**3GPP TSG RAN WG1 #117 R1-240xxxx**

**Fukuoka City, Fukuoka, Japan, May 20th - 24th, 2024**

**Agenda Item: 7**

**Source: Moderator (ZTE)**

**Title: Summary#1 on SSB to CG-SDT PUSCH mapping**

**Document for: Discussion**

# Introduction

This document contains the summary of draft CR R1-2404210 for SSB to CG-SDT PUSCH mapping.

# Discussion (round 1)

## Text proposal

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| ***Reason for change:*** | In RAN1#106-e meeting, the SSB to CG PUSCH mapping method was agreed.

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| **Agreement*** Each N of consecutive SSB indexes associated to one CG configuration are mapped to valid CG PUSCH resources
	+ first, in increasing order of DMRS resource indexes, where a DMRS resource index *DMRSid* is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index
	+ second, in increasing order of CG period indexes in the association period
* The mapping ratio N is explicitly signalled and the association period is implicitly derived
	+ FFS candidate value set of mapping ratio, and whether it is configured per CG configuration or per cell
	+ The SSB to CG PUSCH association period is the duration of multiple of CG periods depending the smallest time duration in the set determined by the CG period such that all SSBs associated with the CG configuration are mapped at least once to CG PUSCH resources.
	+ An association pattern period includes one or more association periods and is determined so that a pattern between CG PUSCH occasions and SS/PBCH block indexes associated with the CG configuration repeats at most every 640 msec.

Note: The mapping ordering and steps may be revisited if multiple CG PUSCH occasions in one CG period is supported |

In RAN1#108-e meeting, it’s further clarified that non-consecutive SSB indexes are also allowed to be configured in SSB subset for mapping.

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| **Agreement**Non-consecutive SSB indexes are allowed to be configured in SSB subset for SSB to CG PUSCH mapping. |

Based on the above agreements, each N SSBs will be mapped to one DMRS port, where N is the mapping ratio, however, current spec does not capture the agreement completely, it’s not clear on the order of SSB indexes and how to map SSBs. For example, SSB#0, 1, 2, 3 are mapped to DMRS port#0 and 1 with mapping ratio 2, based on current spec, there might be 2 different understandings on mapping methods, i.e.1. SSB#0 and 1 are mapped to DMRS port#0, then SSB#2 and 3 are mapped to DMRS port#1.
2. SSB#0 and 1 are mapped to DMRS port#0 and DMRS port#1 respectively, then SSB#2 and 3 are mapped to DMRS port#0 and DMRS port#1 respectively.

The first understanding aligns with the agreement, but current spec may also be misinterpreted as second understanding, which would result in ambiguous implementation from BS and UE. |
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| ***Summary of change:*** | For SSB to CG-SDT PUSCH mapping, capture the missing information from previous agreements, i.e. “Each *N*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to a valid PUSCH occasion and the associated DMRS resource in the following order” |
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| ***Consequences if not approved:*** | SSB to CG-SDT PUSCH mapping is not clear. |

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| **19.1 Configured-grant based PUSCH transmission****< Unchanged text omitted >**Each *N*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to a valid PUSCH occasion and the associated DMRS resource in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexesA PUSCH occasion is valid if it does not overlap with a valid PRACH occasion as described in clause 8.1. For unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1*- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, a PUSCH occasion is valid if the PUSCH occasion- does not precede a SS/PBCH block in the PUSCH slot, and - starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, a PUSCH occasion is valid if the PUSCH occasion- is within UL symbols- starts at least $N\_{gap}$ symbols after a last downlink symbol, and at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2A UE determines a power of a PUSCH transmission as described in clause 7.1.1, where the UE obtains $PL\_{b,f,c}(q\_{d})$ using a RS resource from an SS/PBCH block with index associated with the PUSCH transmission.  |

**< Unchanged text omitted >**

## Companies’ views

Regarding the draft CR above, the following questions are provided:

### Question 1: Do you agree that there is ambiguity on the SSB to CG SDT PUSCH mapping?

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| Company | Comment |
| New H3C | It is fine to clarify SSB to CG SDT PUSCH mapping |
| vivo  | There could be some ambiguity. |
| Xiaomi | We are fine to have a further clarification on the SSB to CG SDT PUSCH resources mapping rule.  |
| Samsung | No. For the their first change (Each *N*,  provided by *sdt-SSB-PerCG-PUSCH,* of *N*PUSCHSS/PBCH SS/PBCH block), it is already covered by the following sentence in the specification.  An association period, starting from frame with SFN 0, for mapping 𝑁PUSCHSS/PBCH SS/PBCH block indexes, from the number of SS/PBCH block indexes, to valid PUSCH occasions and associated DM-RS resources is the smallest value in the set determined by the PUSCH configuration period provided by *periodicity* in *ConfiguredGrantConfig* according to Table 19.1-1 such that 𝑁PUSCHSS/PBCH SS/PBCH block indexes are mapped at least once to valid PUSCH occasions and associated DM-RS resources within the association period. **A UE is provided a number of SS/PBCH block indexes associated with a PUSCH occasion and a DM-RS resource by *sdt-SSB-PerCG-PUSCH***. If after an integer number of SS/PBCH block indexes to PUSCH occasions and associated DMRS resources mapping cycles within the association period there is a set of PUSCH occasions and associated DMRS resources that are not mapped to 𝑁PUSCHSS/PBCH SS/PBCH block indexes, no SS/PBCH block indexes are mapped to the set of PUSCH occasions and associated DMRS resources. An association pattern period includes one or more association periods and is determined so that a pattern between PUSCH occasions with associated DMRS resources and SS/PBCH block indexes repeats at most every 640 msec. PUSCH occasions and associated DMRS resources not associated with SS/PBCH block indexes after an integer number of association periods, if any, are not used for PUSCH transmissions. For the second change (SS/PBCH block indexes in increasing order), it should be naturally understood as increasing order without any clarification. No any ambiguity in current specification.  |

### Question 2: Do you agree with the text proposal in section 2.1? Or any other wording?

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| Company | Comment |
| New H3C | Because subsequent sub bullet already mentioned “increasing order ”,our suggestion is to remove “in increasing order” as follows Each *N*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes ~~in increasing order~~ are mapped to a valid PUSCH occasion and the associated DMRS resource in the following order |
| vivo  | According to the RRC specification, the values of *sdt-SSB-PerCG-PUSCH* could be less than one. Therefore, some additional updates can be made:

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| Each or each *N>1*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to a valid PUSCH occasion and the associated DMRS resource in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexes |

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| Xiaomi | Echo to New H3C: In our view, the “in increasing order” mentioned in the subsequent sub bullet actually refers the order of PUSCH resources (including different DMRs ports). Here, the “in increasing order” added by the moderator actually refers to the order of SSB indexes. This is different so we suggest to keep the “in increasing order” in the CR provided by the FL.Besides, as for the CR, we slightly prefer vivo’s version considering that the value N could be configured less than 1. Furthermore, maybe the following minor modification based on vivo’s version is necessary to address the case of N<1, where one SSB index is associated with 1/N(N<1) PUSCH resources:Each or each *N>1*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to valid PUSCH occasions and associated DMRS resources in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexes |
| Samsung | No, with the above reasons.  |

# Discussion (round 2)

## Text proposal

### TP#1

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| **< Unchanged text omitted >**An association period, starting from frame with SFN 0, for mapping $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes, from the number of SS/PBCH block indexes, to valid PUSCH occasions and associated DM-RS resources is the smallest value in the set determined by the PUSCH configuration period provided by *periodicity* in *ConfiguredGrantConfig* according to Table 19.1-1 such that $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes are mapped at least once to valid PUSCH occasions and associated DM-RS resources within the association period. A UE is provided a number *N* of SS/PBCH block indexes associated with a PUSCH occasion and a DM-RS resource by *sdt-SSB-PerCG-PUSCH*. If after an integer number of SS/PBCH block indexes to PUSCH occasions and associated DMRS resources mapping cycles within the association period there is a set of PUSCH occasions and associated DMRS resources that are not mapped to $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes, no SS/PBCH block indexes are mapped to the set of PUSCH occasions and associated DMRS resources. An association pattern period includes one or more association periods and is determined so that a pattern between PUSCH occasions with associated DMRS resources and SS/PBCH block indexes repeats at most every 640 msec. PUSCH occasions and associated DMRS resources not associated with SS/PBCH block indexes after an integer number of association periods, if any, are not used for PUSCH transmissions.**< Unchanged text omitted >**Each number *N*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to a valid PUSCH occasion and the associated DMRS resource in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexesA PUSCH occasion is valid if it does not overlap with a valid PRACH occasion as described in clause 8.1. **< Unchanged text omitted >** |

### TP#2

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| Each $N\_{SS/PBCH}$ of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to valid PUSCH occasions and associated DMRS resources in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexeswhere $N\_{SS/PBCH}=ceil\left(N\right)$, N is provided by *sdt-SSB-PerCG-PUSCH*. |

## Companies’ views

According to the online discussion, companies would like to further refine the wording, and the N<1 case may be addressed in a more concise way, so the TP in section 3.1 will be further updated according to companies’ inputs before Thursday online session.

Any comments to TP#1 in section 3.1?

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| Company | Comment |
| Xiaomi2 | Of course, the intention of the CR is clear to us. But, TP#1 is still a little bit confusing to us. Each number N of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes, if N is less than 1, e.g., N is 1/2, $N\_{PUSCH}^{SS/PBCH}$ is 4, how to understand it ? Each number 1/2 of 4 SSB indexes are mapped to …? We just wonder whether we need to introduce a separate paragraph to interpret how to use the mapping ratio value N provided by *sdt-SSB-PerCG-PUSCH*, just like the description of SSB-to-RO mapping in TS 38.213 clause 8.1 as follows.

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| For Type-1 random access procedure, or for Type-2 random access procedure with separate configuration of PRACH occasions from Type 1 random access procedure, if $N<1$, one SS/PBCH block index is mapped to ${1}/{N}$ consecutive valid PRACH occasions and $R$ contention based preambles with consecutive indexes associated with the SS/PBCH block index per valid PRACH occasion start from preamble index 0. If $N\geq 1$, $R$ contention based preambles with consecutive indexes associated with SS/PBCH block index $n$, $0\leq n\leq N−1$, per valid PRACH occasion start from preamble index $n{⋅N\_{preamble}^{total}}/{N}$ where $N\_{preamble}^{total}$ is provided by *totalNumberOfRA-Preambles* for Type-1 random access procedure, or by *msgA-TotalNumberOfRA-Preambles* for Type-2 random access procedure with separate configuration of PRACH occasions from a Type 1 random access procedure, and is an integer multiple of $N$. |

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| New H3C | Each or each N>1 is a little bit unclear in updated TP.Proposed text as follows:Each SS/PBCH block index is mapped to valid PUSCH occasions and associated DMRS resources or each N>1, provided by sdt-SSB-PerCG-PUSCH, of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to valid PUSCH occasions and associated DMRS resources in the following orderOr no any change is fine to us. |
| vivo  | “number of” in the new proposal seems does not work for SSB to CG PUSCH mapping in SDT after checking the preamble to PUSCH resource mapping in 2-step RACH where $N\_{preamble}=ceil\left({T\_{preamble}}/{T\_{PUSCH}}\right)$ is always a integer. See following text excerpted from section 8.1 of 38.213 v18.2.0.

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| Each consecutive number of $N\_{preamble}$ preamble indexes from valid PRACH occasions in a PRACH slot- first, in increasing order of preamble indexes within a single PRACH occasion- second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions- third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slotare mapped to a valid PUSCH occasion and the associated DMRS resource- first, in increasing order of frequency resource indexes $f\_{id}$ for frequency multiplexed PUSCH occasions- second, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- third, in increasing order of time resource indexes $t\_{id}$ for time multiplexed PUSCH occasions within a PUSCH slot- fourth, in increasing order of indexes for $N\_{s}$ PUSCH slotswhere $N\_{preamble}=ceil\left({T\_{preamble}}/{T\_{PUSCH}}\right)$, $T\_{preamble}$ is a total number of valid PRACH occasions per association pattern period multiplied by the number of preambles per valid PRACH occasion provided by *rach-ConfigCommonTwoStepRA*, and $T\_{PUSCH}$ is a total number of valid PUSCH occasions per PUSCH configuration per association pattern period multiplied by the number of DMRS resource indexes per valid PUSCH occasion provided by *msgA-DMRS-Config*.  |

If we want to do something similar to preamble to PUSCH resource mapping in 2-step RACH, maybe we try following for SDT:

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| Each consecutive number of $\_{SS/PBCH}$~~, provided by~~ *~~sdt-SSB-PerCG-PUSCH,~~* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes ~~in increasing order~~ are mapped to valid PUSCH occasions and associated DMRS resources in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexeswhere $N\_{SS/PBCH}=ceil\left(N\right)$, N is provided by *sdt-SSB-PerCG-PUSCH*. |

Note that “consecutive number of” is used above instead of introducing “in increasing order” similar to 2-step RACH. |
| Moderator | Based on companies’ feedback, the following TP seems a good alternative, which is also provided as TP#2 in section 3.1.

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| Each $N\_{SS/PBCH}$ of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to valid PUSCH occasions and associated DMRS resources in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexeswhere $N\_{SS/PBCH}=ceil\left(N\right)$, *N* is provided by *sdt-SSB-PerCG-PUSCH*. |

Companies are encouraged to further check TP#1 and TP#2, thanks! |
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# Proposal for Wednesday online session

Based on the comments received, only 1 company think the sentence “A UE is provided a number of SS/PBCH block indexes associated with a PUSCH occasion and a DM-RS resource by sdt-SSB-PerCG-PUSCH” can imply the mapping method of SSBs, while all other companies think that there is ambiguity on the current spec for SSB to CG-SDT mapping. However, the sentence cited by Samsung is only the definition of mapping ratio, but it can not be derived from the sentence that which mapping method illustrated below is correct understanding.

 

Figure 1 Mapping method 1 (aligned with agreement) and Mapping method 2 (misunderstanding)

Then, based on companies’ comments on how to revise it, 2 companies mention that N<1 case should also be considered, 2 companies mention that “in increasing order” is common understanding, no need to mention that.

Moderator copies the SSB to RO mapping and preamble to MsgA PUSCH mapping below:

**SSB to RO mapping:**

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| For Type-1 random access procedure, or for Type-2 random access procedure with separate configuration of PRACH occasions from Type 1 random access procedure, if $N<1$, one SS/PBCH block index is mapped to ${1}/{N}$ consecutive valid PRACH occasions and $R$ contention based preambles with consecutive indexes associated with the SS/PBCH block index per valid PRACH occasion start from preamble index 0. If $N\geq 1$, $R$ contention based preambles with consecutive indexes associated with SS/PBCH block index $n$, $0\leq n\leq N−1$, per valid PRACH occasion start from preamble index $n{⋅N\_{preamble}^{total}}/{N}$ where $N\_{preamble}^{total}$ is provided by *totalNumberOfRA-Preambles* for Type-1 random access procedure, or by *msgA-TotalNumberOfRA-Preambles* for Type-2 random access procedure with separate configuration of PRACH occasions from a Type 1 random access procedure, and is an integer multiple of $N$. SS/PBCH block indexes provided by *ssb-PositionsInBurst* in *SIB1* or in *ServingCellConfigCommon* are mapped to valid PRACH occasions in the following order where the parameters are described in [4, TS 38.211].- First, in increasing order of preamble indexes within a single PRACH occasion- Second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions- Third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slot- Fourth, in increasing order of indexes for PRACH slots |

**preamble to MsgA PUSCH mapping:**

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| Each consecutive number of $N\_{preamble}$ preamble indexes from valid PRACH occasions in a PRACH slot- first, in increasing order of preamble indexes within a single PRACH occasion- second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions- third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slotare mapped to a valid PUSCH occasion and the associated DMRS resource- first, in increasing order of frequency resource indexes $f\_{id}$ for frequency multiplexed PUSCH occasions- second, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- third, in increasing order of time resource indexes $t\_{id}$ for time multiplexed PUSCH occasions within a PUSCH slot- fourth, in increasing order of indexes for $N\_{s}$ PUSCH slots |

According to the spec text above, SSB to RO mapping and preamble to MsgA PUSCH mapping explicitly or implicitly mention the “increasing order”, it should be clarified why “increasing order” does not need to be mentioned for this case.

 Therefore, the following updated TP is provided:

##  Updated TP

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| **19.1 Configured-grant based PUSCH transmission****< Unchanged text omitted >**Each or each *N>1*, provided by *sdt-SSB-PerCG-PUSCH,* of $N\_{PUSCH}^{SS/PBCH}$ SS/PBCH block indexes in increasing order are mapped to valid PUSCH occasions and associated DMRS resources in the following order- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index $DMRS\_{id}$ is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index [4, TS 38.211]- second, in increasing order of PUSCH configuration period indexesA PUSCH occasion is valid if it does not overlap with a valid PRACH occasion as described in clause 8.1. For unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1*- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, a PUSCH occasion is valid if the PUSCH occasion- does not precede a SS/PBCH block in the PUSCH slot, and - starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, a PUSCH occasion is valid if the PUSCH occasion- is within UL symbols- starts at least $N\_{gap}$ symbols after a last downlink symbol, and at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2A UE determines a power of a PUSCH transmission as described in clause 7.1.1, where the UE obtains $PL\_{b,f,c}(q\_{d})$ using a RS resource from an SS/PBCH block with index associated with the PUSCH transmission.  |

**< Unchanged text omitted >**

# Summary

The final proposals will be added later.

# References

1. R1-2404210 Correction on SSB to CG-SDT PUSCH mapping ZTE