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

**E-meeting, January 25th – February 5th, 2021**

**Agenda Item: 8.1.4**

**Source: Moderator (Huawei, HiSilicon)**

**Title: Summary of CSI enhancements for MTRP and FDD (Round 2)**

**Document for: Discussion and Decision**

# Summary of CSI enhancement for FDD

**Possible Agreement**

*For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay, support codebook structure W=W1W2 WfH whereas*

* *W1 is a free selection matrix, with identity matrix as special configuration*
  + *FFS polarization-common/specific selection*
* *Wf is a DFT based compression matrix in which N3 = NCQISubband\*R and Mv>=1*
  + *At least one value of Mv>1, e.g. Mv=2, is supported*
    - *Decide on the value of Mv in RAN1#104bis-e*
  + *[FFS] Support of Mv>1 is a UE optional feature if the UE supports Rel-17 PS codebook enhancement, taking into account UE complexity related to codebook parameters*
  + *FFS other candidate values of R, mechanism of Configured/indicated to the UE and/or mechanism of selected/reported by UE for Wf*
* *Wf can be turned off by gNB. When turned off,* *Wf* *is an all-one vector (FFS; the length of all-one vector)*
* *FFS other signaling/CSI reporting mechanism for trade-off among signaling overhead, UE complexity and performance gain*

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| Company | Comments |
| Huawei (Moderator) | Please comment by RAN1 reflector. Here is just for a reference of final outcome (if any) |
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***Proposal 5:*** *Study following mechanisms of gNB configured/indicated to the UE for Wf (when Mv>1), which are to be decided in RAN1 104bis-e:*

* *Option 1: gNB can indicate selected FD bases used for Wf quantization via dynamic signaling*
* *Option 2: The FD bases used for Wf quantitation limited within a window/set of size N and initial point Minitial can be fixed/configured/indicated by gNB*
* *~~Option 3: The number of CSI-RS ports and the value of M~~~~v~~ ~~is jointly configured per codebook parameter combination~~*

*Other enhancements are not excluded.*

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| Company | Comments |
| Huawei (Moderator) | Please just check whether the text is sufficiently clear, for the sake of making a decision next meeting.  @Nokia: update accordingly  @CATT@QC: is it ok to remove option 3 here? Or any update do you prefer?  @Vivo@MTK: for option 1, do you refer to DCI or MAC-CE?  Option 1: Vivo, MediaTek, Sony  Option 2: Vivo, Nokia/NSB, Oppo, Lenovo/MotM, Intel, Sony |
| Lenovo/MotM | OK with the current proposal |
| CATT | Ok with the current proposal. The following are some wording suggestion:  ***Proposal 5:*** *Study following mechanisms of gNB configuring/indicating Wf to UE (when Mv>1), which are to be decided in RAN1 104bis-e:*   * *Option 1: gNB can indicate FD bases used for Wf quantization via dynamic signaling* * *Option 2: The FD bases used for Wf quantitation limited within a window/set of size N and initial point Minitial can be fixed/configured/indicated by gNB. N can be fixed/configured/indicated by gNB.* * *~~Option 3: The number of CSI-RS ports and the value of M~~~~v~~ ~~is jointly configured per codebook parameter combination~~*   *Other enhancements are not excluded.* |
| vivo | We think option 1 and option 2 can be merged by configuration, so based on CATT’s version, Proposal 5 can be updated to:  ***Proposal 5:*** *Study following mechanisms of gNB configuring/indicating Wf to UE (when Mv>1), which are to be decided in RAN1 104bis-e:*   * *The FD bases used for Wf quantitation limited within K windows/sets, each with size Nk and initial point Minitial,k, can be fixed/configured/indicated by gNB.*   + *FFS: values for K, Nk, Minitial,k* * *~~Option 3: The number of CSI-RS ports and the value of M~~~~v~~ ~~is jointly configured per codebook parameter combination~~*   *Other enhancements are not excluded.* |

# Summary of CSI enhancement for Multi-TRP

***Proposal 6:*** *For CSI measurement associated to a reporting setting CSI-ReportConfig for NCJT, the UE can be configured with Ks ≥ 2 NZP CSI-RS resources in a CSI-RS resource set for CMR and N ≥ 1 NZP CSI-RS resource pairs whereas each pair is used for a NCJT measurement hypothesis, support at least one CMR pairing mechanism by down-selecting from following in RAN1 104e:*

* *Alt.1: Configure UE with N NZP CSI-RS resource pairs within a CMR resource set explicitly, whereas the first Ks-2N CMRs are for single-TRP measurement hypotheses and the remaining 2N CMRs in consecutive N CMR pairs are for N NCJT hypotheses.* 
  + *Note: Network can reuse CMRs of single-TRP hypotheses for NCJT hypotheses at least in FR1 (by configuring the same CSI-RS resource ID of any of the first Ks-2N CMRs for any of the remaining 2N CMRs in the resource set)*
* *Alt.2: N CMR pairs are RRC configured and/or indicated (by MAC-CE) explicitly by a bitmap.* 
  + *Note: the first Ks-2N CMRs in the set are for single-TRP measurement hypotheses.*
* *Alt.3: Configure UE with two CMR groups with Ks = K1+K2 (≥ 2N) CMRs, whereas each CMR group corresponds to one out of two TRPs. N CMR pairs are [explicitly/implicitly] determined from two CMR groups*
  + *FFS. Option 1 N NZP CSI-RS resource within a group can be explicitly/implicitly determined for NCJT measurement hypothesis with one-to-one mapping with the N NZP CSI-RS resource in the other group*
  + *FFS Option 2 UE freely select CMR pairs from two groups (without one-to-one mapping)*
  + *K1 and K2 are the number of CMRs in two groups respectively. FFS K1=K2  or different K1/K2.*
  + *Note that CMRs in one or more CMR groups can also be used for single-TRP measurement hypotheses*
* *Alt.4: N ≥ 1 NZP CSI-RS resource pairs are determined and reported by UE*
* *Alt.5: N= Ks(Ks-1)/2 pairs for all possible pairing from the set*
  + *Note that CMRs in the set can also be used for single-TRP measurement hypotheses*
* *FFS maximal values of N and Ks*

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| Huawei (Moderator) | Could you please check/share your first/second (if any) preferences? My general thought is to focus on at most two Alts by next check point (Monday). Whilst you share your preference, please also consider IMR design, FR1/FR2 applicability and UE complexity at least. Although we don’t decide all things as one go, as a part of spec/RAN1 design, we will make decision after this proposal very soon/next meetings.  Alt 1: QC, ZTE, Docomo, Intel  Alt 2: Nokia  Alt 3: Vivo, CATT, Oppo, NEC, Intel, Docomo, MediaTek, LGE, Lenovo/MoM,  Alt 4: Futurewei  Alt 5: Ericsson |
| Huawei (Moderator) | @Siva @chuangxin: some text for Alt 3 are updated. They are FFS. As long as the concept is clear enough, we can address some detailed design later. |
| QC | Our first preference is Alt1. Our second preference is Alt2 (which in our understanding, is similar to Alt1). We think other alternatives are not appropriate for FR2 since UE may not be able to use CMR of sTRP hypotheses for NCJT hypotheses. |
| ZTE | We support Alt1.  We are OK to the current proposal. However, if we are going to final desicision/down-selection, Alt 3 should be clarified with details. Further, As QC mentioned, all solutions should work well in both FR1 and FR2. |
| Lenovo/MotM | Support Alt 3. To address QC/ZTE’s concerns regarding the operability of Alt3 in FR2, we propose adding an FFS to Alt 3 with minor rewording (highlighted), as follows   * *Alt.3: Configure UE with two CMR groups with Ks = K1+K2 (≥ 2N) CMRs, whereas each CMR group corresponds to one out of two TRPs. N CMR pairs are [explicitly/implicitly] determined from two CMR groups*   + *FFS. Option 1 N NZP CSI-RS resource within a group can be explicitly/implicitly determined for NCJT measurement hypothesis with one-to-one mapping with the N NZP CSI-RS resource in the other group*   + *FFS Option 2 UE freely select CMR pairs from two groups (without one-to-one mapping)*   + *K1 and K2 are the number of CMRs in two groups respectively. FFS K1=K2  or different K1/K2.*   + *Note that a subset of CMRs in one or more CMR groups can also be used for single-TRP measurement hypotheses.* * *FFS: whether the CMRs used for single-TRP measurement hypotheses cannot be used for NCJT hypotheses, at least in FR2* |
| CMCC | We can support Alt 1 and Alt 3. And we prefer Alt 3.  Comparing with Alt 1, all the CMRs in the resource set in Alt 3 can be used for single-TRP hypothesis, which is more flexible in reporting CSI.  For Alt 5, calculating all the possible pairs need too much CPU and the CSI reporting overhead is also unacceptable. |
| Samsung | We support Alt1 and Alt3. Considering FR2 case, we are fine with adding FFS point from Lenovo. |
| CATT | Support Alt. 3.  In our opinion, the issue raised by ZTE and QC applies to Alt. 1 as well, if the same CMRs of single-TRP hypotheses are reused for NCJT hypotheses in FR2. |
| Ericsson | In the main bullet, we suggest to remove ‘at least’ since the intention is to downselect one alternative.  ***Proposal 6:*** *For CSI measurement associated to a reporting setting CSI-ReportConfig for NCJT, the UE can be configured with Ks ≥ 2 NZP CSI-RS resources in a CSI-RS resource set for CMR and N ≥ 1 NZP CSI-RS resource pairs whereas each pair is used for a NCJT measurement hypothesis, support ~~at least~~ one CMR pairing mechanism by down-selecting from following in RAN1 104e:*  Our first preference is Alt 5. But we can also accept Alt 3. To avoid overspecification, we would like to emphasize that only one solution is down-selected in the end.  Regarding QC’s comment ‘other alternatives are not appropriate for FR2 since UE may not be able to use CMR of sTRP hypotheses for NCJT hypotheses’, I don’t see why Alt 3 cannot work for FR2. I think Alt 5 can also work for FR2 if the best beam per TRP is identified via beam reporting. So Alt 1 does not have any special advantages in FR2 over other alternatives.. |
| NTT DOCOMO | We support Alt1 and Alt3.  Fine with revision from Lenovo and E///. |
| MediaTek | Support Alt. 3 and agree with Ericsson that only one solution is needed.  We are open to address QC and ZTE’s concerns for FR2, but we prefer to have a low-overhead design at least for FR1. |
| vivo | In our view, at least for FR1, the CMR used for NCJT hypothesis measurement can reused for STRP hypothesis measurement to simply UE measurement. For FR2, in our opinion, the performance loss is negligible.  Besides, we think Proposal 6 should work for the CSI hypotheses reporting Alternatives considered in Proposal 8. For example, if the UE is configured to report two CSIs associated with single-TRP measurement hypotheses and one CSI associated with NCJT measurement hypothesis, with Alt 1 and Alt 2 in this proposal, the UE cannot tell which TRP the CMR for two single-TRP CSI measurement belongs to and may result in reporting two single-TRP CSIs corresponding to one TRP, which is not our original purpose. Thus, grouping the CMRs in a resource set is needed. And it is also quite aligned with the options in CMR configuration discussed in MTRP multi-beam AI.  We update the Alt.3 to consider other companies’ concerns:   * *Alt.3: Configure UE with two CMR groups with Ks = K1+K2 (≥ 2N) CMRs, whereas each CMR group corresponds to one out of two TRPs. N CMR pairs are [explicitly/implicitly] determined from two CMR groups*   + *FFS. Option 1 N NZP CSI-RS resource within a group can be explicitly/implicitly determined for NCJT measurement hypothesis with one-to-one mapping with the N NZP CSI-RS resource in the other group*   + *FFS Option 2 UE freely select CMR pairs from two groups (without one-to-one mapping)*   + *K1 and K2 are the number of CMRs in two groups respectively. FFS K1=K2  or different K1/K2.*   + *Note that the first N CMRs in one or more CMR groups are used for NCJT measurement hypotheses and can also be used for single-TRP measurement hypotheses, the remaining CMRs in one or more CMR groups are only used for STRP hypotheses*   + *FFS: N CMR pairs are RRC configured and/or indicated (by MAC-CE)* |

***Proposal 8:*** *For a CSI report associated with a Multi-TRP/panel NCJT measurement hypothesis configured by single CSI reporting setting, downselect between the following two options:*

* *Option 1: the UE can be configured to report X CSIs associated with single-TRP measurement hypotheses and one CSI associated with NCJT measurement hypothesis*
  + *Alt. 0: X = 0*
  + *Alt. 1: X = 1*
  + *Alt. 2: X=0, 1*
  + *Alt. 3: X = 0, 1, 2*
  + *FFS omission of CSI associated with NCJT measurement hypothesis*
* *Option 2: the UE can be configured to report one CSI associated with the best one among NCJT and single-TRP measurement hypotheses*
  + *FFS how to report recommended measurement hypothesis associated with that CSI report*

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| Huawei (Moderator) | Could you please vote your first and second (if you have) preferences, i.e. option 1 only, option 2 only, options 1+2?  Option 1 only:  Option 2 only:  Options 1+2:  For the values of X, let us decide online in GTW. I doubt that we can decide by email. I will summarize some arguments for values of X later. |
| QC | Regarding Options: Our first preference: Option 1; Our second preference: Options 1+2  Regarding Alts: Support Alt1. We are still unclear why X=0 is needed. Network should not configure single-TRP hypotheses if they are not needed. This can be easily done by Alt1 of Proposal 6, e.g., by configuring *Ks=2N.* Furthermore, we do not think X=2 is needed. |
| ZTE | Support Option 2.  Furthermore, as QC mentioned, X=0 in Option1 should not be included, it has been precluded based on the following agreement made in last meeting.  **Agreement**  For a CSI reporting setting, support one or more of the following UE reporting mechanism:   * Alt 1: the UE can be expected to report one CSI associated with the best single-TRP measurement hypothesis and one CSI associated with the best NCJT measurement hypothesis, if configured   + FFS omission of CSI associated with NCJT measurement hypothesis * Alt 2: the UE can be expected to report one CSI associated with the best one among NCJT and/or single-TRP measurement hypotheses, if configured   + FFS how to report recommended measurement hypothesis associated with that CSI report * Alt 3: the UE can be expected to report two CSIs associated with the two best single-TRP measurement hypotheses associated with CMRs from two TRPs and one CSI associated with the best NCJT measurement hypothesis, if configured   + FFS omission of CSI associated with NCJT measurement hypothesis   + Whether/How to report a subset of the CSI report quantities * FFS: CSI reporting configuration details |
| Lenovo/MotM | Support Option 1 |
| CMCC | We prefer Option 1, considering there might be different CSI payload associated with single-TRP and NC-JT hypothesis in Option 2. |
| Samsung | Support Option 2. |
| CATT | Support Option 1+Alt. 2/3.  For Alt. 0, if X=0 is configured, does it mean that only the CSI for NC-JT is reported? If so, as ZTE mentioned, this alternative has already been ruled out according to previous agreement. |
| Ericsson | We support Option 1. Our preference is Alt 3. As we already explained in our previous response, X=2 needs to be supported to maximize scheduling flexibility. It should be noted that even if a UE reports an NC-JT CSI, one of the two TRPs associated with the NC-JT CSI may not be available to schedule the UE (i.e., the TRP may be used to schedule other UEs). Hence, it is important to report 2 single TRP hypothesis along with an NC-JT hypothesis.  With option 2, one risk is that the UE may keep reporting single-TRP CSI since the choice of reporting single-TRP CSI vs multi-TRP CSI is up to the UE. Hence, there is no guarantee for the network side to receive an NC-JT CSI from the UE. Hence, we cannot accept Option 2. |
| NTT DOCOMO | First preference: Option 1.  Second preference: both Option 1+ Option 2.  Not support Option 2 only.  For Option 1, support Alt2. |
| MediaTek | Support Option 1.  Our second preference is Options 1+2.  For Option 1, we support Alt. 2. Alt. 1 is also acceptable. |
| vivo | We think there is no need to down select between the two options. In our view, Option1 and Option2 both are useful and suitable to various scenarios. The Network can configure multiple reporting hypotheses to increase the flexibility for scheduler. We prefer Alt.3, i.e., X=0,1,2 to leave the flexibility to the network.  Option 2 can reduce the CSI feedback overhead with good performance.  @Ericsson: if a UE wants to report a single-TRP CSI, at least it will relax the network’s work, won’t it? 😊 Anyway, the network can use a CSI report configured with X=0 in Option 1 to acquire the NCJT CSI if both Options are supported. |

***Proposal 9:*** *For a CSI report associated with a Multi-TRP/panel NCJT measurement hypothesis configured by single CSI reporting setting, the UE can be expected to report:*

* *one RI, one PMI, one LI and one CQI per TRP, up to 2 TRPs, for Multi-DCI based NCJT when the maximal transmission layers is less than or equal to 4.*

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| Huawei (Moderator) | Yes (10): CATT, Futurewei, Docomo, Intel, LG, ZTE, MediaTeck, Spreadtrum, Apple, CMCC  No need (8): Nokia/NSB, QC, Oppo, Lenovo/MotM, NEC, Ericsson  By looking at discussion so far, the main concern from companies prefer not to support is that Cat 2 (which has been agreed as WA) with two reports may support the same functionality in Proposal 9 with inter-TRP interference measurement. On the other hand, companies preferring Proposal 9 may think that the design is more straightforward using single CSI reporting, from the UE perspective.    A general though, from Moderator perspective, could we combine Proposal 9 and following WA discussion so that we can only choose one (either proposal 9 or WA) in Rel-17? Unless the group disagree that we actually need both in Rel-17.  Note that as a part of compromise from last meeting, further details of WA will not be discussed until Cat 1 (like above proposal 6/8) are clarified.  **Working Assumption**  For CSI measurement for multi-DCI based NCJT, down select one of following two options:   * Option 1 (Explicit): CMRs corresponding to different TRPs can be associated with different reporting settings respectively, with the same configurations between two settings except for PUCCH/PUSCH resources and CMR/IMR resources setting(s) * Option 2 (Implicit): a single CSI reporting setting associated with each TRP where a NZP CSI-RS is configured for interference measurement from another TRP * FFS:  how interference from CMR in the linked reporting settings in option 1 or from the NZP CSI-RS configured as IMR in option 2 is considered in CQI calculation   Following restrictions apply to both options:   * At least ‘typeI-SinglePanel’ codebook is supported   + FFS: Other codebook types * Only ‘periodic’ and ‘semiPersistentOnPUCCH’ cases are supported; * The number of ports of two CMRs associated to two reporting settings for NCJT CSI measurement are the same; * The support of larger than 32 ports across two CMRs is optional for a UE supporting Rel. 17 mTRP CSI |
| QC | We agree with Moderator’s assessment that we should only choose one. There is no need for multiple solutions. |
| Lenovo/MotM | We share the same view as moderator/QC, one solution suffices. We prefer explicit configuration (Option 1) |
| CMCC | We have the same option with Moderator, one solution shall be enough. And we prefer Option 1 in the WA. |
| Samsung | We also have same thinking with Moderator. Regarding Working Assumption, we are fine with Option 1. |
| CATT | For FL’s Proposal 9, is the restriction on maximal rank applies to each PDSCH or the two TRPs? In our opinion, because at most one TB per PDSCH can be scheduled in M-DCI case, it does make sense to assume that the maximal transmission layers is less than or equal to 4 per TRP. However, we don’t think it’s necessary to restrict the total number of layers of the two PDSCHs.  So, the following modification to Proposal 9 is suggested:  ***Proposal 9:*** *For a CSI report associated with a Multi-TRP/panel NCJT measurement hypothesis configured by single CSI reporting setting, the UE can be expected to report:*   * *one RI, one PMI, one LI and one CQI per TRP, up to 2 TRPs, for Multi-DCI based NCJT ~~when the maximal transmission layers is less than or equal to 4~~.*   We don’t think downselection between Proposal 9 and WA is needed right now. For the WA, option 1 is preferred. |
| Ericsson | We agree that only one solution is needed. Our preference is not to discuss Proposal 9. We can strive to finalize the NC-JT CSI targeting single-DCI multi-TRP first, and then focus on the solution that we discussed in the working assumption. |
| NTT DOCOMO | If enhancement on multi-DCI based NCJT is to be supported, Proposal 9 is a straightforward solution. Proposal 9 is a discussion proposal under Cat.1, which should be discussed before Cat.2 according to the agreed ‘note’ in last meeting.  We’re fine to postpone the discussion of Proposal 9 under Cat.1, but it should be discussed before Cat.2. |
| MediaTek | We share the same view as Moderator.  We prefer to have Proposal 9 under Cat. 1. |
| vivo | We would like to confirm the work assumption. |