**3GPP TSG-RAN WG1 Meeting #106-e R1-2108254**

**e-Meeting, August 16th – August 27th, 2021**

**Agenda item:** 8.1.2.1

**Source:** Moderator (Qualcomm)

**Title:** Summary #2 of email discussions [106-e-NR-feMIMO-03] for mTRP PDCCH enhancements

**Document for:** Discussion/Decision

# **PDSCH mapping Type B**

The following was agreed in GTW:

**Agreement**

Among the two Alts in RAN1 #104b-e agreement on PDSCH mapping Type B, support Alt1 (The candidate that starts later in time).

Also, the following was noted in Chairman’s notes for comeback

**For comeback, at least select one of the following options in Week2**

***For PDSCH processing time in this case, d1,1 is determined***

* ***Option 2: By considering the PDCCH candidate that results in larger d1,1 value***
* ***Option 3: By considering the number of overlapping symbols from both PDCCH candidates.***
	+ ***Each of the overlapping symbol is counted as a single symbol***
* ***Option 4: By considering the number of overlapping symbols from both PDCCH candidates.***
	+ ***Double-counting each PDSCH symbol that overlaps with both PDCCH candidates.***

In the previous rounds of discussions, majority companies (22 companies) supported Option 2 for *d1,1* calculation.

For reference, the existing specification for *d1,1* calculation in the case of PDSCH mapping Type B is copied below:

- For UE processing capability 1: If the PDSCH is mapping type B as given in clause 7.4.1.1 of [4, TS 38.211], and

- if the number of PDSCH symbols allocated is *L* ≥ 7, then *d1,1* = 0,

- if the number of PDSCH symbols allocated is *L* ≥ 4 and *L* ≤ 6, then *d1,1* = 7- *L.*

- if the number of PDSCH symbols allocated is *L* = *3* then *d1,1 = 3 +* min *(d,1)*, where *d* is the number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH.

- if the number of PDSCH symbols allocated is 2, then *d1,1* = 3*+d*, where *d* is the number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH.

- For UE processing capability 2: If the PDSCH is mapping type B as given in clause 7.4.1.1 of [4, TS 38.211],

- if the number of PDSCH symbols allocated is *L* ≥ 7, then *d1,1* = 0,

- if the number of PDSCH symbols allocated is *L* ≥ 3 and *L* ≤ 6, then *d1,1* is the number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH,

- if the number of PDSCH symbols allocated is 2,

- if the scheduling PDCCH was in a 3-symbol CORESET and the CORESET and the PDSCH had the same starting symbol, then *d1,1* = 3,

- otherwise *d1,1* is the number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH.

It can be seen above that *d1,1* is not the same as d (number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH), and also is not always a function of d. This case in the above is one example where *d1,1* is not a function of d. In addition, in some cases, no matter how large d becomes (as a result of Option 3 or 4), it is capped by value of 1. This case in the above is one example. Hence, the description of Option 3 or Option 4 may require some clarifications.

The following examples may be used for explanations of your answer to the below questions:



**Question 1: Among Options 2, 3, 4 above which one do you prefer? Why?**

**Question 2: How *d1,1* is determined in Option 3 or 4 in this case above (Example 2)?**

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| Company | Comments |
| Spreadtrum | Sorry for the confusion. Update Option 3 below:* ***Option 3: By considering the number of overlapping symbols from both PDCCH candidates.***
	+ ***~~Each of the overlapping symbol is counted as a single symbol~~***
	+ ***Each PDSCH symbol that only overlaps with one of both PDCCH candidates is counted as a single symbol;***
	+ ***Double-counting each PDSCH symbol that overlaps with both PDCCH candidates.***

**Question 1:**Prefer updated option 3. For PDCCH repetition where two individual PDCCHs decoding and soft combing operation perhaps are needed, the processing complexity is much larger than conventional individual PDCCH decoding. Thus for PDCCH repetition case, we prefer to relax PDSCH processing time requirement. Thus we prefer updated option 3. **Question 2:**For the example case, we are fine to enhance the spec to relax PDSCH processing time requirement. For example, * For UE capability 1, d1,1 = 3 + min (d,1)+1
* For UE capability 2, d1,1 = 3 +1

We are open for the enhancement scheme. |
| Apple | Q1: If we choose a single solution for the worst case, we support option 4 with regard to soft combining. If we consider different receivers, we would like to suggest UE reports whether it supports option 2 or option 4.Q2: For Example 2, d1,1 = 3 for option 3 and d1,1 = 5 for option 4. |
| MediaTek | Q1: Prefer option 2 |
| Lenovo/MotM | Q1: Prefer option 2 on account of simple extension based on current specification. |
| QC | Q1: Option 2. We think relaxation of timeline for soft combining, if needed, should be discussed separately as it is not specific to PDSCH mapping Type B.Q2: d\_1,1 is not well-defined for Options 3 and 4 in some cases. |
| Xiaomi | Q1: Prefer Option 2Q2: for example 2 with UE capability 2, with Option 3 or Option 4, it is not clear the yellow part in specification will be used or the otherwise part will be used to determine ***d1,1*** |
| CMCC | Q1: prefer Option 2 for it’s a simple way to solve this issue. |
| Convida Wireless | Q1: Prefer option 2. |
| Samsung | Q1: Support Option 2 first. If relaxed PDSCH processing type is needed for some UEs, Option 4 seems better.Q2: For example 2 above, L = 2 (length of the PDSCH)For UE processing capability 1: * For Option 3, d = 2 since each of the overlapping symbol is counted as a single symbol, hence d1,1 = 3 + d = 5.
* For Option 4, d = 2 + 2 since it counts twice for each PDSCH symbol that overlaps with both PDCCH candidates, hence d1,1 = 3 + d = 7

For UE processing capability 2:The current spec which FL captures is “If the scheduling PDCCH was in a 3-symbol CORESET and the CORESET and the PDSCH had the same starting symbol, then d1,1 = 3”, but, based on the above example, the OFDM symbol lengths of each CORESET containing PDCCH candidate 1 and 2 are 3 and 2, respectively. So it should be also clarified how the highlighted part can be interpreted considering PDCCH repetition using different length of CORESETs. |
| Nokia  | Q1: prefer Option 1 as it provides cleaner solution Q2: Agree with FL assessment that description provided on option 3 and 4 seems not fully complete.  |
| ZTE | Q1: Prefer option 2 |
| OPPO | Q1: We prefer Option 2, but also accept other optionsQ2: For example 2* Option3: d1,1=3+2=5 ( For UE capability 1)
* Option 4: d1,1=3+2\*2=7 ( For UE capability 1)

For UE capability 2, the solution for Option 3/ 4 seem not clear |
| FGI/APT | Q1: Prefer option 2Q2: For example 2 shown as above, the clarification is needed to align with each company’s understanding since it seems that Apple and Samsung hold different opinions. In our understanding, for UE processing capability 1: d = 2 (count each overlapping symbol as one) for option 3 🡪 d1,1 = 3 + d = 5. d = 4 (double count each overlapping symbol )for option 4 🡪 d1,1 = 3 + d = 7 |
| Ericsson | Q1: Prefer option 2 |
| ASUSTeK | Q1: Prefer option 2 |
| vivo | Overlapping symbols from both PDCCH candidates do not affect the PDCCH decoding time, since PDCCH reception is still processed per PDCCH candidate same as legacy behavior no matter these PDCCH candidates carry same or different payload. Therefore, it is reasonable that each of the overlapping symbol is counted as a single symbol as described in Option 3.In 38.214, the wording is copied here for d1,1.

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| d1,1 is the number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH. |

The overlapping symbols between PDCCH and PDSCH is interpreted as actual PDSCH symbols which is overlapped with PDCCH, even though in case of PDCCH repetition. We slightly prefer Option3 which is more close to the current spec, and there is no need to capture option3 in spec. |
| TCL | Q1: Prefer option 2 |
| Huawei, HiSilicon | We prefer option 2, we also have sympathy for companies’ concern on the processing complexity regarding soft combination, therefore, we also support some relaxation of processing time based on option 2. |
| Futurewei | Option 2 works. The updated Option 3 by Spreadtrum seems also working. |

## **Update**

Option 2 is supported by majority of companies:

* **Option 2 (20): Apple (if option 4 is also agreed), MediaTek, Lenovo/MotM, QC, Xiaomi, CMCC, Convida Wireless, Samsung, Nokia, ZTE, OPPO, FGI/APT, Ericsson, ASUSTeK, TCL, Huawei/HiSilicon, Futurewei**
* **Option 3: Spreadtrum (revised Option 3), vivo**
* **Option 4: Apple**

Also, Option 3 and Option 4 are not complete solutions as *d1,1* is not the same as d (number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH). It is not clear if companies are on the same page about the meaning of Option 3 and 4 in terms of final *d1,1* calculation.

@vivo: The complete text in 38.214 is copied above. Please see the discussions. *d1,1* is not always number of overlapping symbols of the scheduling PDCCH and the scheduled PDSCH and depends on various conditions as you can see in the spec. Option 3 does not characterize a complete solution.

@Apple: Option 2 is already taking care of worst case (max among the two). For additional relaxation, what is the justification? If this is related to soft combining, then why PDSCH mapping Type B is relevant here? For example, wouldn’t we need the same relaxation for PDSCH mapping Type A, PUSCH timeline, N / N3 timeline, etc.?

I suggest to go with Option 2 given the above:

***FL Proposal 1-B: If a PDSCH with mapping Type B is scheduled by a DCI in PDCCH candidates that are linked for repetition,*** $d\_{1,1}$$d\_{1,1}$ ***for PDSCH processing time is determined***

* ***Option 2: By considering the PDCCH candidate that results in larger d1,1 value***

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| Company | Comments |
| ZTE | Support |
| LG | Option 2 considers the worst case for separate decoding for the linked candidate without soft combining. If soft combining case, it may need more relaxation not only for d11 but also Z, N2, etc. Rather than optimizing these value for soft combining case by case, we prefer some common approach as much as possible. For this reason, we suggest the following revision:***FL Proposal 1-B: If a PDSCH with mapping Type B is scheduled by a DCI in PDCCH candidates that are linked for repetition,*** $d\_{1,1}$$d\_{1,1}$ ***for PDSCH processing time is determined**** ***Option 2: By considering the PDCCH candidate that results in larger d1,1 value***
* ***FFS relaxation of processing time for soft combining of linked PDCCH candidates including PUSCH processing, PDSCH processing for mapping Type A, AP CSI processing, etc.***

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| Samsung | Support. If companies would like to consider additional option for some UEs with additional UE capability, it is also fine and prefer Option 4 if that is the case. |
| NTT Docomo | Support  |
| MediaTek | Support |

# **The case that one linked candidate overlaps with an individual candidate**

The following was agreed in the previous meeting:

**Agreement**

When one of the linked PDCCH candidates uses the same set of CCEs as an individual (unlinked) PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, for the purpose of BD counting and interpretation of a detected DCI, select one option among the following in RAN1#105-e:

* Option 1: The individual candidate is not counted for monitoring
	+ Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).
* Option 2: The candidate in a higher SS set ID is not counted for monitoring
	+ Interpretation of the detected DCI depends on which candidate is not counted (either based on Rel. 15/16 rules or based on Rel. 17 PDCCH repetition rules).
	+ FFS: Impact to the other linked PDCCH candidate
* Option 3: The candidate associated with SS set(s) with lower priority is not counted for monitoring, where for two linked SS sets, the priority is according to one of the two SS sets with a lower SS set ID
	+ Interpretation of the detected DCI depends on which candidate is not counted (either based on Rel. 15/16 rules or based on Rel. 17 PDCCH repetition rules).
	+ FFS: Impact to the other linked PDCCH candidate
* FFS: Whether a max limit on number of such overlaps is needed.

Additional specification support may be introduced for the purpose of resolving ambiguity (if any) for interpretation of the detected DCI. For example,

* Distinguished by different RNTIs defined for the linked candidate versus the individual candidate
* Distinguished by aggregation level restrictions that can be expected by the UE in the case of overlap

Views in the first round of discussions are summarized below:

* **Support the proposal, i.e., Option 1: NTT Docomo (depending on overbooking), MediaTek (if “not counted” is changed to “not monitored”), Apple, QC (if UE capability is added), Fujitsu, vivo, ZTE, Nokia/NSB, CMCC, NEC, Huawei/HiSilicon, Convida Wireless, FGI/APT, TCL**
* **Support Option 2: Lenovo/MotM, LG, OPPO, Samsung, InterDigital, CATT, Intel**
* **Support Option 3: NTT Docomo (depending on overbooking), LG, Fraunhofer IIS/HHI, Xiaomi, InterDigital, CATT, E///, Futurewei, Intel**

Option 1 has slight majority support. Also, a good number of companies support Option 3.

Docomo suggested to first decide on overbooking issue. From moderator perspective, this issue has been discussed for a long time now, and a decision may be needed in this meeting.

MediaTek suggested that “not counting for monitoring” should be replaced with “not monitored”. In my understanding, these two are not the same. This is also evident from the GTW agreement for the other issue (dropping or not monitoring does not impact the BD count). I think what we already agreed on is “not counting for monitoring” as copied below, which is same as Rel. 15 rule when CORESET/DCI size/CCEs/scrambling are the same. However, if there is a consensus to change the agreement, it can be discussed. A question is asked below regarding this point.

**Agreement**

When two SS sets are linked for PDCCH repetition, they do not contain individual PDCCH candidates.

* Note 1: For configuration of individual PDCCH candidates, a different SS set can be configured by network.
* Note 2: When one of the linked PDCCH candidates uses the same set of CCEs as an individual PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, Rel. 15 rule is followed wrt not counting an additional BD.

LG and a few other companies suggested to combine Option 2 and Option 3. This does not seem to help since these options are already identified and one needs to be selected. If needed, we can down-select between two options first (instead of first combining options and then separating them again). Given that we have been discussing this issue for multiple meetings now, it is preferred to directly select one option.

Also, the following have been mentioned by companies in the first round:

* Option 1: Simplest solution and less specification impact. Discussions on handling the other (non-overlapped) linked candidates would not be needed.
* Option 2: Reuses priority rule of Rel.15/16, and allows for prioritizing either the linked candidate or the individual candidate
* Option 3: Same priority for linked SS sets, and allows for more flexibility

**Question 1: Do you think “not counted for monitoring” should be changed to “not monitored” in the description of the options?**

**Question 2: Among Option 1 and Option 3, can you accept one option? If yes, which one?**

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| Company | Comments |
| Apple | Q1: YesQ2: Option 1, which is simple and seems to be majority’s view. |
| NTT Docomo | Q1: NoQ2: 1st preference is option3.  |
| MediaTek | Q1: YesQ2: Option 1@ DocomoIf we use “not counted for monitoring” here, the UE has to monitor both individual candidate and one of linked candidates anyway even if two candidates are overlapped. The BD is not counted but two candidates should be monitored by following the Rel-15/16 rule. Then why does it matter to support option 1 or option 3? There is no priority between two overlapped candidates in this case. Could you please share any technical concern to use “not monitored”? |
| LG | Q1: YesQ2: Our first preference is option 2 but option 3 is fine. |
| Lenovo/MotM | Q1: Slightly prefer not to change since this proposal focuses on discussing BD counting scheme.Q2: Slightly prefer option 3 on account of flexibility.  |
| QC | Q1: We would be ok with the change, but also realize the previous agreement.@MediaTek: We do not think UE needs to perform 2 BDs in this case with separate decoding. Also with 3BDs, with Option 1, the candidate that is not counted is the individual one. At the same time, UE needs to pay some cost for duplicate candidate determination (the cost is less than performing an additional BD)Q2: Option 1.In the case of 3BDs, it is not clear what “not counted for monitoring” means in Option 3 (or Option 2) when the linked candidate is not counted toward the BD. |
| Xiaomi | Q1: YesQ2: prefer Option 3 |
| CMCC | Q1: NoQ2: Option 1 as it is a simple way to solve this issue. |
| Convida Wireless | Q1: ~~Slightly prefer not to change~~. Update: Given further discussion, we are ok with the change.Q2: Prefer Option 1. |
| Samsung | Q1: YesQ2: Our preference is Option 2. It can reuse the existing Rel-15/16 rule, and based on proper configuration of SS set ID from gNB, Option 2 can have same functionality with Option 1. Moreover, Option 2 can be aligned with the agreement what we made in this meeting (i.e., UE still monitors the linked candidate that is not dropped). |
| Nokia/NSB | Q1: YesQ2: Option 1 |
| ZTE | Q1: YesQ2: Option 1 |
| Fraunhofer IIS/HHI | Q1: Fine with the change.Q2: Option 3 |
| OPPO | Q1: YesQ2: Option 2. The reasons are as below* Option 2 is more aligned with the existing R15/16 design principle
* Option 2 provides more flexibility to gNB since Option 2 can achieve the same purpose of Option 1/3 by proper configuration
* In this meeting, we have agreed that UE should monitoring one of the linked candidate when the other is dropped. Thus, as Samsung commented, Option 2 is more aligned with the new proposal
 |
| FGI/APT | Q1: YesQ2: Prefer option2 and option3 |
| Ericsson | Q1: yesQ2: 1st preference is option3. 2nd preference option 1 |
| CATT | Q1: YesQ2: We support Option 3. Unified solutions for this issue and overbooking rule are expected. |
| NTT Docomo\_2 | Q1: @MediaTek: Thanks a lot for explanation. We don’t think with “not counted for monitoring” means UE has to monitor both individual candidate and one of linked candidates. But we can be OK with the change to “not monitored” to clarify. We would like to understand if it is changed to “not monitored”, whether the one “not monitored” will be counted or not?Q2: 1st preference is option3. 2nd preference can be option1. |
| MediaTek2 | @ DocomoThanks for changing your position. The definition of “not counted for monitoring” is as follows (confirmed by the editor Aris)

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| The UE still needs to monitor the candidate but it is just not counted for BD because it is a byproduct of the same decoding. In this case, the UE still parse both candidates following the associated search space set |

Thus, the UE has to monitor both candidates. That is why we are suggesting this wording shouldn’t be used here. If we use “not monitored”, whether it is counted or not is an another issue.We have several cases for PDCCH dropping or “Not monitored” or officially “is not required to monitor” in the spec. For example, like another proposal, the cases are overlap with SSB or overlap with ratematching pattern, etc. In Rel-15/16, the BD is not impacted (which means counted). Probably, it is because recalculating BD in every slot requires a lot of computation at the UE when some PDCCH candidates are dropped.@ Lenovo, Convida wireless, CMCCI hope you can change the position based on my explanation. |
| vivo | This issue raised aims at resolving two problems. 1. only 1 BD counted in individual SS set or linked SS set for overbooking rule
2. interpretation of detected DCI belongs to individual SS set or linked SS set

Q1: we think the wording “not counted for monitoring” present two answers for two problems, that is only 1BD counted in linked SS set and DCI belongs to PDCCH repetition. If it is changed to “not monitored”, only 1BD counted in which SS set is unanswerable. @ MTK and FL, if I miss your understanding, please correct . Q2: Among option1 and option3, we prefer **Option1** since that is a simple and clear scheme, considering that more complicated cases exist, e.g. different individual PDCCH candidates overlaps with each PDCCH repetition candidates. Regarding Option3, if one of PDCCH repetition candidate is dropped due to issue 2.2 in round 0 or overbooking rule, we think it is strange that the priority is still according to one of the two SS sets with a lower SS set. |
| Lenovo&MotM\_2 | Q1: @MediaTek: Thanks a lot for detail explanation. It resolves our concern on the impact of current specification. We are fine to support your proposal. |
| MediaTek3 | @ Lenovo&MotM and Convida WirelessThanks for changing your position on Q1.@ vivoPlease check the meaning of “not counted for monitoring” in MediaTek2.For issue 1, in Rel-17, the point is that we have to count both BDs for individual candidate and one of linked candidates because two decodings are different unlike the overlapping of two individual candidates in Rel-15/16. That is why we shouldn’t use “not counted for monitoring”.For issue 2, if we change the wording to “not monitored”, then detected DCI belongs to the other candidate which is not dropped. I am not following why you think detected DCI is unanswerable.As I mentioned several times, if we use “not counted for monitoring”, the UE has to monitor both candidates (even if only 1 BD is counted for both candidates). Then, why do you think we need to decide option 1 or option 3? Both candidates are all monitored regardless of option 1 or option 3.Considering almost all companies already support the wording change, please check this again. If you have further question, please let me know. |
| TCL | Q1: Yes.Q2: Option 1 as it is a simple and clear scheme. |
| Huawei, HiSilicon | Q1: we are fine for the change. To be clear, should it be not monitored and not counted either?Q2: We prefer option 1 for simplicity. |
| CMCC\_2 | Q1: @MTK Thanks a lot for the detailed explanation. Since it need different decoding for linked and individual candidates, we can accept the wording change.Q2: Prefer Option 1 as it is a simple way to solve this issue. |
| Futurewei | Q1: Yes, which works fine and simplifies the UE behavior.Q2: We support Option 3. For Option 1, if the individual candidate is in a CSS but not monitored, this may not be desirable. |
| Intel | Q1: No, we understood that the idea is to allow gNB to use this overlap to have individual and linked candidates without additional BD – this is already discussed in RAN1#104e as noted.Q2: prefer Option 3, we would prefer to keep prioritization as in Rel-15/16 due to the latency issue in some cases as mentioned in our tdoc.  |

## **Update**

It seems that all companies are ok with the change suggested by MediaTek. Hence, the updated wording is used, and a note is added to avoid further confusion. With respect to Option 1 versus Option 3, the views are

* **Option 1 (14): Apple, NTT Docomo (2nd), MediaTek, QC, CMCC, Convida Wireless, Nokia/NSB, ZTE, Ericsson (2nd), vivo, TCL, Huawei/HiSilicon**
* **Option 3 (13): NTT Docomo (1st), LG, Lenovo/MotM (slightly prefer), Xiaomi, Fraunhofer, IIS/HHI, FGI/APT, Ericsson (1st), CATT, Futurewei**
* **Still prefer option 2: Samsung, OPPO,**

The situation has not changed much, and there is slightly more support for Option 1. Some companies with first preference for Option 3 seem to be ok with Option 1 now. We have been discussing this issue for multiple meetings now, and from moderator perspective, it would be good if we can conclude.

@vivo: Yes, your understanding is correct on the original intention. However, MediaTek’s suggestion is that we need to still count toward BD as this case (one linked candidate overlaps with an individual candidate) depends on UE implementation (i.e., it may not be possible to do 1 BD only). This concern seems to be valid to me, and companies are ok to change it. A note is added below to clarify this.

***FL Proposal 3: When one of the linked PDCCH candidates uses the same set of CCEs as an individual (unlinked) PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, ~~for the purpose of BD counting and interpretation of a detected DCI~~:***

* ***Option 1: The individual candidate is not monitored ~~counted for monitoring~~***
	+ ***Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).***
* ***Note: This does not impact the BD count, and the following note in the agreement in RAN1#104-e is replaced with this note.***
	+ ***“Note 2: When one of the linked PDCCH candidates uses the same set of CCEs as an individual PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, Rel. 15 rule is followed wrt not counting an additional BD.”***

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| Company | Comments |
| ZTE | Support |
| LG | We are fine with “not monitoring” but still prefer Option 3 for flexibility. |
| Samsung | Still prefer Option 2. As we mentioned, Option 1 can be made by Option 2 based on appropriate gNB configuration for SS set ID. |
| NTT Docomo | Support While we think replacing the previous note may not be needed. With current option1 “the individual candidate is not monitored”, Rel.15 rule wrt not counting an additional BD can still be followed. But we can also be fine if majority agree with it. |
| MediaTek | Support |
| NEC | Support |
| Intel | We have some concerns on this (see comment in previous table copied here):Q1: No, we understood that the idea is to allow gNB to use this overlap to have individual and linked candidates without additional BD – this is already discussed in RAN1#104e as noted.Q2: prefer Option 2or 3, we would prefer to keep prioritization as in Rel-15/16 due to the latency issue in some cases as mentioned in our tdoc. |

# **Details of number of BDs**

In RAN1 #104b-e, the following was agreed:

**Agreement**

For number of BDs corresponding to two PDCCH candidates that are linked for PDCCH repetition, support

* UE reports one [or more] number(s) as required number of BDs for the two PDCCH candidates
	+ Candidate values: 2, 3.
* FFS: Default behaviour
* FFS: Whether one of the candidate values imply that UE supports soft combining
* FFS: Whether additional candidate values are supported (e.g. non-integer numbers)
* FFS: RRC configuration based on reported UE capability

In GTW, the following proposal and conclusion were discussed without an agreement:

***FL Proposal 4:***

***RRC configuration for counting two linked PDCCH candidates as 3 BDs is supported.***

* ***It can be configured only if UE indicates 3 BDs.***
* ***~~When 3 BDs are supported and configured, it implies UE performs soft combining.~~***
	+ ***~~FFS: Any impact on RAN1 specification~~***
* ***If not configured, 2 BDs are assumed.***

***Proposed conclusion:***

***When 3 BDs are supported and configured, it implies UE performs both soft combining and individual decoding.***

Views from the previous round of discussions on the general proposal is summarized below:

* **Support the proposal (): NTT Docomo, MediaTek, QC (w/o second bullet), Lenovo/MotM, Fujitsu, OPPO (w/o second/third bullets), Xiaomi, Samsung (w/o second bullet), vivo, ZTE, E///, CMCC, NEC, Huawei/HiSilicon, Convida Wireless, FGI/APT, TCL, Futurewei (with some additions), Intel**
	+ **Clarification for soft combining for 2 BDs: LG, Fraunhofer IIS/HHI, Spreadtrum, InterDigital, CATT**
* **Do not support: Apple, Nokia/NSB**

It may be helpful to first clarify the intention of the proposal:

**Question 1: If UE indicates 3BDs, is it expected that the UE also supports 2BDs?**

**Question 2: If the answer to Q1 is no, then should the UE be able to indicate that it supports both 2BDs and 3 BDs? i.e., In RAN1 #104b-e Agreement mentioned above “[or more]” is needed?**

**Question 3: If the answer to either of Q1 or Q2 is yes, should we support RRC configuration for 2 BD versus 3 BD?**

**Question 4: For 3BDs, should UE perform both individual decoding as well as soft combining?**

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| Company | Comments |
| Apple | Q1: NoQ2: NoQ3: N/A.Q4: Up to UE implementation |
| NTT Docomo | Q1: YesQ2: Q3: YesQ4: Yes |
| MediaTek | Q1: YesQ2: N/AQ3: RRC can be configured for 3BD. 2BD can be default.Q4: Up to UE implementation |
| LG | Q1: YesQ2: Q3: Q4: It depends on test requirement. If RAN4 test requirement considers strong blockage case or the case transmitting only one of two liked candidates, yes. |
| Lenovo/MotM | Q1: Yes since we think this is a capability related reportingQ2:Q3: Yes on account that RRC signalling can align BD number assumption between gNB and provide the flexibility for gNB to choose BD number based on channel quality. Q4: Yes |
| QC | Q1: Ok either way.Q2: Yes (assuming the principle in Q1 is not agreed)Q3: YesQ4: Prefer to leave it to UE implementation.  |
| Xiaomi | Q1: YesQ2:Q3: YesQ4: prefer to at least support soft combiningAnd we prefer the update proposed conclusion as below:**Proposed conclusion:*****When 3 BDs are supported and configured, it implies UE performs soft combining***  |
| CMCC | Q1: YesQ2:Q3: YesQ4: Up to UE implementation |
| Convida Wireless | Q1: Yes.Q2:Q3: YesQ4: Yes |
| Samsung | Q1: No, our understanding is that if UE indicates 3 BDs, it means not up to 3, but only for 3.Q2: No.Q3: N/AQ4: It’s up to UE implementation and UE’s decoding scheme should not be disclosed. |
| Nokia/NSB | Question 1: Not always. Up to the UE. Question 2: Reporting one still allows to indicate the capability assumed at the UE. Does not always need to report all supported candidate BDs (decoding assumptions). Question 3: Unnecessary to add RRC as only one is reported (based on last RAN1 agreement).Question 4: Numbers match this case. But. nothing that needed to define in the spec.  |
| ZTE | Q1: YesQ3: YesQ4: Yes, we should let RAN4 know the information to provide guidance for RAN4 test. Probably, there is no RAN1 spec impact.  |
| Fraunhofer IIS/HHI | Q1: YesQ2: Q3: Yes, when a value of 3 is reported by the UE, the gNB may configure a BD value of 2 or 3.Q4: Yes |
| OPPO | Q1: Yes, but we need a note to indicate that if gNB configure 2 BD to a UE reporting 3 BD, the performance will be degraded Q2: N/AQ3: support RRC configuration 2 or 3 BDs when UE reports 3 BDs if we can add a note to indicate that if gNB configure 2 BD to a UE reporting 3 BD, the performance will be degradedQ4: Nothing related to the spec.  |
| FGI/APT | Q1: YesQ3: YesQ4: It should be up to UE’s implementation |
| Ericsson | Q1: YesQ2: -Q3: YesQ4: Yes, two individual decodings + 1 soft combined decoding |
| CATT | Q1: YesQ2: N/AQ3: Yes if other non-integer value is supported.Q4: Up to UE implementation |
| vivo | Q1: Yes. it is naturalQ3: prefer the scheme in FL’s proposal Q4: Yes, of course |
| TCL | Q1: YesQ2: -Q3: YesQ4: Yes, two individual decodings as well as soft combining |
| Huawei, HiSilicon | Q1: Yes,Q2: Q3: Yes, gNB should have the flexibility to configure it.Q4: Yes |
| Futurewei | Q1: Open to accept UE vendors’ opinions, but in case the UE vendors cannot reach agreement, we tend to answer “No” here.Q2: YesQ3: YesQ4: YesAgain we suggest that, if UE reports 3 BD, then 3 BD should be the baseline / default. There should not be any controversial in this, and RAN1 can agree on this first. To use 2 BD for this UE with additional RRC signaling can be an optimization for further discussion. |
| Intel | Q1: yes, but happy to discuss if there are concernsQ2; dependsQ3:YesQ4:Yes |

## **Update**

For Q1 (If UE indicates 3BDs, is it expected that the UE also supports 2BDs?), the views are:

* **Yes (21): NTT Docomo, MediaTek, LG, Lenovo/MotM, QC (ok with both), Xiaomi, CMCC, Convida Wireless, ZTE, Fraunhofer IIS/HHI, OPPO, FGI/APT, Ericsson, CATT, vivo, TCL, Huawei/HiSilicon**
* **No: Apple, Samsung, Nokia/NSB**

Majority companies believe that in this case, UE also supports 2BDs. In this case, RRC configuration is also needed (Q3).

@ Futurewei: If UE reports 2 values (2 and 3 BDs) as in Q2, why do we need default?

For Q4 (For 3BDs, should UE perform both individual decoding as well as soft combining?), the views are:

* **Yes: NTT Docomo, LG (depends on RAN4), Lenovo/MotM, Xiaomi, Convida Wireless, ZTE, Fraunhofer IIS/HHI, Ericsson, vivo, TCL, Huawei/HiSilicon, Futurewei**
* **Up to UE / not related to spec: Apple, MediaTek, QC, CMCC, Samsung, Nokia, OPPO, FGI/APT, CATT**

There still seem to be slight majority for at least a conclusion, while a number of companies prefer to leave this to UE implementation.

***FL Proposal 4: RRC configuration for counting two linked PDCCH candidates as 3 BDs is supported.***

* ***It can be configured only if UE indicates 3 BDs.***
* ***If not configured, 2 BDs are assumed.***

***Proposed conclusion: When 3 BDs are supported and configured, it implies UE performs both soft combining and individual decoding.***

Suggest to focus more on FL Proposal 4 as it has RRC impact (conclusion can be discussed during GTW)

|  |  |
| --- | --- |
| Company | Comments |
| ZTE | SupportWe admit the conclusion does not have RAN1 spec impact. In such case, it is better to inform RAN1 this information to give RAN4 guidance for the future evaluation/test.  |
| LG | We need to discuss soft combining for 2BD case. Otherwise, RAN4 cannot make test requirement because they don’t know whether soft combining is applied or not.  |
| Samsung | Do not support. If a UE reports 3 BDs, it means that 3 BDs are needed to decode the linked candidates at least from our understanding. |
| NTT Docomo | Support  |
| MediaTek | Support FL Proposal 4.Don’t support proposed conclusion. It is not necessary. |
| NEC | Support |
| Intel | Support |

# **Overbooking**

Views on different alternatives for Case1/Case2 in the first round are summarized below:

* **Case 1:**
	+ **Alt1: QC, LG, OPPO, Xiaomi, Spreadtrum, vivo, ZTE, ASUSTeK, E///, Nokia/NSB, CMCC, NEC, Convida Wireless, FGI/APT, Futurewei, Intel (depending on 2.4)**
	+ **Alt2: NTT Docomo (or Alt2a), MediaTek, Apple, Lenovo/MotM, Fujitsu, InterDigital, CATT, ASUSTeK, Huawei/HiSilicon, TCL, Futurewei**
	+ **Alt3: CATT**
* **Case 2:**
	+ **Alt1-1: vivo, ASUSTeK, FGI/APT**
	+ **Alt1-2: QC, LG, OPPO, ZTE, ASUSTeK, E///, Nokia/NSB, CMCC, NEC, Convida Wireless, FGI/APT**
	+ **Alt1-3: ASUSTeK, E///**
	+ **Alt2: NTT Docomo (or Alt2a), MediaTek, Apple, Lenovo/MotM, Fujitsu, Xiaomi, InterDigital, CATT, ASUSTeK, Huawei/HiSilicon, TCL, Futurewei**
	+ **Alt3: CATT**

Further discussions are needed. Firstly, Alt3 can be removed. Second, Alt1-3 can be also removed given that companies supporting it, also support other alternatives. This will help more focused discussions. Third, as Docomo mentioned, in Alt2, the priority between linked SS sets and individual SS sets can be also considered.

The following have been observed from the responses in the first round:

* Proponents of Alt1: Less specification impact and consistency with legacy overbooking, smaller probability of PDCCH dropping (instead of increasing granularity of dropping)
* Proponents of Alt2: Not breaking the link between two SS sets, unified solution for Case 1 and Case 2.

Given that there is no clear majority between Alt1 and Alt2, more discussions are invited so that companies understand each other better. We can try to do the down-selection in this meeting or the next meeting. At least for Case 2 (3BDs), one of the alternatives is needed.

***FL Proposal 5: For overbooking in the PCell for USS with two linked SS sets in the same slot/span, select one Alt for each of Case 1 and Case 2 in RAN1 #106-bis-e:***

* ***Case 1: 2 BDs are counted for two linked candidates:***
	+ ***Alt1: No change (use existing spec)***
	+ ***Alt2: Consider the SS set pair together (both are kept or both are dropped), where the priority is based on lower SS set ID among the pair.***
	+ ***~~Alt3: Overbooking is done per linked candidate / linked MO (rather than per SS set level)~~***
* ***Case 2: 3 BDs are counted for two linked candidates:***
	+ ***Alt1: Overbooking is per individual SS set as in Rel. 15/16***
		- ***Alt1-1: The third BD is counted as a virtual SS set (i.e., the virtual SS set for the third BDs is dopped before dropping the linked SS sets).***
		- ***Alt1-2: The third BD is counted as part of the SS set with higher ID.***
		- ***~~Alt1-3: Each SS set is assumed to contain half of the total BDs~~***
	+ ***Alt2: Consider the SS set pair together (both are kept or both are dropped), where the priority is based on lower SS set ID among the pair.***
	+ ***~~Alt3: Overbooking is done per linked candidate / linked MO (rather than per SS set level)~~***
* ***FFS: Inter-span PDCCH repetition for r16monitoringcapablity.***

|  |  |
| --- | --- |
| Company | Comments |
| Apple | OK with the proposal, but we suggest a unified design for both cases.  |
| NTT Docomo | Support in general.For Alt.2, we think this part in bracket “(both are kept or both are dropped)” can be FFS. Whether they are both dropped when they cannot be both allocated can be further discussed. One solution is that when they cannot be both allocated, allow one of the linked SS set to be kept so that one of the PDCCH candidate can be monitored.* ***Alt2: Consider the SS set pair together ~~(both are kept or both are dropped)~~, where the priority is based on lower SS set ID among the pair.***
	+ ***If both SS sets can be allocated, both are kept***
	+ ***FFS: if both SS sets cannot be allocated, whether both are dropped***
 |
| MediaTek | For both cases, prefer Alt 2. |
| LG | Support the proposal  |
| Lenovo&MotM | Support the proposal and prefer Alt 2. Same view as Apple that the unified solution may be better. |
| QC | Support. We are not sure about “unified solution” when Case 1 does not require any new solution (use legacy). |
| Xiaomi | Support the proposal.For case 1, we prefer Alt 1 if no soft combining, else we prefer Alt 2.For case 2, we prefer Alt 2. |
| CMCC | Support the proposal.For Case 1, prefer Alt 1;For Case 2, prefer Alt 1-2. |
| Convida Wireless | Support the proposal.For Case 1, prefer Alt 1.For Case 2, prefer Alt 1-2. |
| Samsung | Support in principle. |
| Nokia/NSB | Ok with the cases listed in the proposal for further study.  |
| ZTE | Support the proposal.For Case 1, prefer Alt 1;For Case 2, prefer Alt 1-2.Please noted that we have to consider inter-span PDCCH repetition further where BD for two repetitions cannot be counted together. That is, Alt 2 cannot work for inter-span case.  |
| Fraunhofer IIS/HHI | Support the proposal |
| OPPO | Support the proposalWe prefer Alt.1 and Alt 1-2 for Case 1 and Case 2, respectivelyMoreover, we prefer to have a common design principle for both the overbook issue and the 2nd issue (aka. the case that one linked candidate overlaps with an individual candidate) |
| FGI/APT | For Case 1, we prefer Alt 1.For Case 2, we prefer Alt 1-2, but Alt1-1 is acceptable if the virtual SS set is well defined. |
| Ericsson | Support the FL proposal with the modification of Alt1-2 to “Two BD is counted for the SS set with higher ID.” |
| CATT | Support the proposal and we prefer Alt2 for both cases. |
| ASUSTeK | Support FL proposal |
| vivo | Support. We suggest the rule for both cases should be taken into account preferentially to achieve lowest dropping probability due to overbooking.  |
| TCL | Support the proposal.For Case 1 and Case 2, we prefer Alt2. |
| Huawei, HiSilicon | Support Alt-2 for both cases, UE doesn’t need to maintain two behaviors on overbooking. |
| Futurewei | Support |

The following is endorsed by Email:

***Agreement***

***For overbooking in the PCell for USS with two linked SS sets in the same slot/span, select one Alt for each of Case 1 and Case 2 in RAN1 #106-bis-e:***

* ***Case 1: 2 BDs are counted for two linked candidates:***
	+ ***Alt1: No change (use existing spec)***
	+ ***Alt2: Consider the SS set pair together (both are kept or both are dropped), where the priority is based on lower SS set ID among the pair.***
* ***Case 2: 3 BDs are counted for two linked candidates:***
	+ ***Alt1: Overbooking is per individual SS set as in Rel. 15/16***
		- ***Alt1-1: The third BD is counted as a virtual SS set (i.e., the virtual SS set for the third BDs is dopped before dropping the linked SS sets).***
		- ***Alt1-2: The third BD is counted as part of the SS set with higher ID.***
	+ ***Alt2: Consider the SS set pair together (both are kept or both are dropped), where the priority is based on lower SS set ID among the pair.***
* ***FFS: Inter-span PDCCH repetition for r16monitoringcapablity.***

# **Determination of two QCL-TypeD**

Based on the following agreement, companies discussed the details of required enhancements to identify two QCL-TypeD properties for multiple overlapping CORESETs.

**Agreement**

For a UE supporting reception with two different beams, support identifying two QCL-TypeD properties for multiple overlapping CORESETs

* FFS: How to enhance existing QCL-TypeD priority rules for overlapping CORESETs
* Note: The primary goal of this enhancement for the purpose of this sub-AI is to support time-overlapping PDCCH repetitions in FR2.

The following alternatives were discussed:

* Alt1: Identify the two QCL-Type D properties based on legacy priority order:
* Alt2: Reuse legacy priority rule to identify the first QCL-TypeD properties, and then, identify the second QCL-TypeD according to one of the SS set that is linked with the SS set with the first QCL-TypeD
* Alt3: Assign same priority for two linked search space sets for PDCCH transmission with overlapping monitoring occasions (and linked SS sets in USS have higher priority than individual SS set)
* Alt4: Based on group beam pair reported by the UE for simultaneous reception
* Alt5: First CORESET is determined among unlinked candidates; second CORESET is determined among linked candidates:

Views on different alternatives in the first round of discussions are summarized below:

* **Alt 1: LG, OPPO, InterDigital, ZTE, Nokia/NSB**
* **Alt 2: NTT Docomo, MediaTek, QC, Fujitsu, Samsung, CATT, Nokia/NSB, CMCC, Huawei/HiSilicon, TCL, Futurewei, Intel**
* **Alt 3: NTT Docomo, MediaTek, Lenovo/MotM, Xiaomi, Samsung, vivo, CATT, Ericsson, CMCC, FGI/APT, TCL**
* **Alt 4: Apple**
* **Alt 5: Spreadtrum**

Further discussions are needed. First, I suggest to remove option 4 and 5 as they are supported by a single company. Option 4 requires a different framework than Rel. 15/16 for QCL-TyeD prioritization. For Option 5 (grouping the CORESETs into linked and individual and select one QCL-TypeD from each), it does not result in two FDM PDCCH repetitions to be monitored, and the procedure is complicated (unlike Alt1).

Also, some clarifications for details of Alt2 and Alt3 are added below based on the responses in the first round of discussions. The intention of the following proposal is to clearly list the alternatives. The (down)select of the alternative can happen in the next meeting

***FL Proposal 6: For a UE supporting reception with two different beams and configured with PDCCH repetitions, for determination of two QCL-TypeD properties for multiple overlapping CORESETs, select one Alt in RAN1 #106-bis-e:***

* ***Alt1: Identify the two QCL-Type D properties based on legacy priority order.***
* ***Alt2: Reuse legacy priority rule to identify the first QCL-TypeD property, and then, identify the second QCL-TypeD according to one of the SS sets that is linked with a SS set with the first QCL-TypeD (among the multiple overlapping CORESETs)***
	+ ***In the case of multiple such SS set pairs, Rel. 15 priority order is followed for the second QCL-TypeD determination***
	+ ***FFS: The case of no such SS set pair***
* ***Alt3: Assign same priority for two linked search space sets for PDCCH transmission with overlapping monitoring occasions (and linked SS sets in USS have higher priority than individual SS set). Theses priority rules combined with Rel. 15 priority order determine the two QCL-TypeD.***
	+ ***FFS: The case that the first QCL-TypeD is from unlinked CSS***
	+ ***FFS: The case of no linked SS sets among the multiple overlapping CORESETs***

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We think Alt1 should be removed, since it may lead to 2 QCL-TypeD that cannot be received by UE simultaneously, or Alt1 proponents may provide some justification.  |
| NTT Docomo | Support in general.For Alt.1, we share similar view with Apple that Alt.1 may lead to 2 QCL-TypeD that cannot be received by UE simultaneously. But we can be OK to keep it.For Alt.2, we think the case where there are multiple such SS set pairs can also be FFS. We see another solution is the priority is based on the lower ID among the linked pair of SS sets. For Alt.3, the sentence “Theses priority rules combined with Rel. 15 priority order determine the two QCL-TypeD” is not clear to us. We think this sentence can be removed because it is still not clear how the priority rules are combined. |
| MediaTek | Support the proposal |
| LG | In our view, in Alt 3, unlinked CSS set should have higher priority than Linked USS set. We suggest the following revision:* ***~~Alt3: Assign same priority for two linked search space sets for PDCCH transmission with overlapping monitoring occasions (and linked SS sets in USS have higher priority than individual SS set). Theses priority rules combined with Rel. 15 priority order determine the two QCL-TypeD.~~***
	+ ***~~FFS: The case that the first QCL-TypeD is from unlinked CSS~~***
* ***Alt3: the following priority rules determine the two QCL-TypeD.***
	+ ***SS type (USS/CSS) > linkage of SS sets > cell index > SS set ID***
		- ***Linked SS set has higher priority than individual SS set***
	+ ***FFS: The case of no linked SS sets among the multiple overlapping CORESETs***
 |
| Lenovo/MotM | Support the proposal and we are also fine with removing Alt 1 on account of capability restriction if without restriction on two QCL-TypeD.  |
| QC | Support. |
| Xiaomi | As for Alt 3, if the linked SS set in USS have higher priority that individual SS set, I think there will be not possible for the first FFS. And we also think it is not reasonable that “linked SS set in USS have higher priority that individual SS set”. We suggest to update Alt 3 as below:* ***Alt3: Assign same priority for two linked search space sets for PDCCH transmission with overlapping monitoring occasions (the priority is according to one of the two SS sets with a lower SS set ID). Theses priority rules combined with Rel. 15 priority order determine the two QCL-TypeD.***
	+ ***FFS: The case that the first QCL-TypeD is from unlinked CSS***
	+ ***FFS: The case of no linked SS sets among the multiple overlapping CORESETs***
 |
| CMCC | Support the proposal.We have the same view with Apple that Alt 1 cannot guarantee the 2 QCL-TypeD can be received simultaneously. |
| Samsung | Support the proposal in principle and prefer to select between Alt2 and Alt3. Also, as we pointed out in the last round, we would like to ask companies when this feature (using two QCL-TypeD properties for multiple overlapping CORESETs) is used, i.e., **when the number of monitored QCL-TypeD properties is two.** Does a UE monitor two different QCL-TypeD properties when PDCCH repetition is configured (e.g., linked SS sets)? Or does a UE monitor two different QCL-TypeD properties when at least one CORESET which is associated with one of two linked SS sets overlaps with other CORESETs at a certain PDCCH monitoring occasion?We think it should be clarified and included in this proposal. |
| Nokia/NSB | Support the FL proposal. From our understanding, Alt.1 select two QCL-TypeD based on extending Rel-15/16 mechanism without fully considering the linking of SSSets (or CORESETs). In summary, the following rules of selection may only consider for the CORESETs associated with other QCL TypeDs than the selected first QCL-TypeD (via same rules with all overlapping CORESETs). *- the CORESET corresponds to the CSS set with the lowest index in the cell with the lowest index containing CSS, if any; otherwise, to the USS set with the lowest index in the cell with lowest index* *- the lowest USS set index is determined over all USS sets with at least one PDCCH candidate in overlapping PDCCH monitoring occasions* |
| ZTE | Support FL proposal |
| OPPO | Support the proposal and prefer Alt.1. Moreover, Alt.2 can be achieved by Alt.1 with proper configuration. Thus, Alt.1 will offer more flexibility to gNB@Apple @DOCOMO: Would you like to share some specific example to show the issue? |
| FGI/APT | Support the proposal. We share the same view with Samsung. Whether to monitor two CORESETs with different QCL-Type D if one of overlapping CORESET is associated with one of linked PDCCH or monitor two CORESETs with different QCL-Type D if overlapping CORESETs are associated with both linked PDCCHs should be clarified. |
| Ericsson | Supporting FL proposal |
| CATT | Support the proposal. |
| ASUSTeK | Support FL proposal |
| vivo | Alt1should be removed, we do not see Alt1 is related to PDCCH repetition. |
| TCL | Support the proposal. We prefer to select between Alt2 and Alt3. |
| Huawei, HiSilicon | We prefer Alt2. We also share the similar view to remove Alt 1, as there would be problem for UEs to receive two QCL-TypeD beams. |
| Futurewei | Support the proposal, and support Alt2. |

## **Update**

The proposal seem to be agreeable to all companies, but some companies have suggestions on the wording or want to preclude Alt1. Moderator’s suggestion is to keep the three alternatives at this stage, and down-select later (next week or next meeting).

@ Docomo: In Alt2, given that linked SS sets are not necessarily considered together, following Rel. 15 order should be find in the sub-bullet. In order to minimize number of FFS’s, I suggest to not change that part.

@ Docomo, LG, Xiaomi: Your suggestion on Alt3 is considered, and the text is revised below based on LG and Xiaomi suggestions. @ Xiaomi: The part on linked SS set having higher priority seem to be a key part of this Alt for most supporting companies. I suggest to keep this part.

@ Samsung, FGI/APT: My understanding is that when UE supports 2 beams (simultaneously) and PDCCH repetition is configured. For some monitoring occasions w/o linked SS sets, or with TDMed linked SS sets, it requires more discussions and is captured by FFS’s.

The suggested wordings from companies are reflected below for Alt3 and the text is cleaned up a bit.

***FL Proposal 6: For a UE supporting reception with two different beams and configured with PDCCH repetitions, for determination of two QCL-TypeD properties for multiple overlapping CORESETs, select one Alt in RAN1 #106-bis-e:***

* ***Alt1: Identify the two QCL-Type D properties based on legacy priority order.***
* ***Alt2: Reuse legacy priority rule to identify the first QCL-TypeD property, and then, identify the second QCL-TypeD according to one of the SS sets that is linked with a SS set with the first QCL-TypeD (among the multiple overlapping CORESETs)***
	+ ***In the case of multiple such SS set pairs, Rel. 15 priority order is followed for the second QCL-TypeD determination***
	+ ***FFS: The case of no such SS set pair***
* ***Alt3: Assign same priority for two linked search space sets for PDCCH transmission with overlapping monitoring occasions (the priority is according to one of the two SS sets with a lower SS set ID)***
	+ ***Priority order: SS type (USS/CSS) > linkage of SS sets > cell index > associated SS set ID***
		- ***Linked SS set has higher priority than individual SS set***
	+ ***FFS: The case that the first QCL-TypeD is from unlinked CSS***
	+ ***FFS: The case of no linked SS sets among the multiple overlapping CORESETs***

|  |  |
| --- | --- |
| Company | Comments |
| ZTE | Support in principle, but we would like not to **preclude some other solutions** to give some room for more thinking as we see problems/uncertainty for each option. Based on the comments before, I think Alt 2 also has some problems since it also may lead to 2 QCL-TypeD that cannot be received by UE simultaneously in the case when the first identified TypeD has no linked CORESET in the same symbol.For case 3, it may drop CSS but keep USS which is not aligned with the existing design.  |
| LG | Support the proposal.  |
| Samsung | Support. Regarding the very last FFS (***The case of no linked SS sets among the multiple overlapping CORESETs)***, we prefer to use legacy Rel-15 operation. |
| NTT Docomo | Support  |
| MediaTek | Support |
| NEC | Support  |

# **CORESETPoolIndex**

The issue of using PDCCH repetitions with multi-DCI based mTRP was discussed in the previous meeting, and some companies preferred more time for studying the issue. There are three alternatives discussed in the contributions:

* Alt1: Support two linked PDCCH candidates to be associated with two CORESETPoolIndex values.
	+ For this Alt, some Rel. 16 multi-DCI based mTRP rules need to be revisited such as scrambling, CRS rate matching, HARQ-Ack, BD counting, etc. For example, a reference candidate is needed for PDSCH scrambling or CRS rate matching.
* Alt2: Two linked PDCCH candidates are not expected to be associated with different CORESETPoolIndex values.
	+ This Alt does not prevent simultaneous configuration of multi-DCI and CORESETPoolIndex as long as linked candidates are associated with the same CORESETPoolIndex
* Alt3: CORESETPoolIndex value is not expected to be configured if PDCCH repetition is configured in the same CC.
	+ This Alt prevents simultaneous configuration of multi-DCI and PDCCH repetition.

Views on the three alternatives are summarized below:

* **Alt1: LG, Fraunhofer IIS/HHI, Samsung, ZTE, CATT, NEC, Futurewei**
* **Alt2: NTT Docomo, Apple, QC, Lenovo/MotM, Fujitsu, Xiaomi, Spreadtrum, InterDigital, Vivo (with some restriction), Nokia/NSB, CMCC, Huawei/HiSilicon, Convida Wireless, TCL, Futurewei, Intel**
* **Alt3: MediaTek, Apple, Lenovo/MotM, OPPO, Spreadtrum, Vivo, E///**

Given that Alt2 has majority support, it is suggested below. It should be noted that Alt2 or Alt3 do not have further specification impact, but Alt1 requires some further work/agreements.

***FL Proposal 8: Two linked PDCCH candidates are not expected to be associated with different CORESETPoolIndex values.***

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support |
| NTT Docomo | Support  |
| MediaTek | Prefer Alt3 but fine with the proposal |
| Lenovo/MotM | Support the proposal |
| QC | Support |
| Xiaomi | Support  |
| CMCC | Support. |
| Convida Wireless | Support |
| Samsung | We still support Alt1. |
| Nokia | Support |
| ZTE | Don’t support the proposal. As we commented before, MDCI based MTRP is a very useful deployment, it is desirable to implement PDCCH repetition across two TRPs together with MDCI based MTRP. The spec impact can be minimized from our view, e.g. select one of two PDCCH candidates for PDSCH scrambling, CRS rate matching.  |
| Fraunhofer IIS/HHI | Agree with ZTE’s views. The spec impact is straightforward. Prefer Alt. 1 |
| OPPO | We still prefer Alt.3. During R16 M-TRP design, it is a common understanding each CORESETPoolIndex corresponds to a different TRP. If two linked PDCCH candidates are configured with the same CORESETPoolIndex, it means each CORESETPoolIndex is associated with two different TRPs, which are conflicting with R16 design principle  |
| Ericsson | Support |
| vivo | If Alt2 is supported, why PDSCH repetition scheme and configuration of different CORESETPoolIndexs are mutually exclusive in Rel.16, but PDCCH repetition and CORESETPoolIndexs configuration can be existed together in Rel.17?  |
| TCL | Support the proposal. |
| Huawei, HiSilicon | Support the proposal |
| Futurewei | Open to Alt 2 (for its simplicity) and Alt 1. Though we are fine with the proposal, we also agree with ZTE on the limitation of Alt 2. Is it possible to make Alt 1 an FFS point and support in R17 if time allows? |

## **Update**

The proposal is supported by majority of companies.

@ Samsung, ZTE, Fraunhofer IIS/HHI: I think majority of companies do not support Alt1. In my understanding, there seem to be only two possible outcomes based on the discussions: Alt2 or Alt3 given that these two do not have further spec impact. Since we discussed the issue multiple times, we may need to make a decision in this meeting. Given this, can you accept Alt2?

@ OPPO, vivo: In Rel. 16, that issue was discussed late during maintenance. If I remember correctly, the concern was possible late specification impacts during maintenance. For this issue, it as been discussed for multiple meetings now. Also, there may not be further spec impact (beyond the restriction) with Alt2, or if there is any (I have not seen any such proposal so far), there could still be time to address those. Given this, can you accept Alt2?

The proposal is unchanged:

***FL Proposal 8: Two linked PDCCH candidates are not expected to be associated with different CORESETPoolIndex values.***

|  |  |
| --- | --- |
| Company | Comments |
| ZTE | We prefer to further discuss this issue. The concern on Alt.1 is not clear to us (many companies just concern on spec effort). As we explained several times, the agreed rule can be reused for Alt.1, e.g. one of PDCCH candidate is used for the reference. We don’t think much spec effort is needed.  |
| LG | We have similar view with ZTE. Spec impact of Alt 1 is to set reference PDCCH candidate as we already agreed for many cases. In addition, Alt 2 needs more CORESET (at least 3 CORESETs) to support MDCI MTRP and MTRP PDCCH at the same time than Alt 1.  |
| Samsung | Still support Alt1 in the original proposal. Similar view with ZTE and LG. |
| NTT Docomo | Support  |
| MediaTek | Support |
| NEC | Fine with the proposal based on majority view. |

# **Complexity handling related to numbers / locations of linked candidates**

Based on the discussions in the first round, majority of companies agree with the issue or are open to study it further. More details may be needed on the solution to handle various cases. The details can be discussed in the next meeting given that there are not many specifics at this point.

***FL Proposal 11: Study whether/how to handle UE complexity / memory requirements for linked PDCCH candidates***

* ***The following cases can be considered:***
	+ ***Case 1: One pair of linked MO’s of one pair of linked SS sets in a given slot with large number of candidates.***
	+ ***Case 2: Multiple pairs of linked MO’s of one pair of linked SS sets in a given slot, where MO’s of the two SS sets are not interlaced (similar to Case 2 in the figure above)***
	+ ***Case 3: For two pairs of linked SS sets (e.g. SS sets 1 and 2 are linked, and SS sets 3 and 4 are linked), a MO of any of the SS sets (e.g. SS set 3) is in between two linked MOs of another two SS sets (e.g. SS sets 1 and 2).***
	+ ***Other cases are not precluded.***
* ***Examples of possible mechanisms to address the issue: Restrictions in the spec, UE capability, limit total number linked candidates in a slot, limit total number of linked candidates / CCEs at any given time (similar to CPU occupation)***
* ***Whether the solution should also depend on AL of linked candidates***
* ***The case of CA can also be considered***

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support |
| NTT Docomo | Support  |
| MediaTek | Support |
| LG | Support |
| Lenovo/MotM | Support |
| QC | Support |
| Xiaomi | Support  |
| CMCC | Support. |
| Samsung | Support |
| Nokia | Study is ok. |
| ZTE | OK in principle. The wording should be refined, e.g. ***(similar to Case 2 in the figure above)*** should be removed from case 2. |
| Fraunhofer IIS/HHI | Support |
| OPPO | Support |
| FGI/APT | Support |
| Ericsson | Support |
| CATT | Support |
| ASUSTeK | Support |
| vivo | Support |
| TCL | Support |
| Huawei, HiSilicon | Support. |
| Futurewei | Support |

The following is endorsed by Email:

***Agreement***

***Study whether/how to handle UE complexity / memory requirements for linked PDCCH candidates***

* ***The following cases can be considered:***
	+ ***Case 1: One pair of linked MO’s of one pair of linked SS sets in a given slot with large number of candidates.***
	+ ***Case 2: Multiple pairs of linked MO’s of one pair of linked SS sets in a given slot, where MO’s of the two SS sets are not interlaced ~~(similar to Case 2 in the figure above)~~***
	+ ***Case 3: For two pairs of linked SS sets (e.g. SS sets 1 and 2 are linked, and SS sets 3 and 4 are linked), a MO of any of the SS sets (e.g. SS set 3) is in between two linked MOs of another two SS sets (e.g. SS sets 1 and 2).***
	+ ***Other cases are not precluded.***
* ***Examples of possible mechanisms to address the issue: Restrictions in the spec, UE capability, limit total number linked candidates in a slot, limit total number of linked candidates / CCEs at any given time (similar to CPU occupation)***
* ***Whether the solution should also depend on AL of linked candidates***
* ***The case of CA can also be considered***

# **Inter-slot PDCCH repetition**

This issue has been discussed multiple times without a clear conclusion or agreement. In this meeting, multiple companies (ZTE, NEC, Xiaomi, Intel) proposed to support inter-slot PDCCH repetition in addition to intra-slot case. We need a resolution in this meeting. For the case of inter-span PDCCH repetition, it will be separately discussed (see FFS in the Proposal in Section 4).

**Question: Do you support inter-slot PDCCH repetition?**

|  |  |
| --- | --- |
| Company | Comments |
| Apple | No |
| MediaTek | No |
| Lenovo/MotM | Support inter-slot PDCCH repetition since it can improve reliability similar as intra-slot PDCCH repetition and inter-slot is a typical scenario for PDCCH repetition.  |
| QC | No |
| Xiaomi | Yes, with 2 as the number of repetitions.  |
| Convida Wireless | Yes |
| Samsung | No |
| Nokia | Support. If companies wish to use this PDCCH repetition in practice, as network vendor we suggest considering this scheme. In FR2, intra-slot PDCCH repetition will require very tight coordination and ideal BH between TRPs and will not be feasible. Also, slot duration is small and the UE complexity / memory requirements for linked PDCCH candidates should not be a problem.  |
| ZTE | Support. Agree with Nokia’s analysis. To compromise, we are fine to restrict PDCCH repetitions in consecutive DL slots.  |
| OPPO | Support |
| FGI/APT | Support |
| Ericsson | No |
| CATT | Yes |
| vivo | Do not support in Rel.17 |
| TCL | Support |
| Huawei, HiSilicon | We think the inter-span case should be of higher priority, regarding the listed cases. |
| Futurewei | Support |

## **Update**

Views are summarized below:

* **Support Inter-slot: Lenovo/MotM, Xiaomi, Convida Wireless, Nokia, ZTE, OPPO, FGI/APT, CATT, TCL, Futurewei**
* **Do not support inter-slot: Apple, MediaTek, QC, Samsung, Ericsson, vivo**
* **Not high priority: Huawei/HiSilicon,**

The situation requires decision during GTW. One of the following is needed in this meeting:

***Alt1 (Proposal): Support inter-slot PDCCH repetition in two consecutive slots.***

***Alt2 (conclusion): There is no consensus in RAN1 to support inter-slot PDCCH repetition in Rel. 17.***

|  |  |
| --- | --- |
| Company | Comments |
| ZTE | Support Alt 1. PDCCH repetition is most like to be used for FR2 in blockage scenarios. However, intra-slot PDCCH repetition will require very tight coordination between TRPs, and may also cause PDCCH congestion.  |
| LG | We prefer to complete intra slot case first.  |
| Samsung | Support Alt2. |
| MediaTek | Support Alt2. Shouldn’t we also discuss inter-span repetition regarding whether we allow it or not? |
| NEC | Support Alt 1. |

# **CSS for PDCCH repetition**

Views based on the contributions are summarized below:

* Convida, Ericsson, and Qualcomm propose to discuss some of the DCI formats 2\_x (CSS Type3).
* Vivo and Lenovo/MotM proposed to discuss whether different CSS types (0/0A/1/2) are supported for PDCCH repetition or not.
* Fraunhofer: QCL assumption for PDCCH with RA-RNTI and scheduled PDSCH with CFRA-based PDCCH order.

CSS Type 3 is configured in RRC connected, and the existing framework is applicable. Also, the following was concluded before:

**Conclusion**

Group-common DCI formats (DCI formats 2\_x) are not precluded for multi-TRP PDCCH reliability enhancements and can be discussed with a lower priority compared to UE-specific DCI formats.

Note: Enhancements required for DCI formats 2\_x, if any, can be discussed case-by-case.

Hence, for CSS Type 3, the required clarifications are related to specific procedures in DCI format 2\_x (e.g. timeline conditions, reference PDCCH candidate).

Regarding CSS Type 0/0A/1/2, the possible applicability to PDCCH repetition may be limited to RRC connected mode (given that configuration of SS set linking is needed). Also, the existing configuration of SS sets for these CSS types are slightly different than USS or CSS Type3 as shown below:



With respect to the point mentioned by Fraunhofer, the following specification texts are noted, which means that the PDCCH order and the DCI with RA-RNTI and the scheduled PDSCH have the same beam

38.214: When receiving a PDSCH scheduled with RA-RNTI in response to a random access procedure triggered by a PDCCH order which triggers contention-free random access procedure for the SpCell [10, TS 38.321], the UE may assume that the DM-RS port of the received PDCCH order and the DM-RS ports of the corresponding PDSCH scheduled with RA-RNTI are quasi co-located with the same SS/PBCH block or CSI-RS with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable.

38.213: If the UE attempts to detect the DCI format 1\_0 with CRC scrambled by the corresponding RA-RNTI in response to a PRACH transmission initiated by a PDCCH order that triggers a contention-free random access procedure for the SpCell [11, TS 38.321], the UE may assume that the PDCCH that includes the DCI format 1\_0 and the PDCCH order have same DM-RS antenna port quasi co-location properties.

This is illustrated in the figure below if my understanding of the above is correct:



When the PDCCH order is transmitted by PDCCH repetitions with two different beams, some discussions seem to be necessary as to how the beam of the DCI with RA-RNTI and the scheduled PDSCH are selected.

**Question 1: Which of the following CSS types should / should not be supported for PDCCH repetition in Rel. 17?**

* **CSS Type3 (DCI formats 2\_x)**
* **CSS Type0/0A/1/2 in RRC connected**

**Question 2: Do you agree with the issue mentioned by Fraunhofer and described above? If yes, what is your preferred solution?**

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Q1: In our view, Type3 can be supported.Q2: Yes. The PDCCH beam is based on the beam associated with PRACH after PRACH transmission.  |
| LG | Q1: Type3 can be supported.Q2: The issue can be simply addressed by gNB implementation; UE does not expect repetition transmission of PDCCH order. |
| Lenovo/MotM | Q1: Support both mentioned common CSS with PDCCH repetition to provide similar reliability for both CSS and USS. For CSS Type 0/0A/2, soft combination can be made between two candidates from search space set 0 on two different monitoring occasions. Alternatively, soft combination can be made between candidate from search space set 0 and candidate from another configured associated search space set. |
| QC | Q1: At least Type3 can be supportedQ2: Yes |
| CMCC | Q1: Type3 can be supported.Q2: Yes. |
| Convida Wireless | Q1: CSS Type3Q2: Yes. |
| Samsung | Q1: Type3 can be enhancedQ2: Yes, but it depends on the outcome of Q1. |
| Nokia | Need further study |
| ZTE | Q1: Type3 can be supported. We are also OK not to support PDCCH repetition for CSS.Q2: Yes. |
| Fraunhofer IIS/HHI | Q1: Support at least Type3 CSSQ2: We are open to study both specification-based and implementation-based solutions |
| OPPO | Q1: we are open to discuss CSS Type 3.Q2: Yes. |
| Ericsson | Q1: CSS Type 3 should be supported. Q2: Yes. One possible solution could be to introduce some restriction (FFS) |
| ASUSTeK | Q1: CSS Type3 can be supportedQ2: Share same view with LG and Ericsson, introduce some restriction could be a simple solution. |
| vivo | Q1: Since two PDCCH repetition candidates from single-TRP has been accepted by many companies and same CORESET ID with two linked SS sets is also supported. At least, PDCCH repetition for all of CSS types from single-TRP should be discussed and supported if possible. |
| TCL | Q1:CSS Type3.Q2: Yes. |
| Huawei, HiSilicon | Q1: CSS Type3. |
| Futurewei | Q1: Support CSS Type 3. Q2: Is there any use case that the PDCCH order is transmitted by PDCCH repetitions with two different beams? It seems not, and it is questionable why a gNB would do so, especially given the current specs. |

## **Update**

For the first issue, view are:

* **Support Type3 CSS (18): Apple, LG, Lenovo/MotM, QC, CMCC, Convida Wireless, Samsung, ZTE, Fraunhofer IIS/HHI, Ericsson, ASUSTeK, vivo (for single-TRP), TCL, Huawei/HiSilicon, Futurewei**
* **Support Type0/0A/1/2 CSS: Lenovo/MotM, vivo (for single-TRP)**
* **Need further study / open to discuss: Nokia, OPPO (for Type 3)**

There seem to be no concern with supporting Type3 CSS.

For the second question, most companies think that this is a valid issue, but depends on the outcome of the first issue, and needs further study.

@ LG, Futurewei: There is no restriction to use send PDCCH order with PDCCH repetition with two beams. In fact, in the GTW agreement (for timeline purpose), PDCCH order is already listed.

***FL Proposal 14: Support PDCCH repetition for Type3 CSS.***

***FL Proposal 15: For PDCCH repetition in Rel. 17, study the following aspects:***

* ***Whether/how to support PDCCH repetition for Type0/0A/1/2 CSS***
* ***When PDCCH order is transmitted with PDCCH repetitions with different beams triggering CFRA for SpCell, how to determine the QCL assumption for the PDCCH that includes the DCI format 1\_0 with RA-RNTI and the corresponding scheduled PDSCH.***

|  |  |
| --- | --- |
| Company | Comments |
| ZTE | OK |
| LG | We suggest the following revision.***FL Proposal 15: For PDCCH repetition in Rel. 17, study the following aspects:**** ***Whether/how to support PDCCH repetition for Type0/0A/1/2 CSS***
* ***~~When~~Whether to support PDCCH order transmitted with PDCCH repetitions with different beams triggering CFRA for SpCell, and if it is supported how to determine the QCL assumption for the PDCCH that includes the DCI format 1\_0 with RA-RNTI and the corresponding scheduled PDSCH.***
 |
| Samsung | Support and prefer LG’s updated one. |
| NTT Docomo | Support and also fine with LG’s revision. |
| MediaTek | Prefer LG’s revision. |
| NEC | Support  |

# **Issues related to BFR**

Apple mentioned the following in their contribution:

* Support UE to report 2 new beams in BFRQ for PCell/SCell BFR, and after UE receives BFR response it can apply the 2 beams for reception of PDCCH repetition with 2 beams
* SS-BFR should not be linked with other SS for PDCCH repetitions

At least for the second issue, my understanding is that some discussions are needed. This is because “recoverySearchSpaceId” is specifically configured for BFR response, and the CORESET associated with this SS set cannot be used for any other SS set. Also, the beam of that CORESET is based on q\_new (new identified beam after BFR). Hence, some questions are asked below:

**Question 1: Can the recoverySearchSpaceId be linked with another SS set (for PDCCH repetition of BFR response on the PCell)?**

**Question 2: If answer to Q1 is yes, can the linked SS set be associated with the same BFR-CORESET (PDCCH repetition with same beam) or can be associated with a different CORESET?**

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Q1: No |
| NTT Docomo | Q1: Yes Q2: the two linked SS sets should be associated with same CORESET. |
| MediaTek | Q1: No because we need two CORESET-BFRs to support BFR |
| LG | Q1: No |
| Lenovo/MotM | Q1: We are open to discuss introducing another special SS set paired with recover search space on account that it can improve PDCCH receiving reliability. More discussion is required if introducing additional CORESET for BFR.  |
| QC | Q1: YesQ2: Repetition with the same beam (same CORESET) can be easily supported, but repetition with 2 beams can be complicated since two candidate beams (q\_new) may be needed. |
| Xiaomi | Q1: No. if the two linked SS sets associated with same CORESET, only the same beam will be used. Else, two CORESETs will be needed. |
| Convida Wireless | Q1: No |
| Nokia | No |
| ZTE | No |
| OPPO | Q1: No |
| CATT | Q1: No. If at most one new candidate beam can be reported by UE, the benefit of PDCCH repetition will be unclear. |
| TCL | Q1: No |
| Huawei, HiSilicon | Q1: No. |
| Futurwei | Q1: No |

The following is endorsed by Email:

***Agreement***

***SS set configured by recoverySearchSpaceId cannot be linked to another SS set for PDCCH repetition.***

# **AP-CSI-RS scheduled by PDCCH repetition**

In GTW, the following was agreed for PDSCH with mapping Type B:

**Agreement**

Among the two Alts in RAN1 #104b-e agreement on PDSCH mapping Type B, support Alt1 (The candidate that starts later in time).

Qualcomm proposed in their contribution to have a similar restriction for AP-CSI-RS scheduled by PDCCH repetitions. In Rel. 15, both cases of PDSCH mapping Type B and AP-CSI-RS have similar restriction”

The UE is not expected to receive a PDSCH with mapping type B in a slot, if the first symbol of the PDCCH scheduling the PDSCH was received in a later symbol than the first symbol indicated in the PDSCH time domain resource allocation.

The UE does not expect that aperiodic CSI-RS is transmitted before the OFDM symbol(s) carrying its triggering DCI.

The following was suggested by Qualcomm: For AP-CSI-RS scheduled by two PDCCH candidates that are linked for repetition, the UE does not expect that the AP-CSI-RS is transmitted before the first symbol of the PDCCH candidate that starts later in time.

**Question: Do you agree with the issue mentioned above for AP-CSI-RS scheduled by PDCCH repetitions?**

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Yes.  |
| NTT Docomo | Yes. |
| MediaTek | yes |
| LG | Yes.  |
| Lenovo/MotM | Yes |
| QC | Yes. |
| Xiaomi | Yes |
| CMCC | Yes. |
| Convida Wireless | Yes |
| Samsung | Yes. |
| Nokia | Yes |
| ZTE | Yes |
| Fraunhofer IIS/HHI | Yes |
| OPPO | Yes |
| Ericsson | Yes |
| CATT | Yes. |
| ASUSTeK | Yes |
| vivo | In Ran1 #104meeting, **Agreement**For Option 2, at least for the following purposes, a reference PDCCH candidate is defined as the candidate that ends later in time among the two linked PDCCH candidates in the time domain:* To determine the scheduling offset to identify whether a default beam should be used for PDSCH / CSI-RS reception.

Based on the agreement, A-CSI-RS is not transmitted before the second PDCCH candidate in time. So, we think this issue is not needed to be further clarified and discussed.  |
| TCL | Yes |
| Huawei, HiSilicon | OK |
| Futurewei | Yes |

The following is endorsed by Email:

***Agreement***

***For AP-CSI-RS scheduled by two PDCCH candidates that are linked for repetition, the UE does not expect that the AP-CSI-RS is transmitted before the first symbol of the PDCCH candidate that starts later in time.***