nokia, NSB | We have assumed option 1, and the detailed signalling mechanism for the configuration is RAN2 business. |
| InterDigital | Option 1 can be used and assumed.  |

### Second round comments

Moderator’s observation based on the first round discussion

* Seems we are aligned that the CG configuration mechanism can be reused in principle. More details can be further discussed, e.g. support of multiple DMRS resources, limitation of configuration period, interpretation of repetition number, etc.
* Regarding the second question whether the contention resolution is needed or not, we can simply follow RAN2 agreement that no contention resolution procedure is assumed for CG-SDT as pointed out by Apple.

Based on the above, the following conclusion is proposed.

**Proposed conclusion 1:**

* It is RAN1’s common understanding that the CG configuration mechanism in licensed band can be reused for CG-SDT in principle.

Any comments on the proposed conclusion?

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with FL proposal. |
| Ericsson | We’re generally fine with the intention of the proposal. However, we propose to include the FFS bullet for companies to discuss any additional changes needed for SSB to PUSCH mapping:**Proposed conclusion 1:*** It is RAN1’s common understanding that the CG configuration mechanism in licensed band can be reused for CG-SDT in principle.
	+ FFS specific changes needed to support SSB to CG PUSCH mapping
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|  |  |

## Association between the SSBs and the CG resources for CG-SDT

Based on the contributions submitted to this meeting:

Opt. 1 is supported by CATT (R1-2102578), OPPO (R1-2102837), vivo (R1-2102932), Ericsson (R1-2103678).

But the details are still different, i.e. in CATT’s contribution it is proposed that the SSBs are map to time domain resources only, while in the contribution of OPPO and vivo, the proposal is to support 1-to-1 mapping between SSB and one PUSCH resource associated with one PUSCH DMRS. Furthermore, in Ericsson’s contribution it is mentioned that opt 1 and opt 2 are not exclusive, and proposed to FFS whether different subset of SSBs should be mapped to different CG PUSCH configurations.

Opt. 2 is supported by Huawei (R1-2102312), Nokia (R1-2102647), Intel (R1-2103013), Apple (R1-2103075), InterDigital (R1-2103380), LGE (R1-2103334), ZTE (R1-2103494)

It is noticed that in Huawei’s contribution it is proposed to additionally configure the mapping ratio so that PUSCH resource in different CG periods under the same CG configuration may be associated with different SSBs; while the other proponents’ views are that there is no need to define another SSB-to-PUSCH transmission occasion mapping within the CG configuration. In addition, in LGE’s contribution it is further proposed that different CG configurations should be mapped to different SSBs.

Based on the moderator’s understanding, there are actually three alternatives: 1) the SSBs are mapped to the PUSCH resource units (PUSCH occasion + DMRS); 2) the SSBs are mapped to the PUSCH configuration, no need to differentiate the PUSCH resources in the configuration; 3) the SSBs are mapped to the time-domain PUSCH resources (CG period), corresponding to the figures and proposals in the contributions by Huawei and CATT. It is proposed to do the down-selection among them in this meeting and provide the reply LS to RAN2.

***Discussion point #1:***

* Down-select from the following alternatives for the mapping between SSBs and CG resources for CG-SDT in this meeting
	+ Alt. 1: The SSBs are mapped to the PUSCH resources units (a unit is defined as a transmission occasion and a DMRS port used for PUSCH transmission), reusing the SSB-to-RO mapping as the baseline.
	+ Alt. 2: CG resources per CG configuration are associated with a set of SSB(s) by explicit signalling. No need to define another SSB-to-PUSCH transmission occasion mapping within the CG configuration.
	+ Alt. 3: Each CG configuration is configured with a set of SSB(s) by explicit signalling. The SSBs in the set are further mapped to the PUSCH resources by configuring the mapping ratio of SSBs associated with CG periods per CG configuration.

### First round comments

Please indicate which alternative is preferred/acceptable/not acceptable for the mapping between SSBs and CG resources for CG-SDT in the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company | Alt(s) preferred | Alt(s) acceptable | Alt(s) NOT acceptable | Comments |
| Samsung  | Alt.1 |  |  | One clarification for Alt.1 is that, whether DMRS port maybe need to change to DMRS resource to include potentially different DMRS sequence? In Alt.2, if multiple SSB associated with on CG resource, and when UE needs to send the CG-PUSCH, how could gNB differentiate the preferred SSB selected by UE if there is no SSB-to-PUSCH transmission occasion mapping within the CG configuration?Is the intention of alt.3 the combination of alt.1 and alt.2 somehow?  |
| CATT | Alt.1 |  |  | For Alt.1, first of all, mapping between SSBs and CG occasions is executed and then DMRS resource should further be used for difference of SSBs if needed.For Alt.2, each CG resources per CG configuration is associated with a set of SSB(s). Because gNB receives initial CG PUSCH transmission by a set of SSBs, gNB can’t identify which SSB is selected by the UE. If the CG PUSCH retransmission happens, gNB doesn’t know which beam is used to receive the CG PUSCH retransmission. In addition, multiple CG configurations with the same CG configuration parameters can be used to support all of SSBs. |
| ZTE | Alt.2 |  |  | Alt.2 is preferred due to less spec effort and better resource utilization. We think the issue of multiple SSBs associated with the same CG resource mentioned by Samsung can be handled by proper gNB implementation. The similar behavior also exists for RACH, i.e. if the SSB-to-RO mapping ratio is larger than 1.Unlike the RACH or MsgA resources that are common to multiple UEs, the CG resources may be dedicated to a UE. If different SSBs are mapped to different CG resources like Alt.1 or Alt.3, the resource utilization would be limited. |
| Ericsson | Alt.1, Alt3? |  |  | In our view, to make it possible for gNB to know which SSB is preferred by UE, SSB should be mapped to each PUSCH resource unit (time/frequency/DMRS), which is the motivation of introducing SSB to CG PUSCH mapping. And this doesn’t have to cause much spec. impact since a mapping rule can be defined in either RRC parameter field descriptions or in RAN1 spec. similar to preamble to PUSCH mapping in CFRA or SSB to RO mapping in CBRA.For alt3, not sure why we need to explicitly configure a mapping ratio, isn’t enough that the mapping ratio is determined by the number of SSBs for the CG configuration and the number of PUSCH resource unit in one mapping period (e.g. one CG configuration period) ? This is already used by SSB to RO mapping in legacy and we should try to avoid optimization on the mapping itself in our understanding. |
| vivo | Alt.1 |  |  | We think multiple CG PUSCH resources, e.g. multiple CG PUSCH occasions or a PUSCH occasion with multiple DMRS resources, need to be supported, as mentioned in the question 4.1.In this regard, Alt. 1 is preferred since different SSBs can be identified by different PUSCH resource units. |
| Huawei, HiSilicon | Alt. 3 |  |  | We should first confirm whether the number of SSBs mapping to one CG configuration is configurable, mainly for Alt.1. Then, the difference of the 3 Alts is which resource level the corresponding SSBs associated to. Alt.2 is to the CG configuration level, Alt.3 is to the CG period level (assuming 1 DMRS for one CG configuration), and Alt.1 is to the CG period+DMRS (so-called PUSCH resources units) level. For both Alt.3 and Alt.1, mapping ratio is used and we support the one-to-one, one-to-multiple, multiple-to-one SSB-to-CG period mapping ratio like SSB-to-RO mapping.Note that in Alt.1, the PUSCH resources units is defined for msgA PUSCH, which is no relationship with CG-SDT PUSCH as mentioned in Section 4.1.1. |
| Spreadtrum | Alt.1 |  |  | In our view, gNB needs to know which SSB is preferred by UE. Thus, SSB should be mapped to each PUSCH resource unit (time/frequency/DMRS). |
| LG | Alt 2 and/or Alt 3 |  |  | We prefer Alt 2 and/or Alt 3. In Alt 2, gNB may not need to know a set of SSB(s) associated to the CG resources per CG configuration e.g. by a single RX beam. If gNB needs to know which SSB is preferred by UE, different SSBs could be mapped to different CG configurations with or without the mapping ratio as in Alt 3. Or, if UE does not need to be provided with more than one SSB (e.g. stationary or indoor UE), only one SSB could be mapped to a CG configuration without the mapping ratio.Note that, in our view, one or more CG configurations provided to a UE do not need to be mapped to all SSBs of a serving cell for the single UE, depending on gNB configuration. If a best SSB is not mapped to any CG configuration, UE may use RACH e.g. for non-SDT. |
| Apple | Alt 2 |  |  | The implicit association between SSB and CG-SDT resource is not necessary, dedicated CG-SDT resource are allocated to UE, i.e., contention free, which is different from RO or MsgA shared by multiple users. So from this perspective, the explicit signaling the association is straightforward and simpler.If it is agreeable to signal the association explicitly, then the configuring the association is more like RAN2 issue. Comparing with Alt2 and Alt3, the Alt 2 could save the higher layer signalling, as many parameters in one CG configuration, i.e.,*ConfiguredGrantConfig,* could be reused for SSB association.  |
| Intel | Alt. 2 |  |  | In our view, the main difference between Alt. 1 and Alt. 2 is that it highly depends on how many SSBs that gNB would configure for UE to operate for CG-SDT. If the number of SSBs is limited, which we think this is the general case for proper SDT operation, Alt.2 can provide more flexibility as gNB can configure separate CG-PUSCH resources for each configured SSBs. Further, we do not need to design the SSB to PO association and simply reuse the existing configuration for CG-PUSCH resource to minimize the spec impact. A clarification for Alt. 3: does that mean mapping rule still needs to be defined, e.g., ordering of SSB/CG-PUSCH resource? if this is correct understanding, what is the difference between Alt. 1 and Alt. 3 assuming Alt. 1 also configures a set of SSBs?  |
| Nokia | Alt.2 (not sure we fully understand the difference of Alt.3 relative to Alt.2) |  |  | Alt.2 is preferred due to its simplicity. There is no need to define any new concepts, just associate a CG-PUSCH configuration with one (or more if applicable) SSBs and you are done.This question on Alt.2 seems to be asked again and again: “*In Alt.2, if multiple SSB associated with on CG resource, and when UE needs to send the CG-PUSCH, how could gNB differentiate the preferred SSB selected by UE if there is no SSB-to-PUSCH transmission occasion mapping within the CG configuration?”* If the gNB needs to make the differentiation, then it does not configure the resources this way. Do note that Rel-15 allows for mapping of several SSBs to the same RO, but if you need to know the SSB the UE sees then you don’t use this configuration there either. If you need 1-to-1 mapping, then you configure 1-to-1 mapping. |
| InterDigital | Alt. 2 |  |  | Alt2 provides the flexibility for the network to configure each CG resource with the applicable set of SSB(s), without requiring much spec changes. |

### Second round comments

Moderator’s observation based on the first round discussion

* Alt.1 is supported by 5 companies (Samsung, CATT, Ericsson, vivo, Spreadtrum)
	+ The benefit is that gNB can identified the SSB selected by the UE based on the mapping
	+ The main concern is about the extra spec efforts, which may not be necessary as the contention resolution is not needed.
* Alt.2 is supported by 6 companies (ZTE, LGE, Apple, Intel, Nokia, InterDigital)
	+ The main concern is how gNB could differentiate the preferred SSB selected by UE if multiple SSBs are associated to a CG PUSCH resource.
	+ The above concern is clarified as up to gNB configuration, similar to the SSB-to-RO mapping in Rel-15.
* Alt.3 is supported by 2 companies (Huawei, LGE)
	+ One company asked about the difference between Alt.1 and Alt.3. Based on the moderator’s understanding, alt.3 and alt.1 is identical if multiple DMRS per CG configuration is not supported and a subset of SSB can be configured per CG configuration.
	+ One company asked about the difference between Alt.2 and Alt.3. Based on the moderator’s understanding, alt.3 allows to associate different SSBs to different PUSCH occasions within a CG configuration by introducing a mapping ratio.

Although the views are still a bit diverse, but it seems that none of the alternatives are strongly objected. All the alternatives can work. If we go with Alt.1, probably some FFS would be needed to specify the details, e.g. multiple DMRS for CG configuration, value range of mapping ratio, potential limitation of configuration period, etc. Since we’ve already had two meetings discussing this issue, the moderator would like to propose to go with Alt.2 to save the RAN1 efforts if there is no strong concern. However, if this is no achievable, perhaps we could first agree on the main bullet, and leave the sub-bullet for further study.

**Proposal 2:**

* CG resources per CG configuration are associated with a set of SSB(s) by explicit signalling.
	+ No need to define another SSB-to-PUSCH transmission occasion (with or without DMRS resource) mapping within the CG configuration.

Any strong concern or suggestion on the proposal 2?

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| --- | --- |
| Company | Comment |
| CATT | We still think Alt.1 is reasonable, considering UE mobility in the inactive-mode.Comparing with Alt.2, gNB needn’t configure multiple CG configurations to support all of SSBs. In our understanding, different CG configuration should correspond to the different type of traffic service. In addition, gNB can identified the SSB selected by the UE based on the mapping.So we would like to modify proposed2 as follows:**Proposal 2:**CG resources per CG configuration are associated with a set of SSB(s) /all of SSBs by explicit signaling. * + ~~No~~ Need to define ~~another~~ SSB-to-PUSCH transmission occasion (with or without DMRS resource) mapping within the CG configuration.
 |
| Ericsson | Regarding the concern of alt1 summarized: “The main concern is about the extra spec efforts, which may not be necessary as the contention resolution is not needed.”.Could the company that raised this concern help to clarify why contention resolution is needed when a mapping rule between SSB and PUSCH occasions with a period is applied? The mapping is only used for gNB to identify good-enough/best SSB beam that the UE prefers for CG PUSCH transmission.For the updated proposal, it’s not clear to us how the explicit signaling is needed to define a mapping. It should be the SSB resources and the CG PUSCH resources that are explicitly configured, and some rules (e.g. resource ordering etc.) are enough to define the mapping between the set of CG resources and the set of SSBs. And whether any specific signaling is really needed for the mapping itself can be FFS.According to above, and considering that the mapping rules can be either defined in RAN2 spec. or RAN1 spec., we propose:**Proposal 2:*** CG resources per CG configuration and ~~are~~ the associated ~~with a~~ set of SSB(s) defined by explicit signalling are mapped based on rules either defined in RAN1 spec. or defined in the field descriptions of the corresponding RRC parameters by RAN2.
	+ FFS the mapping rules
	+ FFS the need of additional signaling for the mapping
	+ ~~No need to define another SSB-to-PUSCH transmission occasion (with or without DMRS resource) mapping within the CG configuration.~~
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## Repetition of CG PUSCH for CG-SDT

Several companies supporting the alt.2 or alt.3 for the association (Huawei, CATT, Nokia, Apple, ZTE) point out that repetition can be supported based on the existing CG configuration.

One company supporting alt.1 (vivo) mentioned that if CG-SDT PUSCH repetitions are supported, all PUSCH repetitions should be associated with the same SSB(s), and a RV sequence for CG-SDT PUSCH repetitions are defined, e.g. RV= {0, 2, 3, 1}.

One company (InterDigital) proposed not to address the FFS for repetition, for the reason that coverage enhancement is not pursued.

***Discussion point #2:***

* Is there any additional spec impact to support repetition for CG-SDT?

### First round comments

Any comments on the discussion point #2?

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| Company | Comment |
| Samsung  | We don’t think the repetition function is necessary for CG-SDT, as in RAN2 discussion, the UE will decide to do which type of SDT based on channel measurement, apparently only the UE with better channel will do CG-SDT.Besides, we can reuse the configuration of repetition number to interpret as number of PUSCH transmission occasion in one CG period.  |
| CATT | When PUSCH repetition is applied for Type1 CG configuration during CG-SDT, the same SS/PBCH blocks should be associated with one TO bundle including K TOs corresponding to the K repetitions. |
| ZTE | Repetition can be supported naturally for alt.2 |
| Ericsson | Repetition is already supported for CG type 1 in legacy, we do not see the real reason to preclude it for SDT. However, to reduce the complexity of CG PUSCH transmission for small data, maybe Type-A PUSCH repetition is enough and different SSBs can be mapped to different repetitions when multiple SSB to one PUSCH transmission (could have multiple repetitions) is configured, we’re open to discuss on this. |
| vivo | Although repetitions are supported for CG in connected mode, we think the necessity to support repetitions for CG-SDT should be further clarified first. If CG-SDT PUSCH repetitions are supported, all PUSCH repetitions within a bundle should be associated with the same SSB(s) |
| Huawei, HiSilicon | Repetitions in R15/16 CG configuration can be reused for CG-SDT. It can be considered as a baseline that all the repetition occasions within one CG period are associated with the same SSB(s). Whether to associate the repetition occasions to different SSBs can be FFS. |
| Spreadtrum | The necessity to support repetitions for CG-SDT should be further studied. |
| LG | We are fine to support repetition for CG-SDT. Different PUSCH repetition in a CG periodicity could be mapped to a same SSB (or different SSBs, if needed). |
| Apple | Repetition can be supported with less standard effort. If the overhead is the concerns, repetition can be disabled by configuring with no repetition, the choice is left to network. |
| Intel | We support repetition for CG-SDT and we do not see the spec impact for this, which is based on existing CG configuration. All repetitions for a CG-PUSCH resource should be associated with an SSB |
| Nokia, NSB | CG-PUSCH supports repetition and we don’t see any spec impact supporting it for SDT-CG-PUSCH either. We also do agree that repetition may not be very practical for SDT, but there doesn’t seem to be a need to exclude it. |
| InterDigital | RAN2 agreed that an RSRP threshold is used to select between SDT and non-SDT procedure, and this threshold is used for both CG-SDT and RA-SDT. With such threshold, the network can ensure that SDT is used in good channel conditions to support the payload. We therefore thing that no enhancements are needed for repetitions in INACTIVE state, and CG repetitions can be reused as is. The network can simply disable the configuration of CG repetitions. |

Moderator’s observation based on the first round discussion:

* The discussion is also related to the association design in section 4.2, probably we can revisit it after the association mechanism is determined.

## PUSCH validation

In R1-2102932 (vivo) and R1-2103013 (Intel), it is proposed to reuse the msgA PUSCH validation rule for the validation of CG-PUSCH occasions for CG-SDT

Intel also mentioned that overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH should be further studied.

***Discussion point #3:***

* Reuse the msgA PUSCH validation rule for the validation of CG-PUSCH occasions for CG-SDT
	+ FFS overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH

### First round comments

Any comments on the discussion point #3?

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| --- | --- |
| Company | Comment |
| Samsung  | If the CG-PUSCH configuration is upto gNB configuration, it may not be necessary to apply the validation rules, since unlike 2step RACH, the msgA PUSCH is highly related to the RACH which is configured by gNB with only limited options. |
| CATT | We have the same view with Samsung. |
| ZTE | We share with Samsung’s observation if it is up to gNB configuration and the UE behavior could be similar as the normal PUSCH. We are also open to discuss any additional validation rules if needed. |
| Ericsson | Since this validation depends on how the resources are configured, it would be good to discuss the resource allocation and the basic mapping rule in high level first in our view. This is similar to our discussions for MsgA PUSCH in 2-step RACH topic. We’re open to discuss this later after the resource allocation and general mapping scheme is clear. |
| vivo | Support the main bullet of proposal.For the FFS in sub-bullet, it can be up to UE implementation to handle the overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH. Similar to the case of overlapping between MsgA PUSCH and the other PUSCH, it is up to UE implementation when MsgA PUSCH and CG PUSCH for SDT are overlapping in time within a same slot or when a gap between MsgA PUSCH transmission and the CG PUSCH for SDT transmission is separated by less than N symbols, where *N* = 2 for **= 0 or **= 1, *N* = 4 for **= 2 or **= 3, and ** is the SCS configuration for the active UL BWP. |
| Huawei, HiSilicon | As given by the understanding in Section 4.1.1, i.e. the CG configuration is not related to msgA PUSCH occasion, then no need to discuss this. |
| Spreadtrum | We shared the similar views with Samsung. |
| LG | As Ericsson pointed out, we also think that it is desirable to discuss basic resource allocation for CG SDT at first. We could discuss whether PUSCH validation rule is needed or not later. |
| Apple | We share the views with Samsung. Validation rule is not really necessary. |
| Intel | We support this proposal.  |
| Nokia, NSB | Agree with Ericsson, we can revisit this question after the resource configuration mechanisms are agreed, and at least in that sense agree with Samsung that there is a good chance that no validation is required. |
| InterDigital | Agree with Samsung |

Moderator’s observation based on the first round discussion:

* The majority view is that the validation rule may not be necessary. Could be revisited after the basic resource allocation is determined

## Retransmission of CG-SDT

In R1-2103334, LGE propose to support multiple HARQ processes for a CG configuration, and support PDCCH based retransmission for CG SDT.

***Discussion point #4***

* Support multiple HARQ processes for a CG configuration, and support PDCCH based retransmission for CG SDT

### First round comments

Any comments on the discussion point #4?

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| --- | --- |
| Company | Comment |
| Samsung | RAN2 to discuss first. |
| CATT | RAN2 should handle this issue. |
| ZTE | We share the same view as Samsung and CATT that it can be discussed in RAN2 first. |
| Ericsson | Up to RAN2 to discuss. |
| vivo | Same view as other companies that RAN2 should discuss the issue first. |
| Spreadtrum | Up to RAN2 to discuss. |
| LG | We are fine to let RAN2 discuss need for multiple HARQ processes. Then, RAN1 could discuss it later based on the outcome of RAN2 discussion, if needed.Meanwhile, if dynamic scheduling is supported for retransmission of CG-SDT, search space and DCI for PDCCH based retransmission for CG-SDT need to be discussed in RAN1. |
| Apple | Up to RAN2 to discuss. |
| Intel | It seems RAN2 is currently discussing this issue. We do not need to duplicate the discussion in RAN1.  |
| Nokia, NSB | Up to RAN2 to discuss. |
| InterDigital | This is discussed in RAN2 |

Moderator’s observation based on the first round discussion:

* The majority view is that it is up to RAN2 to discuss first. So let us refrain from a duplicated discussion in RAN1.

# Beam correspondence in RRC\_INACTIVE

In R1-2102647, Nokia mention that the UE in RRC\_INACTIVE needs to support beam correspondence for the SDT-CG-PUSCH resource to SSB relation to be useful. And it is proposed to send an LS to RAN4 requesting the beam correspondence requirements to be applied to RRC\_INACTIVE.

***Discussion point #5***

* Support beam correspondence for the SDT-CG-PUSCH resource to SSB relation. Send an LS to RAN4 requesting the beam correspondence requirements to be applied to RRC\_INACTIVE.

### First round comments

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | RAN2 to discuss first and this is probably out of scope. |
| CATT | We are fine with FL proposal. |
| ZTE | Agree with Samsung |
| Ericsson | Isn’t the SSB selection (e.g. based on SS-RSRP threshold criteria) for CG PUSCH resource determination procedure supposed to be defined in MAC spec.? Could you clarify the beam correspondence requirements? |
| vivo | Discuss in RAN2 first |
| vivo | Discuss in RAN2 first |
| Nokia, NSB | With beam correspondence requirement we mean that there is a testable RAN4 requirement ensuring that the UE is able to direct its transmit beam to the direction from which it is receiving its best SSB. For the time being our understanding is that such requirement in RAN4 only apply to RRC\_CONNECTED, and if not extended to RRC\_INACTIVE the UE Tx beam could point to a different direction than where the SSB is received from, and the whole SDT-CG-PUSCH transmission is lost. Hence we think it would be important to trigger this to RAN4. |
| InterDigital | In RAN2’s discussion, most companies seem to think this can be discussed in RAN1. RAN1 can wait for further conclusions from R2 though. |

Moderator’s observation based on the first round discussion:

* The majority view is that it should be discussed in RAN2 first. So it is suggested that the proponent bring the contribution to RAN2 and trigger the discussion in RAN4/RAN1.

# CORESET/SS for RA-SDT

Agreements from the last meeting:

* From RAN1 perspective, at least a separate SearchSpace that is different from the existing common SearchSpace should be supported for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT
	+ It is up to RAN2 decision if the separate SearchSpace is UE-specific or common to the UEs performing RA-SDT
* If the separate SearchSpace is not configured, type-1 PDCCH CSS can be reused.
* FFS UE-specific CORESET or common CORESET

Three contributions (R1-2102578, R1-2103286, R1-2103380) mention about the CORESET/SS configuration for RA-SDT. Based on the agreement in the last meeting, it is the moderator’s view that we should wait for RAN2’s response on the UE-specific or common SearchSpace before we continue the discussion.

***FL recommendation***: Wait for RAN2’s response on the UE-specific or common SearchSpace before we continue the discussion.

### First round comments

Any comment on the FL recommendation?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung  | Fine with FL recommendation |
| CATT | We are fine with FL proposal. |
| ZTE | Fine with FL recommendation |
| Ericsson | Fine. |
| vivo | Fine with FL recommendation |
| Spreadtrum | Fine with FL recommendation |
| LG | Fine with FL recommendation |
| Apple | Fine with FL recommendation |
| Intel | We are fine with the FL’s recommendation. |
| Nokia, NSB | Agree with the FL recommendation |
| InterDigital | Fine with FL recommendation |

# BWP related issues

1. In R1-2103334, LGE proposed that CG SDT can be performed on SDT specific BWP configured by RRC Release message or System Information. If no SDT specific BWP is configured, the initial BWP is used for CG-SDT.
2. In R1-2103494, ZTE proposed that if non-initial BWP is configured with CG resource for CG-SDT, common CORESET and common search space should be configured in the paired DL BWP in order to receive SI and paging.

It is the moderator’s view that we should wait for RAN2’s input on the configuration of BWP for SDT before we initiate the discussion in RAN1.

***FL recommendation***: Wait for RAN2’s input on the configuration of BWP for SDT before we initiate the discussion in RAN1.

### First round comments

Any comment on the FL recommendation?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Fine with FL recommendation |
| CATT | We are fine with FL proposal. |
| ZTE | Fine with FL recommendation |
| Ericsson | Fine. |
| vivo | Fine with FL recommendation |
| Spreadtrum | Fine with FL recommendation |
| LG | Fine with FL recommendation |
| Apple | Fine with FL recommendation |
| Intel | We are fine with the FL’s recommendation. |
| Nokia, NSB | Agree with the FL recommendation |
| InterDigital | Fine with FL recommendation |

# Others

Any other issues or comments?

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

# Summary

The final proposals will be added later.

# References

1. R1-2100025 LS on physical layer aspects of small data transmission RAN2, ZTE
2. R1-2102125 Reply LS on physical layer aspects of small data transmission RAN1, ZTE
3. R1-2102286 LS on uplink timing alignment for small data transmissions RAN2, Lenovo
4. R1-2102312 RA and CG based small data transmission Huawei, HiSilicon
5. R1-2102578 Discussion on remaining issues on small data transmission CATT
6. R1-2102647 On physical layer aspects of small data transmission Nokia, Nokia Shanghai Bell
7. R1-2102837 Discussion on NR small data transmissions in INACTIVE state OPPO
8. R1-2102930 Draft Reply LS on uplink timing alignment for small data transmissions vivo
9. R1-2102932 Discussion on RAN1 impacts for small data transmisison vivo
10. R1-2103013 Discussion on physical layer aspects of small data transmission Intel Corporation
11. R1-2103075 Discussion on physical layer aspects of small data transmission Apple
12. R1-2103139 UL timing alignment for SDT Qualcomm Incorporated
13. R1-2103211 Discussion on TA validity check based on RSRP threshold Samsung
14. R1-2103286 Configuration of CORESET and search space for SDT Sony
15. R1-2103334 Discussion on physical layer aspects of small data transmission LG Electronics
16. R1-2103380 Physical layer aspects of small data transmission InterDigital, Inc.
17. R1-2103494 Discussion on the physical layer aspects of small data transmission ZTE, Sanechips
18. R1-2103678 Discussion on RAN1 aspects for NR small data transmissions in INACTIVE state Ericsson

# Appendix

List of proposals in the submitted contributions.

|  |  |
| --- | --- |
| TDoc | Proposals |
| R1-2102312Huawei, Hisi | ***Observation 1:*** *UE in RRC\_INACTIVE can move within the serving cell and maintain the valid TA if the distance between UE and gNB does not change much.****Observation 2:*** *Considering the multi-beam operation in NR,* *the RSRP of the downlink pathloss reference is used to select SUL/NUL, 2-step/4-step RA type and Group A/B, while the SS-RSRP is used only for SSB selection.****Observation 3:*** *For the UEs with stable location, the TA can stay valid regardless of time duration. For UEs (e.g. IWSN in the factory) that camp on a small cell, the performance loss is not obvious even though the TA is not accurate due to UE motion.****Proposal 1:*** *The number of SSBs mapping to one CG configuration should be configurable. It is up to the network whether and how to configure all the SSBs mapping to CG resources in one or multiple CG configurations.* ***Proposal 2:*** *Specification should support network can explicitly configure the mapped SSBs and the mapping ratio of SSBs associated with CG periods per CG configuration.****Proposal 3:*** *RAN1 confirm that the RSRP change of the downlink pathloss reference can be a suitable criterion for determining the validity of the uplink timing alignment for CG-SDT. The threshold can be explicitly configured to a UE transferring to RRC\_INACTIVE.****Proposal 4:*** *Support network to configure infinite TAT value in CG-SDT configuration, or take the implicit way like PUR in LTE such that when the TAT IE is not configured, the TAT is not considered as the criterion of TA validation.* |
| R1-2102578CATT | **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-CG-PUSCH mapping rule for the association between the SSBs and the CG resources per CG configuration for CG-SDT 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 times of CG period and is configured by high layer signaling. Starting of the association period is SFN 0.****Proposal 4: PUSCH repetition mechanism 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.****Proposal 5: The TA validation mechanism for CG-SDT is based on RSRP change.** |
| R1-2102647Nokia | **Configuration of association between the type 1 CG resource(s) for CG-SDT and SSB(s)****Observation 1**: Defining a concept of SSB-to-SDT-CG-PUSCH transmission occasion mapping is redundant when each SSB can be provided with a specific SDT-CG-PUSCH configurartion when needed**Proposal 1:** The SDT-CG-PUSCH resource to SSB relation is provided explicitely in the RRC configuration allowing one SDT-CG-PUSCH configuration per 1-N SSBs. No other SSB-to-PUSCH transmission occasion relation is defined.**PUSCH repetition with SDT-CG-PUSCH****Observation 2**: 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.**Beam Correspondence in RRC\_INACTIVE****Observation 3:** The UE in RRC\_INACTIVE needs to support beam correspondence for the SDT-CG-PUSCH resource to SSB relation to be useful.**Proposal 3:** Send an LS to RAN4 requesting the beam correspondence requirements to be applied to RRC\_INACTIVE**TA validity within and across SSBs****Observation 4:** TA validation based on serving cell RSRP variation is not robust in a NR system due to the multi-beam scenarios.**Proposal 4:** RAN1 should study enhancements to the serving cell RSRP variation based TA validation that work in multi-beam cells. |
| R1-2102837OPPO | ***Proposal 1: Opt. 1(Define the SSB-to-CG-PUSCH mapping rule) is preferred.******Proposal 2: Multiple PUSCH resources can be configured in one PUSCH occasion and each PUSCH resource is associated with a unique PUSCH DMRS.******Proposal 3: Support one-to-one mapping between SSB and one PUSCH resource associated with one PUSCH DMRS.******Proposal 4: The mapping rule between SSB and RACH Occasions can be reused. The association period/association pattern period between SSB and PUSCH can also follow the design of that for association between SSB and RACH Occasions.*** ***Proposal 5: RSRP can be used as the criterion for determining the validity of the uplink timing alignment for CG-SDT.******Proposal 6: Cell level RSRP shall be used for uplink timing alignment validation.*** |
| R1-2102932vivo | **Proposal 1: For CG-SDT, validity of uplink TA can be determined based on the serving cell level RSRP change.****Proposal 2: For configuration of CG-SDT PUSCH resource, option 2 is preferred, i.e. reuse the configuration mechanism for msgA PUSCH configuration of 2-step RACH.****Proposal 3: For mapping between SSB and CG-SDT resources, option 1 is preferred, i.e.*** + **Opt. 1: Define the SSB-to-CG-PUSCH mapping rule**
		- **Reuse the SSB-to-RO mapping as the baseline**
		- **One-to-one mapping is adopted for an SSB and a CG PUSCH with a DMRS resource.**

**Proposal 4: For CG-SDT resource, msgA PUSCH validation rule can be reused.****Proposal 5: If CG-SDT PUSCH repetitions are supported, all PUSCH repetitions are associated with the same SSB(s). A RV sequence for CG-SDT PUSCH repetitions are defined, e.g. RV= {0, 2, 3, 1}.** |
| R1-2103013Intel | **Proposal 1*** *Opt. 2 is supported for association between SSB and CG resource for CG-SDT.*

**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.*

**Proposal 3*** *It is feasible to utilize SS-RSRP change for TA validation of CG-SDT.*
 |
| R1-2103075Apple | **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.** |
| R1-2103139Qualcomm | Since the SSB transmission in NR is beam-specific, and M (M≥1) SSB beams can be associated with a CG-SDT configuration, UE needs to select a SSB beam as reference for TA validation. The beam selection needs to be completed before the 1st CG-SDT occasion. The criterion for beam selection has been agreed by RAN2, which is based on a SS-RSRP threshold $γ\_{s}$ determined by the NW. UE selects one of the SSB beams whose SS-RSRP is above the threshold and uses the associated CG resources for SDT. At the end of beam selection, the L1-RSRP measurement of the reference beam, say $γ\_{0}$ , is kept by UE as a baseline for TA validation.Once the reference beam is selected, UE will keep measuring the L1-RSRP of the reference beam before each CG-SDT occasion, and comparing the latest measurement $γ\_{n}$ with baseline $γ\_{0}$ and threshold $γ\_{s}$. * If $γ\_{n}$ is above $γ\_{s}$ and the difference between the baseline and the latest measurement is within a range determined by NW, i.e.

$γ\_{n}>γ\_{s}$ and $∆\_{RSRP,decrease}\leq γ\_{n}-γ\_{0}\leq ∆\_{RSRP,increase}$where $∆\_{TA, decrease}$ and $∆\_{TA, increase}$ are two thresholds configured by the NW, the TA is validated and the CG-SDT can proceed. * Otherwise, the TA is considered as invalid and UE needs to skip the CG-SDT and re-acquire UL timing by RACH.

The thresholds used in the reference beam selection and TA validation procedures can be signaled to UE in RRCRelease message.A special case for TA validation is a stationary UE configured with CG-SDT resources. Based on the UE capability signaling of a stationary UE, NW can relax the TA validation criteria, including reducing the duty cycle of measurements or configuring the TAT-SDT expiration time as infinity. |
| R1-2103211Samsung | ***Observation 1: the applicability of RSRP based TA validation mechanism is high related to gNB implementation (e.g., number of beams, beam width, the setting the RSRP change threshold etc).******Proposal 1: a TA validation mechanism for SDT based on the RSRP change of best SSB could be used. The threshold should be carefully configured by gNB.*** |
| R1-2103286Sony | **Proposal 1: After the successful completion of the random-access procedure for SDT, a UE monitors CSS Type 1 and CORESET#0 if *PDCCH-ConfigCommon* does not configure another common search space (CSS Type X)*.* If *PDCCH-ConfigCommon* configures another common search space (CSS Type X)*,* a UE should monitor this CSS Type X and its associated common CORESET#Y.****Observation 1:** If C-RNTI is also associated when a UE is in Inactive state, it could have a different meaning or purpose than the legacy C-RNTI in the spec, for example, for a given statement in the spec whether the stated C-RNTI is for SDT functionality or non-SDT functionalities.**Proposal 2: For RA-SDT, upon successful completion of contention resolution, the UE shall monitor the SDT-RNTI or SDT-C-RNTI. If adopted, RAN1 should send an LS to RAN2 about the name change.** |
| R1-2103334LGE | ***Observation: Option 1 seems similar to RACH resource configuration which may require some UL resource overhead if RACH-like CG PUSCH occasions are dedicated to a UE.******Proposal 1: Clarify whether a CG PUCCH occasion is dedicated to one UE or common to all UEs capable of SDT at a cell.******Proposal 2: Clarify whether a CG PUSCH transmission in Option 1 requires contention resolution.*** ***Observation: If both RA-SDT and CG-SDT are configured at a cell, it would be sufficient to map only a few SSBs to CG PUSCH occasions (e.g. for temporarily or almost permanently stationary UEs or indoor UEs in FR2).*** ***Proposal 3: In Option 2, CG resources per CG configuration are associated with a set of SSB(s) by UE dedicated message. UE may not be provided CG resources for all SSBs for CG-SDT.******Proposal 4: In Option 2, if multiple CG configurations are configured for a UE, different CG configurations are mapped to different subsets of SSBs of a cell.*** ***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.******Proposal 6: Even if the best SSB of a cell is not associated to any other CG PUSCH occasion 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 7: 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 8: Support PDCCH based retransmission for CG SDT.******Proposal 9: Repetition of PUSCH transmissions associated to a same or different SSBs in a CG period is supported for CG-SDT.******Proposal 10: Support multiple HARQ processes for a CG configuration. The number of HARQ processes for each CG can be configured by RRC Release message.******Proposal 11: CG SDT can be performed on SDT specific BWP configured by RRC Release message or System Information. If no SDT specific BWP is configured, the initial BWP is used for CG-SDT.*** |
| R1-2103380InterDigital | ***Proposal 1:*** *For PDCCH monitoring addressed to C-RNTI after successful completion of the RA:**- The UE-specific CORESET can be configured as a dedicated search space.**- It is up to RAN2 how the UE keeps coreset and search space configurations upon transitioning into INACTIVE state.***Observation 1:** *The UE select the CG resource associated with the best measured SSB-rsrp, similar to RO selection.***Proposal 2:** *For the association between SSBs and SDT CG resources, support Opt. 2. RRC configures each CG SDT resource with one or more associated SSBs.* **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**: *No need to handle FFS issues on repetitions or TA validation, as those are already addressed by R2.* |
| R1-2103494ZTE | ***Proposal 1: For CG-SDT, support to optionally configure a subset of SSB by RRC Release message.******Proposal 2: Considering the RAN1 specification effort, it is preferable to associate the CG resources per CG configuration with a set of SSB(s) by explicit signalling.******Proposal 3:*** * ***For CG-SDT, it is beneficial to introduce TA validation mechanism based on RSRP variation.***
	+ ***The RSRP of the DL pathloss reference can be used for TA validation.***

***Proposal 4:**** ***It is up to network configuration whether or not to enable the TA validation mechanism.***
	+ ***If not configured, the TA is always considered as valid.***

***Proposal 5: If non-initial BWP is configured with CG resource for CG-SDT, common CORESET and common search space should be configured in the paired DL BWP in order to receive SI and paging.*** |
| R1-2103678Ericsson | **Observation 1 RSRP change based on single SSB may not reflect whether TA is changing in NR.**[Proposal 1 Option 1 is used for the mapping between SSB to CG PUSCH.](#_Toc68624322)[Proposal 2 Further discuss whether different subset of SSBs should be mapped to different CG PUSCH configurations.](#_Toc68624323)[Proposal 3 Use RSRP measurement on a set of SSBs per CG PUSCH configuration to derive an RSRP change for TA validation in CG based SDT, and the set of SSBs can be determined based on an absolute RSRP criterial with an absolute RSRP threshold configured for TA validation.](#_Toc68624324)[Proposal 4 Different RSRP variation thresholds and TAT configuations can be configured for different sets of SSBs with different beam width which can be e.g. in different CG PUSCH configuations.](#_Toc68624325)[Proposal 5 On top of the TA validation based on RSRP change, support TDOA based crieterial for TA validation in CG based SDT.](#_Toc68624326) |