**3GPP TSG-RAN WG1 Meeting #107-e R1-211xxxx**

**e-Meeting, November 11th – 19th, 2021**

**Agenda Item: 5.2**

**Source: Moderator (ZTE)**

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

**Document for: Discussion**

# Introduction

In this meeting, it is necessary to continue the discussion on the remaining physical layer issues, i.e. mapping details of SSB to PUSCH mapping details and some other SDT related procedures.

This document contains the summary of remaining issues related to the physical layer aspects of small data transmission in RAN1#107-e meeting.

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

* 1st check point: November 15
* Final check point: November 19

# SSB to PUSCH mapping details for CG-SDT

## Mapping ratio and association period

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. For the candidate value set of SSB to CG PUSCH mapping ratio, support the values {1/8,1/4,1/2} 2. Allow different SSB to CG PUSCH mapping ratio for different CG-SDT configurations. 3. If the CG period values for SDT are the same as those defined for CG Type 1 PUSCH, the candidate values of SSB to CG PUSCH association period is defined similar to the candidate values of SSB to RO association period according to Table 1. 4. RAN1 to send LS to RAN2 asking RAN2 to provide feedback regarding whether or not the period values for CG-SDT are the same as those defined for CG Type 1 PUSCH. RAN1 to design the SSB to CG PUSCH association period for SDT based on the feedback from RAN2. |
| R1-2110812 Huawei [2] | ***Proposal 2:*** *Mapping ratio of SSB to CG PUSCH is configured per CG configuration. No restriction on the value across the CG configuration.* |
| R1-2110973 vivo [3] | **Proposal 1: It is not necessary for CG-SDT to restrict the same value for all CG configurations.**  **Proposal 2: The candidate value set of mapping ratio of SSB-to-PRACH occasion {1/8,1/4,1/2} is supported.** |
| R1-2111083 Spreadtrum [4] | ***Proposal 2: Do not restrict the same value for all CG configurations.***  ***Proposal 3: Do not support the candidate values {1/8, 1/4, 1/2} for mapping ratio of SSB to CG PUSCH per CG configuration.*** |
| R1-2111356 ZTE [5] | ***Proposal 1: There is no need to restrict the same value of mapping ratio for all CG configurations.***  ***Proposal 2: Do not introduce mapping ratio N<1 for CG-SDT.*** |
| R1-2111473 Intel [7] | **Proposal 1**   * *For the mapping ratio of SSB to CG PUSCH resource*   + *Different mapping ratios can be configured for different CG configurations.*   + *Do not support mapping ratio < 1.* |
| R1-2111539 Xiaomi [8] | **Proposal 1: Reuse the similar mapping relationship between SSBs and ROs.**  **Proposal 4: Support only 1-to-1 mapping ratio between the SSB and the DMRS resource in a definite PO.** |
| R1-2111711 Samsung [9] | ***Observation 2: if one SSB could only be in one CG-PUSCH configuration, the benefit to configure different mapping ratio is unclear;***  ***Observation 3: if one SSB could be in multiple CG-PUSCH configurations, the benefits of having different mapping ratios may or may not exist depending on whether the subset and all indicated SSBs are in multiple CG-PUSCH configurations, respectively.***  ***Proposal 3: different mapping ratio is not supported.*** |
| R1-2111844 Apple [10] | **Proposal 1: One SSB mapping to multiple CG PUSCH resources is not supported.** |

### 2.1.1 First round discussion

One remaining issue for candidate value set of mapping ratio is whether to introduce {1/8, 1/4, 1/2}, 2 companies[1] [3] support to introduce N<1, the reason is that the mapping ratio of SSB to RO mapping can be directly reused, 5 companies[4][5][7][8][10] do not support N<1 since mapping ratio for CG-SDT is UE specific, there is no benefit to allow UE to randomly select CG PUSCH resource. One company[8] even only supports N=1, however, {1, 2, 4, 8, 16} have already been agreed in last meeting, there is no strong motivation to revert previous agreement.

Another issue is whether to restrict same mapping ratio for all CG configurations and/or allow different values for different CG configurations, 6 companies[1][2][3][4][5][7] think there is no need to restrict same value for all CG configurations, while one company[9] still believes there is no benefit to allow different values for different CG configurations.

One company[1] suggests to define the candidate value set of association period for SSB to CG PUSCH mapping, it’s noted that RAN1 has already asked RAN2 about whether to restrict CG period value set, so moderator suggests to wait for RAN2’s decision on CG period and then come back to association period if needed.

***Conclusion #2.1:***

* No need to restrict the same value of mapping ratio for all CG configurations.
* Do not introduce mapping ratio N<1 for CG-SDT.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Question to FL, sorry from the summary I did not see the benefits to having different mapping ratio for different CG-PUSCH configuration for a single given UE. I see you mentioned 6 companies thinks there is no need to restrict, but could you clarify what’s the main purpose and use cases? Thank you. |
| Spreadtrum | CG configuration is beam set specific. Different CG configuration can have different beam set. |
| Ericsson | We are fine with first bullet.  We are NOT fine with the second bullet. The N<1 values are anyway configurable by the NW. We also would like to check with the FL if N<1 is not supported, would this have impact on configuration of repetitions for CG PUSCH? |
| Intel | We are fine with the conclusion.  Different CG-PUSCH configurations may have different DMRS resources/CG-PUSCH periodicity/MCS/amounts of resources/number of associated SSBs, it is not reasonable to assume same mapping ratios between SSB and CG-PUSCH resources in different configurations.  As CG-PUSCH configuration is configured in RRC release message and is UE specific, transmission of CG-PUSCH would be contention free. Our view is that it is not necessary to allow UE to randomly select one CG-PUSCH resource. In this case, N < 1 is not justified. |
| Apple | We are fine with the conclusion.  For the second bullet, RAN2 already agreed that “*Configuration is only type 1 CG with no contention resolution procedure for CG*”.” If mapping ratio N<1, it violates the RAN2 agreement, and we don’t see any benefits to have such configuration. |
| Qualcomm | We are fine with the first bullet. For the second bullet, we think N<1 can be configured by NW and it is not against RAN2’s agreement, wherein contention refers to different UEs choose the same DMRS/PUSCH resources. |
| HW, HiSi | We are fine with the proposal. |
| ZTE, Sanechips | We are fine with the conclusion. For the 2nd bullet, although N<1 does not violate RAN2 agreement, it seems not beneficial to allow UE to randomly select from multiple PUSCH resource. Since CG configuration is UE specific, it means the PUSCH resources allocated to one UE cannot be used by other UEs to avoid contention resolution, it may cause resource waste. |
| Xiaomi | We are fine with the first bullet.  For the second bullet, N<1 is beneficial for the case that SSB shave a long periodicity but the CG has a short periodicity. |
| vivo1 | Fine with the first bullet.  Do not support 2nd bullet, supporting N<1 means that one SSB can be mapped to multiple CG PUSCH occasions/DMRS resources which could be used by more static UEs in our understanding, i.e. when the beam change is not that fast while multiple SSB beams are configured in one CG configuration. |

### 2.1.2 Second round discussion

Proposal to be updated

## Repetitions

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. Support repetition of a TB across multiple slots for CG-SDT. |
| R1-2110812 Huawei [2] | ***Proposal 1:*** *The repetition mechanism in CG configuration in licensed band is reused for CG-SDT.* |
| R1-2111356 ZTE [5] | ***Proposal 5: For CG-SDT, the repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s).*** |
| R1-2111473 Intel [7] | **Proposal 3**   * *Repetition of CG-PUSCH is supported.*    + *The repetitions are considered as a bundle of transmission occasions that are mapped to a same SSB.* |
| R1-2111711 Samsung [9] | ***Observation 1: the repetition in CG-SDT is not motivated and no clear benefit could be identified.***  ***Proposal 2: the repletion in CG-SDT is not supported.*** |
|  |  |

### 2.2.1 First round discussion

5 companies mentioned repetitions, 4 companies[1][2][5][7] among them support repetitions and consider the repetitions as a bundle of transmission occasions that are mapped to the same SSB(s), while one company[9] does not support repetitions and think the repetition has no clear benefit. Since this is the last meeting in Rel-17, and repetition has RRC impact, we have to make a decision in this meeting.

***Proposal #2.2***:

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

In addition to the proposal above, Moderator would like to make sure all companies understand the concern from the objecting company, so companies are also encouraged to provide comments on the following questions.

Q1: Do you think repetition is beneficial for CG-SDT? If so, what is the benefit of repetition?

Q2: If some of the repetitions are invalid, it may result in different number of repetitions mapped to different SSBs, e.g. repK is configured as 4, SSB1 is associated with 4 repetitions while SSB2 is associated with 2 repetitions(2 other repetitions are invalid), do you think it will cause problems for the unequal number of repetitions associated with different SSBs?

Any comments on the proposal and questions?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | To save sometime, we want to ask the direct/basic question since the above 2 questions might still get us to repeat each other and the way how it is asked is questionable. We are not in the CR phase; causing problem is NOT the criteria, whether having justification and benefits should be. So instead, we want to ask the proponents for supporting repetition, especially when the same number of repetition cannot be guaranteed, for which we can compromise to same number of repetition cases.  Q: which use case is beneficial when the number of repetitions are not equal (e.g., one SSB with 4 repetitions and another SSB without repetition), given the fact that gNB has no idea on which SSB this UE will select? |
| Spreadtrum | Q1: beneficial for coverage  Q2: up to gNB implementation |
| Ericsson | Fine with proposal.  Q1: Yes. It may be beneficial for coverage reasons. Also, the repetitions are anyway configurable by the NW.  Q2: No. The gNB can also rely on retransmissions if there are coverage issues due to unequal repetitions. |
| Intel | Q1: this is beneficial as commented multiple times.  Q2: this will not lead to issue for the unbalanced number of repetitions for different SSBs. This can also happen for normal PUSCH repetitions, e.g., due to collision with DL symbols, higher priority transmission, etc.  If there is really concern for this, our suggestion is to invalidate all the repetitions for a CG PUSCH occasion if one repetition is invalidated. This can help avoid unbalanced mapping and meanwhile guarantee the performance. |
| Apple | Q1: it’s beneficial for the coverage  Q2: don’t see the issue for unbalanced repetitions. gNB has the flexibility to configure repetition or not, and the repetition number. |
| Qualcomm | Q1: repetitions can improve coverage/reliability.  Q2: no. |
| Huawei, HiSilicon | Q1: The repetition is benefit for improving the receiving performance of PUSCH. We gives an example of use case in our tdoc [2]. In RRC\_INACTIVE, The RSRP threshold for CG-SDT cannot always guarantee the gNB’s receiving performance of CG PUSCH because this is a cell-level RSRP calculated by averaging the RSRP of several SSBs such as SSB0~7, which is not for specific SSB, e.g. SSB1. However, the gNB shall probably receive the PUSCH according to the beam of SSB1 if UE chooses the PUSCH occasion associated to SSB1. In this case, the receiving performance cannot be guaranteed and the repetition can help to improve the receiving performance.  Q2: We do not see any problem from the unequal number of repetitions associated with different SSBs. |
| ZTE, Sanechips | Q1: Repetitions are beneficial for coverage, it will allow more UEs to transmit SDT.  Q2: We also don’t see the issue with unequal number of repetitions.  Q from Samsung: Although gNB has no idea on which SSB this UE will select, it’s most probably that the actual repetition number of selected SSB is not 1, it still has benefit compared with no repetitions. |
| LG Electronics | Q1: It’s beneficial for the coverage.  Q2: We don’t see the issue. |
| Xiaomi | Q1: Benefit to improve the coverage.  Q2: Don’t see the problem of the unequal number of repetitions associated with different SSBs. |
| vivo1 | Q1: Repetitions are of course beneficial for coverage, which is an important feature being further enhanced in URLLC topic in Rel-16 and coverage enhancement topic in Rel-17.  Q2: No. The number of actual repetitions for each transmission can be different even in legacy PUSCH repetitions. We can not understand why we need to introduce such restrictions in PUSCH repetitions in SDT topic, which is quite strange to the majority companies as we’ve repeated many times. |

### 2.2.2 Second round discussion

Proposal to be updated

## Validation of PUSCH occasion

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. A CG PUSCH occasion is not valid if it overlaps with MsgA PUSCH occasion at least for CBRA. 2. Further discuss in RAN1 on whether CG-SDT in RRC inactive state is allowed on flexible symbols. 3. If CG-SDT is only allowed in uplink symbols, additional UE specific TDD uplink-downlink configuration should be supported in the RRC release message. 4. To support CG-SDT in flexible symbols, *enableConfiguredUL* can be configured in the RRC release message. 5. There is no need to define validation rules for CG PUSCH for paired spectrum for RedCap UEs operating in Type-A HD FDD mode. |
| R1-2110812 Huawei [2] | ***Proposal 3:*** *A CG PUSCH occasion is valid if it overlaps with MsgA PUSCH occasion.* |
| R1-2110973 vivo [3] | **Proposal 4: No need to define UL/DL pattern type of validation rule specific for paired spectrum for RedCap UEs. The collision handling mechanisms agreed in RedCap WI are reused for SDT for RedCap UEs.**  **Proposal 5: It is up to UE implementation to handle the overlapping between CG-PUSCH occasions for CG-SDT and any valid MsgA PUSCH occasion.** |
| R1-2111356 ZTE [5] | ***Proposal 3: It’s up to UE implementation to handle the overlapping between CG PUSCH occasions and MsgA PUSCH occasions.*** |
| R1-2111539 Xiaomi [8] | **Proposal 8: For the PUSCH occasion validation for HD-FDD Redcap UEs, reuse the same rules as ROs discussed in AI.8.6.1.3.**  **Proposal 9：For UEs with 2-step RACH feature, the CG-SDT POs are invalid if they are overlapping with msgA POs mapping to the preamble of valid ROs.** |
| R1-2111844 Apple [10] | **Proposal 2: No new validation rule is defined for CG PUSCH occasion. It’s up to gNB implementation to avoid the overlap between CG PUSCH occasion and MsgA PUSCH occasion.** |
| R1-2112189 Qualcomm [12] | ***If a UE is configured with both CG-SDT and 2-step RACH resources in RRC inactive state, it is not expected to handle overlap between CG-PUSCH occasions and msgA PUSCH occasions configured by higher layers.*** |

### 2.3.1 First round discussion

3 companies[1][3][8] think that there is no need to define validation rule for CG PUSCH for RedCap UEs. the collision handling mechanisms defined in RedCap WI can be reused.

As for the overlapping between CG PUSCH occasions and MsgA PUSCH occasions, 2 companies[1][8] think the CG PUSCH occasion is invalid if it overlaps with MsgA PUSCH occasions, while 5 companies[2][3][5][10][12] think that there is no need to define validation rule to handle the overlapping between CG PUSCH occasions and MsgA PUSCH occasions because they are all optional features.

Considering that majority companies prefer to not define additional validation rule other than already agreed, Moderator suggests to go with the following conclusion.

***Conclusion #2.3***

* No need to define validation rule for CG PUSCH for RedCap UEs.
* No need to define validation rule to handle overlapping between CG PUSCH occasions and MsgA PUSCH occasions.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Seems ok.  For second bullet, one question to ask, does 2step RACH is a mandated feature for supporting SDT? If not, then some UE may not even see the msgA PUSCH occasions. |
| Ericsson | Fine with the first bullet. However, it could be clarified that the proposal concerns RedCap UEs operating in HD-FDD Type A mode.  NOT fine with the second bullet. In our view, CG PUSCH occasion is not valid if it overlaps with MsgA PUSCH at least for CBRA of 2-step RA type. In our understanding, even if a CG-SDT UE doesn’t support 2-step RACH, it can know where the MsgA PUSCH occasions when it reads the configuration in SIB1. |
| Intel | Regarding validation rule for CG PUSCH for RedCap UEs, our understanding is that they can simply follow what was defined for FDD, i.e., when CG PUSCH overlaps with ROs, it is invalid. We are open to consider for SSB symbols to validate the CG PUSCH for RedCap UEs.  Regarding overlapping between CG PUSCH occasions and MsgA PUSCH occasion, we share similar view as Ericsson that CG PUSCH occasion is not valid if it overlaps with MsgA PUSCH. The design is similar to the MsgA PUSCH validation when colliding with ROs for 4-step and 2-step RACH. |
| Apple | Ok with the conclusions.  For the second bullet, SDT UE will not response any 2-step RACH related signalings if it doesn’t support 2-step RACH feature. |
| Qualcomm | The wording of the first bullet is a bit confusing to us. Does it actually mean R17 SDT will not define *RedCap-specific* validation rules for CG PUSCH occasions ? If so, we propose to revise it as:  *If a R17 RedCap UE supports CG-SDT, the RedCap UE is expected to re-use the CG PUSCH occasion validation rules specified for non-RedCap UE in both TDD and FDD.* |
| Huawei, HiSilicon | Fine with the conclusion |
| ZTE, Sanechips | Fine with the conclusion. |
| LG Electronics | Fine with the conclusion. |
| Xiaomi | Fine with the first bullet.  For the second bullet, we think at least for UEs with 2-step RACH feature, the CG PUSCH occasion is not valid if it is overlapping with Msg.A PUSCH occasions, in case of influencing other UEs’ RACH procedure. |
| vivo1 | Fine. |

### 2.3.2 Second round discussion

Proposal to be updated

## Multiple CG occasions per CG period

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. Multiple CG PUSCH occasions in time and/or frequency domain can be configured per CG period for CG-SDT in RRC inactive state. 2. DMRS configuration can be independent from the configurations of multiple CG PUSCH occasions. |
| R1-2110973 vivo [3] | **Proposal 3: For CG-SDT, multiple TDMed and/or FDMed CG PUSCH occasions in one CG period can be configured.** |
| R1-2111356 ZTE [5] | ***Proposal 4: Multiple CG occasions per CG period is not supported.*** |
| R1-2111473 Intel [7] | **Proposal 2**   * *Multiple PUSCH occasions in a CG-PUSCH period are supported for a CG-PUSCH configuration.* |
| R1-2111539 Xiaomi [8] | **Proposal 3: Support multiple POs configured in a configured grant period.** |
| R1-2111711 Samsung [9] | ***Proposal 1: Configure the number of PUSCH transmission occasion (PO) in one CG-PUSCH period by re-interpreting the number of repetitions configured.*** |

### 2.4.1 First round discussion

6 companies[1][3][5][7][8][9] have mentioned multiple CG PUSCH occasions per CG period, companies’ views are summarized as below:

* Option 1: Configure multiple TDMed and/or FDMed CG PUSCH occasions in one CG period, similar as multiple MsgA PUSCH occasions[1][3][7][8]
* Option 2: Configure the number of PUSCH transmission occasion (PO) in one CG-PUSCH period by re-interpreting the number of repetitions configured.[9]
* Option 3: Multiple CG occasions per CG period is not supported[5]

***Proposal #2.4***

Down-select among the following options in RAN1#107e:

* Option 1: Configure multiple TDMed and/or FDMed CG PUSCH occasions in one CG period, similar as multiple MsgA PUSCH occasions.
* Option 2: Configure the number of PUSCH transmission occasion (PO) in one CG-PUSCH period by re-interpreting the number of repetitions configured.
* Option 3: Multiple CG occasions per CG period is not supported.

Any preference on the above options?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | Option 2 or 3; |
| Ericsson | Option 1 |
| Intel | We support Option 1.  In our view, multiple CG-PUSCH occasions in a CG-PUSCH period for a CG-PUSCH configuration can be helpful to reduce the latency for CG-SDT operation, especially when number of DMRS resources is relatively small. The design can simply reuse what was defined for MsgA PUSCH configuration |
| Apple | We don’t see strong motivation to support TDMed /FDMed CG PUSCH occasion. It will have large impacts on current CG configuration. We already agreed the SSB to CG PUSCH association period and association pattern period, there are enough space to mapping the SSB to CG-PUSCH resource.  Option 3 is preferred. |
| Qualcomm | Option 1 |
| HW, HiSi | Our understanding is Option 3 includes the case of multiple DMRSs and Option 1 require changes on the previous agreements about SSB index mapping with CG configuration, wherein only DMRS indexes, CG period indexes is considered.  So Option 3 is preferred. |
| ZTE, Sanechips | Option 3 |
| Xiaomi | Option 1. |
| vivo1 | Fine with FL proposal.  Option 1 is slightly preferred (compared to option 3) by us considering more POs may be needed when a smaller number of DMRS resources is configured. We can not see how option 1 reverts any earlier agreements made in RAN1 so far.  We do not think option 2 is necessary, repetition should be independent from SSB to CG PUSCH resource mapping and all repetitions should have same mapping as the first repetitions. In addition, multiple PUSCH resources and repetitions could be separate discussion. |

### 2.4.2 Second round discussion

Proposal to be updated

## Other mapping issues

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. When multiple CG PUSCH configurations are provided, additional information from the UE can be provided to the gNB to determine the SSB associated with the UL data received on an overlapping PUSCH resource associated with multiple CG configurations. 2. A UE specific TDRA list for CG PUSCH resource allocation in RRC inactive state should be configured in the RRC release message. Which TDRA list or table to select for CG-SDT can be based on predetermined rules when multiple TDRA lists, or tables are available. |
|  |  |
|  |  |

### 2.5.1 First round discussion

The following mapping related issues are summarized based on the submitted contributions:

Issue 2.5-1 UE specific TDRA table in RRC inactive state [1]

Issue 2.5-2 SSB determination based on overlapped PUSCH resource in multiple CG configuration [1]

These issues are resubmitted and proposed by single company, so moderator would suggest companies to provide views on these issues to identify which one is critical. Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | 1. One more issue to raise that the SSB-PUSCH association period determination, previously in RACH, since the RACH period is 10ms based, and SSB-RACH association is also 10ms based; but now the CG-PUSCH period has different value as well as symbol-level periodicity and candidate value set is dependent on the SCS. We think this issue should be resolved.  2. another one is similar to SSB-RACH, there should be a starting time for SSB-PUSCH association as well, e.g., SFN0 as in SSB-RACH association. |
| Ericsson | In our view, both issues are critical and needs to be addressed.  With regards to Issue 2.5-2, the details on what additional information from the UE can be provided to the gNB can be FFS or can be decided in RAN2. |
| HW, HiSi | We don’t see strong motivation to have extra efforts towards these issues (not meaning they are not issues while they seem to be able to be addressed automatically by reusing current mechanisms and gNB configuration). |
| vivo1 | For 2.5-1, RAN1 needs to conclude whether UE specific TDRA table is needed or not, if not whether legacy SIB1 configured TDRA table is used or not.  For issue 2.5-2, to avoid blind decoding of PUSCH configured by different CG configurations, it might be enough to require UE to transmit PUSCH configured by the first CG configuration in this case. |

### 2.5.2 Second round discussion

Proposal to be updated

# SDT related procedures

## Beam related

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2111356 ZTE [5] | ***Proposal 6: Consider to report preferred DL beam by UCI included in PUSCH transmission to gNB.*** |
| R1-2111379 Sony [6] | **Proposal 1: After beam failure for the subsequent RA-SDT, a UE triggers RACH procedure for reporting the beam change to gNB.**  **Proposal 2: After a UE has transmitted a contention-based PRACH preamble, a UE monitors any DCI addressed to C-RNTI on the “new SSB” within a widow of time. If the UE receives a DCI addressed to C-RNTI on the common search space and common CORESET that are configured for SDT in the cell, then the UE assumes the beam change is successful.** |
| R1-2111473 Intel [7] | **Proposal 4**   * *For CG-SDT, UE transmits the PUCCH carrying HARQ-ACK feedback in response to a PDSCH with a same spatial domain transmission filter as a last PUSCH transmission.* |
| R1-2111539 Xiaomi [8] | **Proposal 6: Don’t support any additional explicit or implicit way to report the beam change.** |
| R1-2111711 Samsung [9] | ***Observation 4: RA-SDT can already support DL beam change during RACH procedure.***  ***Proposal 7: UCI piggybacked in PUSCH can be supported to indicate the preferred DL beam (e.g., SSB index) for PUSCH after msg4 in RA-SDT and CG-SDT.***  ***Proposal 8: for RA-SDT, the UL tx beam for PUSCH after msg4/B could be same as that one for last msg3 transmission, or last PUCCH transmission.***  ***Proposal 9: for CG-SDT, the first UL transmission could be also up to UE implementation*** |
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|  |  |
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### 3.1.1 First round discussion

4 companies[5][6][8][9] has mentioned the beam change related issues, regarding whether and how to report the beam change to gNB, companies’ views are summarized as below:

* Option 1: Report preferred DL beam by UCI piggybacked in PUSCH for RA-SDT and CG-SDT.[5][9]
* Option 2: For subsequent RA-SDT, report beam change through RACH procedure.[6]
* Option 3: No need to report beam change to gNB.[8]

One company[7] mentions that the beam used for PUCCH transmission for CG-SDT should be same as last PUSCH transmission. Another company[9] thinks for RA-SDT, the UL tx beam for PUSCH after msg4/B could be same as that one for last msg3 transmission, or last PUCCH transmission.

***Discussion point #3.1***:

* Down-select among the following options on beam change during subsequent data transmission in RAN1#107e:
  + Option 1: Report preferred DL beam by UCI piggybacked in PUSCH for RA-SDT and CG-SDT.
  + Option 2: For subsequent RA-SDT, report beam change through RACH procedure.
  + Option 3: No need to report beam change to gNB.
* For CG-SDT, UE transmits the PUCCH carrying HARQ-ACK feedback in response to a PDSCH with a same spatial domain transmission filter as a last PUSCH transmission.
* For RA-SDT, the UL tx beam for PUSCH after msg4/B could be same as that one for last msg3 transmission, or last PUCCH transmission.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | For 2nd bullet, what is the CG-SDT PUSCH beam determination? It could be changed by UE automatically? |
| Spreadtrum | Option 3. As TA validation is per cell in some companies’ view, there should be none of beam operation in CG-SDT procedure. It is very strange that mobility-caused TA change is per cell, but mobility-caused location change is per beam. |
| Ericsson | 1st main bullet: OK. Our preference is Option 3. But open to further discuss.  2nd main bullet: In our understanding, this issue also depends on whether L1/L2/L3 ACK supported for CG-SDT PUSCH transmission. For example, there may be possibility to unform the UE of the new spatial relation for PUCCH in the PDSCH transmission associated with the ACK (or associated with other PDSCH transmissions). Therefore, this can be FFS.  3rd main bullet: The intention of this bullet is not clear to us. |
| Intel | We do not think beam report is needed. If there is an issue, UE may trigger CG-PUSCH transmission which corresponds to different SSB for uplink transmission, or even fall-back to RA-SDT and conventional RACH procedure for subsequent data transmission. We support Option 3.  We are fine with 2nd bullet.  We may need further discussion on 3rd bullet. |
| Qualcomm | For the first bullet, we are ok with Option 3 (No need to report beam change to gNB).  For the second bullet, we are wondering if there is a “last PUSCH” before the PUCCH. In other words, PUCCH transmission may happen before CG PUSCH transmission starts in the initial UL BWP. |
| Huawei, HiSilicon | Fine with the discussion point 3.1.  For the first main bullet, RAN2 has agreed that UE can initiate legacy RACH when no qualified SSB, so Option 1 may not be necessary and Option 2 is already supported.  For the second and third main bullet, we think these will help to improve the transmission performance and both of them should be supported. |
| ZTE, Sanechips | For the first bullet, we prefer Option 1 and can accept Option 3 if this is majority’s view. |
| LG Electronics | For the first bullet, we prefer Option 1 or Option 2. For Option 2, we also think that UE can initiate RACH when no qualified SSB. |
| Xiaomi | For the first bullet, we prefer Option 3.  For the second and third bullet, just as the Msg.3 uplink transmission beam is determined based on UE’s implementation, we think there is no need to specify the beams for the uplink transmission in inactive state. |
| vivo1 | No need to introduce beam report, subsequent SDT can be assumed to have same beam as the initial SDT considering the time gap between initial and subsequent SDT should be that large.  For the HARQ feedback on PUCCH in RRC inactive state for SDT, the beam should be assumed to be same as the last CG PUSCH transmission for SDT in our understanding.  For RA-SDT, following text in current spec. in section 9.2.1 of 38.213 seems enough when dedicated PUCCH resource is not provided:   |  | | --- | | The UE transmits the PUCCH using the same spatial domain transmission filter as for a PUSCH transmission scheduled by a RAR UL grant as described in clause 8.3. | |

### 3.1.2 Second round discussion

Proposal to be updated

## Power control

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. If the SSB beam selected for CG-SDT PUSCH resource selection is changed, the TPC accumulation for the power control of CG PUSCH should be suspended. 2. RAN1 to discuss whether TPC command can be received in DCI format 2\_2 with CRC scrambled by TPC-PUSCH-RNTI for CG-SDT in inactive state. 3. RAN1 to discuss the UE-specific power control parameters for CG-SDT in RRC inactive state. |
| R1-2111356 ZTE [5] | ***Proposal 10: Align the understanding of RAN1 and RAN2 on power control parameters for RA-SDT.***  ***Proposal 11: Reuse power control mechanism in PUR, i.e. P0 and alpha should be configured for CG-SDT.*** |
|  |  |

### First round discussion

2 companies[1][5] propose to discuss UE specific power control parameters for CG-SDT, one company[5] thinks power control mechanism in PUR can be reused for CG-SDT, i.e. P0 and alpha. The reason is that, in inactive state, the existing power control parameter in CG configuration cannot be obtained. One company[1] considers the TPC accumulation for the power control of CG PUSCH should be suspended if SSB beam is changed. This company also suggests RAN1 to discuss whether TPC command can be received in DCI format 2\_2 with CRC scrambled by TPC-PUSCH-RNTI for CG-SDT in inactive state.

|  |
| --- |
| Agreement from RAN1:   * For RA-SDT in shared ROs and separate ROs with non-SDT, the power control parameters follow those for non-SDT,   - i.e. preambleReceivedTargetPower and power ramping setting follow those for non-SDT.  Agreement from RAN2  At least the following parameters can be RA-SDT specific.   * SSB selection related parameters, i.e., rsrp-ThresholdSSB, msgA-RSRP-ThresholdSSB. * Power control related parameters, i.e., preambleReceivedTargetPower/gA-PreambleReceivedTargetPower, powerRampingStep/msgA-PreamblePowerRampingStep, msg3-DeltaPreamble/msgA-DeltaPreamble. |

Another issue mentioned by [5] is that, RAN1 and RAN2’s agreements on power control parameters for RA-SDT is controversial, the understanding of RAN1 and RAN2 may need to be aligned.

***Discussion point #3.2***

* Reuse power control mechanism in PUR, i.e. P0 and alpha should be configured for CG-SDT.
* If the SSB beam selected for CG-SDT PUSCH resource selection is changed, the TPC accumulation for the power control of CG PUSCH should be suspended.
* Whether TPC command can be received in DCI format 2\_2 with CRC scrambled by TPC-PUSCH-RNTI for CG-SDT in inactive state.
* Down-select among the following options on power control parameters for RA-SDT:
  + Option 1: For RA-SDT, confirm RAN2’s agreement that the power control parameters can be RA-SDT specific.
  + Option 2: For RA-SDT, the power control parameters should follow that for non-SDT and ask RAN2 to revert their agreements.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | For 1st bullet, what is exactly power control mechanism in PUR?  For 2nd bullet, what is legacy behavior in current spec if beam changed during CG-PUSCH in RRC connected mode?  For 3rd bullet, may not be needed, open to discuss.  For 4th bullet, RAN2 agreement is fine. |
| Ericsson | * 1st main bullet: OK. In our understanding, PUR also supports open-loop power control mechanism. However, CG-SDT should support closed-loop power control mechanism. The FL could clarify this aspect to avoid misunderstanding. * 2nd main bullet: OK * 3rd main bullet: We don’t see a strong reason to support DCI format 2\_2 in inactive state * 4th main bullet: Option 1 |
| Intel | 1. What is PUR? Or it is intended for SDT?  2. is this simply to follow legacy behavior?  3. we do not see the need.  4. We support Option 1. |
| Apple | First bullet, we are open to discuss it, as there is subsequent transmission, the closed loop power control could be helpful.  Second bullet, this seems related to the third bullet, the TPC command accumulation need to support group common power control.  Third bullet, according to our understanding, small data transmission is infrequent transmissions in short time, no need to support group common power control.  Fourth bullet, Option1 is ok. |
| Qualcomm | Agree with the comments of Ericsson. |
| Huawei, HiSilicon | On the third bullet, whether DCI format 2\_2 should be detected in RRC\_INACTIVE is not clear, we do not see strong motivation to send TPC command through DCI format 2\_2.  On the fourth bullet, prefer Option 1 to confirm RAN2’s agreement. |
| ZTE, Sanechips | 1st bullet, this proposal is simply to say we may need to introduce P0 and alpha, if companies have concern on PUR mechanism, it can be removed. As for the existing power control parameter P0-PUSCH-AlphaSetId, it may not be used if UE specific power control is not configured.  2nd bullet, we thinks it’s not the legacy behavior, it would be better if proponent could clarify.  3rd bullet, we share similar view as Ericsson.  4th bullet, Option 1. |
| Xiaomi | 2nd bullet: OK  4th bullet: Option 1. |
| vivo1 | 1st bullet, it seems fine since this is the CG SDT in RRC inactive state.  2nd bullet, OK.  3rd bullet, group common TPC command may be not needed for SDT.  4th bullet, this depends on whether separate ROs or separate preambles in shared RO are used for differentiating SDT RA and non-SDT RA.  For shared RO, option 2 should be supported considering potential impact to legacy RA performance when different power control parameters are configured for different preambles in one RO; for separate RO, option 1 can be supported to allow more flexible power control configurations for SDT RA and non-SDT RA. |

### 3.2.2 Second round discussion

Proposal to be updated

## SDT for RedCap UE

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2112044 LGE [11] | ***Observation 1: If a separate initial BWP is configured, RedCap UE could not perform RACH on the legacy initial BWP because the legacy initial UL BWP for non-RedCap UEs is wider than the maximum RedCap UE bandwidth.***  ***Proposal 1: Clarify whether RedCap UE can support RA-SDT in Rel-17.***  ***Proposal 2: Discuss whether RA-SDT can be supported in a separate initial UL BWP for RedCap UEs.***  ***Proposal 3: Clarify whether RedCap UE can support CG-SDT in Rel-17.***  ***Proposal 4: Discuss whether CG-SDT can be supported in a separate initial UL BWP for RedCap UEs.*** |
| R1-2112189 Qualcomm [12] | ***Both RA-SDT and CG-SDT are supported by Rel-17 RedCap UEs***   * ***The RA-SDT and CG-SDT resources of a RedCap UE are configured in the initial UL BWP of the RedCap UEs*** * ***For a cell that supports SDT of RedCap UEs, the specification impacts of paging reception, UE power saving and S777DT can be minimized, if SSB and CORESET/CSS for paging and SDT are configured in the initial DL BWP of RedCap UE.*** * ***For both RA-SDT and CG-SDT, intra-slot frequency hopping of PUCCH can be enabled/disabled for RedCap UEs by SIB.*** |
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### 3.3.1 First round discussion

2 companies[11][12] would like to discuss whether CG-SDT and RA-SDT can be supported for RedCap UEs, if so, another issue is whether SDT can be configured on separate initial BWP configured for RedCap UEs and whether intra-slot frequency hopping of PUCCH can be enabled/disabled for RedCap UEs by SIB.

***Discussion point #3.3***:

* Whether RA-SDT and CG-SDT can be supported for RedCap UEs.
  + Whether RA-SDT and CG-SDT can be configured on separate initial BWP configured for RedCap UEs.
  + Whether intra-slot frequency hopping of PUCCH can be enabled/disabled for RedCap UEs by SIB.

Moderator would like to ask companies whether this joint discussion on SDT and RedCap should be discussed here, if so, companies are encouraged to provide comments on the following discussion point.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | We tends to design the SDT without considering specific optimization for Redcap, if need, they can adjust their Redcap feature for this. |
| Spreadtrum | SDT CSS for the separate initial BWP was mentioned in RedCap discussion. RA-SDT and CD-SDT should be supported by the separate initial BWP for RedCap UEs. |
| Ericsson | 1st sub-bullet: OK for RA-SDT. Wait for progress in the RedCap WI for CG-SDT.  2nd sub-bullet: OK |
| Intel | We are fine with the main bullet.  For the sub-bullets, we suggest to defer the discussions once all the details are clear for the support of separate initial BWP and frequency hopping for PUCCH in RedCap, in order to avoid duplicated discussions. |
| Apple | This is the last meeting for Rel-17. Before answer the question, we need to know how many aspects need to be considered for support RedCap UE, how much the specification impacts. After that, decision can be made. |
| Qualcomm | We think RA-SDT and CG-SDT can be supported for RedCap UE as optional UE features. The details of initial BWP configurations and intra-slot PUCCH FH can be discussed later. |
| Huawei, HiSi | We think the discussion is not needed - can be part of UE feature discussion. |
| ZTE, Sanechips | We think SDT can be supported for RedCap UE if no specific changes is needed for SDT. |
| LG Electronics | 1st sub-bullet: If gNB configures a separate initial BWP configured for RedCap UEs by SIB for a cell, RA-SDT and CG-SDT can be configured on separate initial BWP configured for RedCap UEs for the cell, e.g. depending on UE capability.  In this case, RedCap UEs may not support the legacy initial BWP at the cell. If so, RedCap UEs would not expect configuring/using RA-SDT and CG-SDT on the legacy initial BWP, if any, for the cell.  2nd sub-bullet: OK |
| Xiaomi | Share the same view as Intel and fine with the main bullet. |
| vivo1 | For the main bullet, we think RA-SDT and CG-SDT can be optionally supported for RedCap UEs, it can be discussed in UE feature agenda.  For the two sub-bullets, those can be discussed later depending on the progress in RedCap WI. |

### 3.3.2 Second round discussion

Proposal to be updated

## Search space

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2111356 ZTE [5] | ***Proposal 8: Separate common search space for RA-SDT can also be used for CG-SDT.*** |
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### 3.4.1 First round discussion

1 company[5] has noticed that in last meeting RAN1 has confirmed RAN2 working assumption that USS can be configured for CG-SDT, and it does not exclude CSS for CG-SDT. But it’s not clear which type of CSS can be used for CG-SDT, so this company suggests that the separate common search space defined for RA-SDT can also be used for CG-SDT.

***Discussion point #3.4***:

* Separate common search space for RA-SDT can also be used for CG-SDT.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | Fine |
| Intel | It is good to clarify what is the separate common search space for RA-SDT? Is this a new type CSS or existing type? |
| Qualcomm | We are ok with the proposal, if both RA-SDT and CG-SDT share the SSB/CORESET/CSS configurations of initial DL BWP. |
| HW, HiSi | Agree with Intel |
| ZTE, Sanechips | Fine with the proposal. We think the separate common search space for RA-SDT means a new type of CSS, that is what “separate” means, and it has already been agreed in RAN2. For CG-SDT, it’s natural to use the CSS defined for RA-SDT rather than existing CSS for other uses. |
| Xiaomi | Fine. |
| vivo1 | Fine with the intention of the proposal.  However, it would be also good to clarify whether such CSS could be the SS0, RA search space, RA search space for RA SDT etc., as configured in PDCCH-configCommon:   |  | | --- | | PDCCH-ConfigCommon ::= SEQUENCE {  controlResourceSetZero ControlResourceSetZero OPTIONAL, -- Cond InitialBWP-Only  commonControlResourceSet ControlResourceSet OPTIONAL, -- Need R  searchSpaceZero SearchSpaceZero OPTIONAL, -- Cond InitialBWP-Only  commonSearchSpaceList SEQUENCE (SIZE(1..4)) OF SearchSpace OPTIONAL, -- Need R  searchSpaceSIB1 SearchSpaceId OPTIONAL, -- Need S  searchSpaceOtherSystemInformation SearchSpaceId OPTIONAL, -- Need S  pagingSearchSpace SearchSpaceId OPTIONAL, -- Need S  ra-SearchSpace SearchSpaceId OPTIONAL, -- Need S | |

### 3.4.2 Second round discussion

Proposal to be updated

# Other physical layer issues

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

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2110774 Ericsson [1] | 1. SSB subset for RSRP based TA validation is within a set of SSBs per CG PUSCH configuration. 2. RSRP change can calculated as the difference between RSRP calculated at the time instant when the UE receives the latest TAC from the network and the RSRP calculated at the time instant when UE determines TA validation for CG-SDT. 3. In addition to the RSRP and TAT based TA validation mechanisms, support TDOA based TA validation based on SFTD measurements for CG- SDT in RRC inactive state. 4. The TA based on the latest UL transmissions in the RRC connected state should be provided in the RRC release message as the initial TA to be used for CG PUSCH transmission in RRC inactive state. 5. The TA for CG-SDT should be relative to the subcarrier spacing of the initial UL BWP for CG-SDT. 6. TA offset can be optionally configured in the RRC release message for CG-SDT. If the TA offset is configured, the UE applies this TA offset for CG PUSCH transmissions on this serving cell. If this field is absent, the UE applies the default value defined for the duplex mode and frequency range of this serving cell. |
| R1-2111083 Spreadtrum [4] | ***Proposal 1: The SSB subset for RSRP based TA validation is determined at least based on a configured absolute RSRP threshold, where the subset of SSBs is a set of SSBs configured per CG configuration.*** |
| R1-2111356 ZTE [5] | ***Proposal 7: From RAN1’s perspective, if CG-SDT is supported for unlicensed band, the solutions for mapping can be reused for unlicensed band CG-SDT, and the CG configuration in unlicensed band can also be reused for unlicensed band CG-SDT.***  ***Proposal 9: The following options can be considered for configuration of CG-SDT:***   * ***Option 1: Reuse existing BWP dedicated configuration (i.e. BWP-DownlinkDedicated and BWP-UplinkDedicated) for CG-SDT and clarify in RAN1 which parameters (e.g. pucch-Config, beamFailureRecoveryConfig) are applicable to CONNECTED mode only and should be ignored in CG-SDT operation.*** * ***Option 2: Define/use a new BWP dedicated (i.e. BWP-DownlinkDedicatedSDT and BWP-UplinkDedicatedSDT )configuration for SDT instead of the legacy one. RAN1 needs to identify the parameter list for the new SDT specific BWP dedicated configuration, and ask RAN2 to formulate the details of the IE structure.***   ***Proposal 12: srs-ResourceIndicator in ConfiguredGrantConfig is not applicable to CG-SDT.*** |
| R1-2111539 Xiaomi [8] | **Proposal 2: Support FDM between the different ROs.**  **Proposal 5: Do NOT support configuring CG-SDT resource on separate SDT BWP**  **Proposal 7: Don’t support any additional explicit L1 feedback signaling for CG-SDT.** |
| R1-2111711 Samsung [9] | ***Proposal 4: a PRACH mask index is supported for subset RO sharing for SDT purpose.***  ***Proposal 5: a RA Type (***4step RA, 2step RA,4step RA-SDT***) is supported to be indicated for subset RO sharing for SDT purpose.***  ***Proposal 6: only number of preamble for SDT in one RO for a SSB is necessary to be indicated. These preambles are counting from the end of the total preambles for one SSB in one RO.*** |
| R1-2112189 Qualcomm [12] | ***For an inactive UE performing CG-SDT or RA-SDT, the initial DL BWP is configured with at least SSB, CORESET/CSS for paging and SDT.***  ***In RA-SDT or CG-SDT, PUCCH can be transmitted by an inactive UE with valid TA***   * ***FFS if TA validation procedure of CG-SDT PUSCH can be applied to PUCCH transmission configured by higher layer during CG-SDT.*** * ***FFS if UCI multiplexing is supported by CG-SDT when PUCCH overlaps with CG PUSCH.*** |

## First round discussion

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

* 4.1 RO configuration[9]
* 4.2 TA validation[1][4]
* 4.3 CG-SDT for unlicensed band[5]
* 4.4 BWP level configuration for CG-SDT[5]
* 4.5 *srs-ResourceIndicator* in CG configuration[5]
* 4.6 Restriction on PUCCH transmission[12]

Shared RO mask has already been agreed in RAN1, RO configuration issue is being discussed in RAN2 feature combination, so moderator thinks that RAN2 will make the decision based on the general consideration of different WIs.

Subset of SSBs for TA validation will be decided in RAN2, other methods for TA accuracy are up to RAN4, so there is no need for RAN1 to further discuss it.

CG-SDT for unlicensed band has been discussed in RAN2, moderator would like to check whether it requires RAN1’s input.

BWP level configuration is about RRC parameters, if Option 1 is adopted, RAN1 may need to add restriction on some of the existing parameters in *BWP-DownlinkDedicated* and *BWP-UplinkDedicated*, and if Option 2 is adopted, RAN1 may need to tell RAN2 about which parameters can be included in the SDT specific BWP level configuration. This can also be discussed in RRC parameter related email discussion.

The parameter *srs-ResourceIndicator* in CG configuration is used for UL beam indication, but this may not needed in CG-SDT since gNB cannot obtain the beam measurement results in inactive state. This can also be discussed in RRC parameter related email discussion.

So the moderator suggests to first identify which issues are critical and need RAN1’s input. Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Ericsson | TDOA based TA validation is critical for a reliable CG SDT feature. This needs to be discussed. |
| Huawei, HiSilicon | Fine with moderator’s view on these issues. |
|  |  |
|  |  |

## Second round discussion

Proposal to be updated

# Summary

The final proposals will be added later.

# References

1. R1-2110774 RAN1 aspects for NR small data transmissions in INACTIVE state Ericsson
2. R1-2110812 Physical layer aspects of CG-SDT Huawei, HiSilicon
3. R1-2110973 Remaining RAN1 impacts for small data transmission vivo
4. R1-2111083 Discussion on physical layer aspects of small data transmission Spreadtrum Communications
5. R1-2111356 Discussion on the remaining physical layer issues of small data transmission ZTE, Sanechips
6. R1-2111379 Remaining issues of physical layer aspects for SDT Sony
7. R1-2111473 Discussion on physical layer aspects of small data transmission Intel Corporation
8. R1-2111539 Physical layer aspects for NR small data transmissions in INACTIVE state Xiaomi
9. R1-2111711 Discussion on physical layer aspects for NR small data transmissions in INACTIVE state Samsung
10. R1-2111844 Discussion on physical layer aspects of small data transmission Apple
11. R1-2112044 Discussion on physical layer aspects of small data transmission LG Electronics
12. R1-2112189 Draft reply LS on the physical layer aspects of small data transmission Qualcomm Incorporated