**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 3)**

**Document for: Discussion and Decision**

# Summary of CSI enhancement for FDD

***Proposal 2:*** *For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay, down-select codebook structure W=W1W2 WfH with*

* *Alt 3-0, i.e. W1 ∈ N^{PCSI-RS × K1} (K1 ≤ PCSI-RS ) is a port selection matrix* 
  + *Lenono/MotM, Oppo, Ericsson, Intel, Vivo, Sony*
* *Alt 5, i.e. W1∈ N^{PSD-FD × K2} (K2 ≤ PSD-FD=Of PCSI-RS) is a SD-FD basis selection matrix*
  + *ZTE,*
* *Note that PCSI-RS is the number of CSI-RS ports.*

***Proposal 3:*** *For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay, support one or a combination of following options for CSI-RS configurations associated with Rel-17 PS codebook and to be decided in RAN1 104bis:*

* + *Option 1: Support configuring a lower CSI-RS density per CSI-RS resource, e.g. 0.25*
    - *Nokia/NSB, Apple, Sony*
  + *Option 2:Support configuring one or multiple CSI-RS patterns per CSI-RS resource associated with Rel-17 PS codebook* 
    - *Nokia/NSB*
  + *Option 3:Support configuring multiple CSI-RS resources per CSI reporting configuration associated with Rel-17 PS codebook* 
    - *ZTE, Ericsson, Sony*
  + *Option 4:*
    - *W1∈ N^{PSD-FD × K2} (K2 ≤ PSD-FD=Of PCSI-RS), single CSI-RS resource with single CSI-RS pattern per resource and normal CSI-RS density*
      * *Vivo,Nokia/NSB, Spreadtrum, DOCOMO, ZTE*
    - *W1 ∈ N^{PCSI-RS × K1} (K1 ≤ PCSI-RS )and Wf ∈ C^{N3 × Mv} (PSD-FD=Of PCSI-RS, Mv ≤ Of ), single CSI-RS resource with single CSI-RS pattern per resource and normal CSI-RS density.*

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| Company | Comments |
| Huawei (Moderator) | Some companies have commented that it is preferred to discuss P3 firstly before P2, or vice versa. On the other hand, Alt 3-0 seems to be the majority view.  To provide a better picture, I just put them together, by removing Alt 5 in Proposal 2.  However Lenovo/MotM, Intel and Samsung have concerns about Proposal 3. Therefore, from Moderator perspective, P3 may be needed to be studied firstly.  Please share your view, if we jointly consider both proposals. |
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***Proposal 5:*** *Study following mechanisms, which are to be decided in RAN1 104bis-e:*

* *If configuring/indicating Wf to the UE* 
  + *Option 1: The FD bases used for Wf quantitation is limited within K windows/sets, with size Nk and initial point Minitial,k, which can be fixed/configured/indicated by gNB.*
    - *FFS: candidate values and value ranges for K, Nk, Minitial,k*
    - *FFS: signaling mechanism by MAC-CE or RRC or hybrid*
  + *FFS: The number of CSI-RS ports and the value of Mv is jointly configured per codebook parameter combination*
* *If selecting/reporting Wf to the gNB*
  + *Option 1: UE is not required to report the index of Wf*  *(which is equivalent to UCI reporting with 0 bit), e.g. if some codebook parameters are configured/indicated by the NW*
  + *Option 2: UE is required to report the index of Wf**within a window of size Nk*

*Other enhancements are not excluded.*

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| Huawei (Moderator) | Thanks for the feedback. I intent to make proposal 5 at high level so that we can have more information about how to use Wf here, which may be different from Rel-16 PS. Of cause companies are encouraged to show your understanding in more details. If you prefer to list more options, please suggest.  Note the discussion here is not to intent to exclude solutions but to elaborate concepts to help further evaluation/simulations.  @CATT @Vivo: update accordingly.  @LG: update accordingly  @SS: Understand. Let us have one round comment to see whether you can change minds later. Of cause you have all right saying no, even if it is proposed later.  @QC: OK to keep FFS |
| Apple | We do not see a strong need to make an agreement on this study since it is at very high level anyway.  Furthermore, in Rel-16, we have frequency basis selection design especially when the number of subbands is large. It is mainly because potential large value of C(N3-1, Mv-1). However, in Rel-17, it is not even clear about the condition we should discuss the frequency basis selection   * We have not decided on the value of Mv, some proponent wants Mv =2 which is already much smaller than what Rel-17 allows * We have not decided on the R and N3, in general, the larger N3 and R=2 do not seem to be necessary   Without a clear direction of the subband size and the potential value of Mv, it is hard to make an agreement on the study. But companies can still study, there is just no need to make an agreement on this. |
| Samsung3 | In addition to my earlier comments, we also have concern about his statement “*Other enhancements are not excluded*” Our concern is about the potential scope expansion. So far the scope of FDD CSI keeps expanding (we already expanded the scope by moving away from angle and delay reciprocity based design, by accommodating Wf in the CB design, for weak reciprocity scenarios). Not to mention that we have mTRP CSI, in this to FDD CSI.  Also, based on the replies from companies in the appendix, it is clear that companies have different understanding about these options. This is perhaps due to the lack of time spent on studying this.  Besides, this issue is about signaling of a codebook component (Wf), which we have not designed yet. We are puzzled what is the point of discussing something which we have not designed and agreed on yet. |
| CATT | We havn’t agreed to support gNB indicating Wf or UE reporting Wf for Rel-17 PS codebook. Current formulation of Proposal 5 seems to imply that both of them are supported. We can add ‘(if supported)’ in the two bullets to make it clear that gNB indicating or UE reporting are still undecided.  For the FFS part of the first bullet, as we commented earlier, it is not necessary to be part of this proposal. The codebook parameter combination is further detail and can be discusssed after the mechanism of configuring/indicating Wf is agreed.    On Option 1 of the first bullet, if UE is not required to report, why it is listed as one option under ‘if selecting/reporting to gNB’? This option can be removed.  On Option 2 of the second bullet, the value of Nk is not defined. Is it the same definitiona as that of the first bullet? |
| Lenovo/MotM | The merit of using *K*>1 windows is not justified, or at least the proposal is not clear to us. Initially, our understanding is that the window location (parametrized by *M*initial) approach would be UE indicated to correct misalignments in case of imperfect reciprocity, especially that indicating Minitial by the UE requires very few bits. One window should be enough with a few bits to report window location similar to Rel. 16 CB, no need to unnecessarily complicate the design |
| Qualcomm | We think the discussion go way further and people start to mix CSI-RS channel estimation, CSI calculation and PMI reporting. In our view, UE is only provided with a CSI-RS pattern, and a PMI codebook. Only these two issues can be discussed in the air-interface level, what left in the middle, including how to perform channel estimation and how to calculate PMI, are UE implementation. We should not touch it.  Going back to the topic of this proposal, we think it is just a component in PMI codebook. It has nothing to do with channel estimation and PMI calculation. Even though network configure Wf being 1 and 2, it does not mean UE only needs to measure these two taps in channel estimation, and also does not mean UE only needs to calculate CSI on these two taps.   * For channel estimation, UE tries best effort to estimate all taps on each port, so as to support better CSI calculation including PMI RI and CQI. * For CSI calculation, UE tries best to optimize its CSI algos. Even with timing misalignment, there are many ways to solve it in implementation. One way is to find the best tap(s) to calculate the PMI. Specifically, UE may find the best taps being FD bases 3 and 4 in PMI calculation, but can associate the PMI calculation results with FD bases 1 and 2 in the reporting – there is no difference in reported PMI and CQI, as FD bases 3/4 are just cyclic shift to FD bases 1/2. Another way is to follow similar algo of Rel-16 CB, UE may calculate subband SVD, and find the best FD bases for compression. These best FD bases could be FD bases 3 and 4, but UE can associate PMI calculation results with FD bases 1 and 2 in the reporting.   So, from these perspectives, we don’t see the need of Mini (or it should be fixed to zero). The only reason that R16 CB needs Mini is that UE needs to keep the strongest coefficient in the PMI (please note that it is PMI, not the channel) at FD bases zero.  Regarding multiplexing multiple UEs on the same CSI-RS resource but in delay domain, we think it is related to CSI-RS design with a new cover code. Without clarifying in CSI-RS pattern, UE will consider all the taps in the delay domain are associated to its own channel rather than as stated by Nokia. Wf and Mini do not achieve the goal, as it is just a component in the PMI codebook and not related to specific CSI algo. So, we suggest it to be discussed in options of P3. |
| Fraunhofer IIS,  Fraunhofer HHI | We think that the specific design depends on the agreed value(s) of which have not yet been agreed. If the agreed value(s) of are rather small, the specific design can be very simple at the end. We prefer to decide at first if the gNB indicates , or the UE reports . The detailed design can be either FFS or to be discussed at a later stage. If the FL decides to list possible options, we would like to add Option 2 below the first main bullet which can be considered as a variant of Option 1.  *Option 2:* *The FD bases used for Wf quantitation are limited within a single window with size N and initial point Minitial, which can be fixed/configured/indicated by gNB. FFS: value(s) of N and Minit* |
| NTT DOCOMO | As pointed out by Lenovo/MotM, we are also not clear about the requirement of having *K*>1windows/sets. It is appreciated if a proper justification can be provided.  Regarding the two (broad) options proposed for identifying which are, 1) indicated by gNB, and 2) reported by UE, we think that there should be sufficient flexibility at the UE side to select and report . We do acknowledge that the indication of by gNB can reduce CSI reporting overhead. However, this comes with the underlying assumption that the gNB is accurately estimating delay(s) associated with a particular DL port considering UL RS transmission. This is not always true especially given the fact that the effective antenna-spacing is different in two bands for FDD. Hence, we prefer to let UE to select *Mv* FD bases either freely or from a preconfigured window of size *N* |
| ZTE | Share similar view as Qualcomm. The timing misalignment between UE and gNB can be solved by UE implementation.   * We are not sure about the need of M\_initial. * We don’t see the need of multiple windows either.   But we are open to further discuss these issues.  Another question for the current FL proposal:  For the UE reporting part, the two options are not clear to us.   * + *Option 1: UE is not required to report the index of Wf*  *(which is equivalent to UCI reporting with 0 bit), e.g. if some codebook parameters are configured/indicated by the NW*   + *Option 2: UE is required to report the index of Wf**within a window of size Nk*   We have (almost) agreed in proposal 1 that gNB can turn off Wf. In this case, there should not be any reporting for Wf, which is Option 1. If Wf is to be reported by UE, and gNB does not turn it off, UE should report the index of Wf. Hence we are not sure about the point of discussing Option 1 and Option 2. The discussion point should be whether UE reporting is supported or not. |
| OPPO | The use case of multiple windows is unclear to us now. With delay reciprocity we don’t see channel will be more spread. At least single window size 2M as in Rel-16 is enough.  Agree with Qualcomm that Wf in Rel-16 reflects relative delays, but to support UE measurement in option 2 an absolute delay window indication may be needed. We are open for further discussion. |
| Spreadtrum | We don’t have strong concern on each options since they’re high level. But we are not sure what we should decide in next meeting. Are we going to decide whether supporting configuring/indicating Wf to the UE and/or selecting/reporting Wf to the gNB? Are we going to further down select between different options?  Regarding the FFS on ‘The number of CSI-RS ports and the value of Mv is jointly configured per codebook parameter combination’, since it’s not an option comparing with the parallel bullet, it seems not related to this proposal and should be removed. |
| Intel | We have concerns on opening this high-level discussion by agreeing to the proposal. In our view the options presented in the proposal are too broad and such agreement is not useful at all.  In our understanding it is clear for all the interested companies that there are three main approaches how to deal with Wf.   * Wf fixed in the specification * Wf indicated by the gNB * Wf selected by the UE   There are a variety of combinations and detailed design for the above approaches and our work in RAN1 is to select the best one for scenario with FDD reciprocity (simulation assumptions are already agreed). So, proponents of particular solution can directly propose it in the next RAN1 meeting without any high-level agreement now.  In our view codebook design with Mv = 1 is already very good option, it is challenging to outperform it in the simulations. For Mv > 1 we may consider two corner cases: Wf fixed in specification and Wf indicated by the gNB. |
| LG | We think this proposal can provide discussion point for the next meeting. Actually, high level description for this proposal has already been captured in the agreement as follows, so more details can help further discussion.  o   *FFS candidate value(s)  of R, mechanism for configuring/indicating to the UE and/or mechanism for selecting/reporting by UE for* ***Wf***  However, regarding multiple windows/sets, we think single window/set will be enough for a UE. If multiple windows/sets are for supporting multiplexing multiple UEs, then supporting of multiple windows/sets should be discussed separately from this proposal. |
| Nokia/NSB | We support the FL’s proposal to provide sufficiently high-level description to identify more precise alternatives at the next meeting.  Some comments below in response to questions from other companies and suggestions that may help clarify the wording further  Regarding gNB’s configuration/indication of   * We also don’t see the need to configure multiple windows, so . In our view, configuring a single window per UE is sufficient, whereas configuring multiple windows per port increases indication overhead in the PDCCH and makes UE’s complexity similar to that of Rel-16 PS. However, we are not against keeping it there for study, as we are not downselecting yet. * Regarding , to simplify things, this would be applicable, in our view, only for a single window per UE. The reason for considering in this study is the possibility for the NW to configure two UEs in the same port on two windows well separated in the delay domain. For example, if R=4, the delay domain is 4 times wider than for R=1, and two UEs may be configured, for example, with , respectively, if the two channels are well separated in the delay domain.   @QC: this operation is part of the FD precoding, which applies different weights for different PMI subbands and is separate from the cover code in CSI-RS design which applies different coefficient per RB, regardless of the PMI subband size.  Regarding UE’s selection/reporting of   * We think the understanding of the two options is clear, as explained by Ericsson, for example. Maybe the wording can be improved. In our view Option 1 is for what Alt 0 is for , i.e., the UE selects all the FD components configured by the NW without explicit reporting of the components. A possible rewording may be along these lines   + *Option 1: UE selects all FD components configured/indicated by the NW without reporting them*   + *Option 2: UE selects and reports the index of components within a window of size*   @ZTE: “*If Wf is to be reported by UE, and gNB does not turn it off, UE should report the index of Wf.*” As elaborated above, if is configured, option 1 means that the UE selects all components and does not need to report their indices explicitly. |

# 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 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.3: Configure UE with two CMR groups with Ks = K1+K2 CMRs, whereas each CMR group corresponds to one out of two TRPs. CMR pairs are determined from two CMR groups by following method(s).* 
  + *K1 and K2 are the number of CMRs in two groups respectively. FFS K1=K2 or different K1/K2.*
  + *Note that the first M1 (or M2) CMRs in each CMR group can be used for both NCJT and Single-TRP measurement hypotheses, the remaining CMRs are only used for single-TRP measurement hypotheses*
  + *FFS. Option 1: N NZP CSI-RS resource within a group can be one-to-one mapping with the N NZP CSI-RS resource in the other group*
    - *N= M1=M2, signalling mechanism can be discussed further*
  + *FFS Option 1.5: N CMR pairs are RRC configured and/or indicated (by MAC-CE) by selecting from all possible pairs*
    - *signalling mechanism can be discussed further, e.g. using a bitmap*
  + *FFS Option 2: UE freely select CMR pairs from two groups (without one-to-one mapping)* 
    - *N= M1M2*
  + *Starting from M1=M2=1*
  + *Further down-selection and/or consolidation above options will be done in RAN1 104bis*
* *Support N=1 and Ks =2, FFS other maximal values of N>1 and Ks*>2

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| Huawei (Moderator) | Alt 1: QC (1st), ZTE, Intel (1st), Samsung  Alt 3: Vivo, CATT, Oppo, NEC, Intel(2nd), MediaTek, LG, Lenovo/MoM, CMCC, Samsung, Ericsson (2nd), Futurewei (2nd), Fraunhofer IIS/Fraunhofer HHI, Nokia (2nd), CMCC (option 2)  Either Alt 1 or Alt 3: Apple, Docomo  @QC @ZTE: From Feature lead perspective, companies are converging to Alt3 and they are willing to leave difference of signaling later. It is just a matter that how signaling is designed to form N pairs from groups in the same set. Option 1 and 2 can be two ends of option 1.5, in my view, e.g. TRP1 {1, 2}, TRP {3,4} can form {1,2}{1,3}{2,3}{2,4} so that RRC can select {1,3}{2,4} as Option 1, or 4 pairs if N=4 and M=2, as Option 2.  Of cause if companies may have different understanding or minor variations of signaling design, it is always possible to be clarified, justified and unified thereafter.  @DC: Let us keep existing wording. Actually current wording in Alt 3 seems to include Alt 1 already except that we have re-arranged/saved some CSI-RS resource ID with implicit two groups, in a different manner.  @Intel @Ericsson: let us start from simple examples, with small candidate values at first, as red part.  FL recommendation is to agree with Alt 3.  However RAN1 will discuss further until Tuesday GTW:   * Whether there is any issue to support FR2 from Alt3 by comparing to Alt 1 * Whether/how to support more than 2 TRPs? * Design pros/cons in terms of singling overhead |
| QC | Note sure why we need to agree with Alt3 before it is clarified wrt basic questions asked before. At the very least, the change suggested by Docomo (no mandating to use NCJT CMR pairs for sTRP hypotheses) and vivo (extend it to G groups rather than 2 groups) are needed to adress the FR2 issue and FR1 issue (more than 2 TRPs), respectively.  In our view, Alt1 adresses all the issues above, is simple/clean, and has minimal specification impact. |
| Nokia/NSB | We support the FL’s proposal and have a preference for Alt 3 – Option 1.5  @Moderator, all: we suggest adding the corresponding definition of , for Option 1.5 as follows   * + ***FFS Option 1.5: N CMR pairs are RRC configured and/or indicated (by MAC-CE) by selecting from all possible pairs***     - ***, signalling mechanism can be discussed further, e.g. using a bitmap***   Note that, in Alt 1 the total number of CPU calculations, , for sTRP and NCJT is assumed to be , so under the combination , , no sTRP measurement can be configured.  Similar assumptions can be made with Alt 3, by fixing with respect to . For example, for Option 1.5, we can fix , such that is the number of sTRP measurements (FFS: if the same definition applies in FR2 and FR1)  @ QC: regarding your question “*Is it correct to say that if M>0, we always reuse the first M CMRs for both NCJT and sTRP hypotheses?*”. The answer is no, at least for Option 1.5, because the NW may configure different CMR resources for NCJT than those used for sTRP measurement. The case with only NCJT can be supported in Alt 3, at least for Option 1.5 without need for X=0 in P8. In fact, if is the UE’s CPU capability, then is the number of sTRP measurements the UE can calculate. So, if , the NW can configure only NCJT measurement, without need for X=0 in P8.  @ QC, @Intel: Regarding the support of more than 2 TRPs in the cluster, Alt 3 does not imply any TRP association to the CMR groups. These groups are only for pairing purpose, so a NW can associate CMRs from more than 2 TRPs in each of the two groups.  @QC: regarding RRC configuration overhead, in Alt 3, at least for Option 1.5, the CMR grouping can be assumed fixed, so the only overhead compared to a Rel-16 CSI Reporting Setting is the CMR pairing, which only needs bits for the possible pairs.  @QC: regarding the NW signalling mechanism via MAC-CE to indicate the CMR pairs for NCJT, this is not mandated in Alt 3 - Option 1.5, as it is assumed there is a default configuration for NCJT pairs in the Reporting Setting. However, whilst Alt 3 – Option 1.5 allows for the NW to dynamically override the configuration with -bit indication, Alt 1 does not have this flexibility and a change of NCJT pairs would require an RRC reconfiguration. |

***Proposal 8:*** *For a CSI report associated with a Multi-TRP/panel NCJT measurement hypothesis configured by single CSI reporting setting, support 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. 3: X = 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*

***Proposal 8’:*** *For a CSI report associated with a Multi-TRP/panel NCJT measurement hypothesis configured by single CSI reporting setting, support following option:*

* *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. 1: X = 1*
  + *FFS omission of CSI associated with NCJT measurement hypothesis*

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| Huawei (Moderator) | Option 1 only (12): QC (1st), Lenono/MotM (X=0/1/2), CMCC, CATT, Ericsson, DOCOMO (1st), MediaTek (1st), Futurewei, Intel, Nokia/NSB  Option 2 only (7): ZTE, Samsung, Oppo, LG (1st), Spreadtrum (1st) , Fraunhofer IIS  Fraunhofer HHI  Options 1+2: Vivo, QC (2nd) , DOCOMO (2nd) , MediaTek (2nd) , LG (2nd), Spreadtrum (2nd), Oppo (X=1 only), ZTE (X=1 only)   * There are a few companies, e.g. QC, Oppo, ZTE, raising concerns that even if we can compromise to Options 1+2, we shall simplify specification, i.e. single value of X * Also ZTE raised a question whether X=0 is needed due to the discussion of Proposal 6 by which at least one CSI reporting based on single-TRP measurement hypothesis is reported. * A few companies, e.g. Ericsson, has some strong concern over Option 2, which is insufficient to gNB.   FL recommendation is to either   * Compromised Proposal 8: Support Option 1 (with X=1 and 2) and Option 2, by removing X=0, with the maximal flexibility but also with a higher spec cost. Option 2 can be considered as a subset of Option 1. The UE will determine one of two hypotheses (if following option 2), or report both (if following option 1) whereas NW will determine X=1 or 2 by RRC configuration for required reports. It is a kind of middle point so that each company may step ahead one feet. * Compromised Proposal 8’: Support Option 1 (with X=1 only) to simplify specification changes. It seems to be another kind of middle point so that each company may have to step back one feet.   If we cannot reach a consensus for Proposal 8, likely I would suggest Propose 8’ for Tuesday GTW, at least it looks simpler, spec wise. Any comments are welcome. |
| QC | We support Proposal 8’. Another proposal, which may be worth trying is in between proposal 8 and 8’, which is Alt1 of Option1 + Option 2, which may have higher chance. |
| Nokia/NSB | We support proposal 8 |

***Conclusion:***

* Strive to mitigate the spec impact by discussing following options
  + Option 1: 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
  + Option 2: The design was agreed by Working Assumption in RAN1 103e.
* The time of decision is RAN1 106e (August 2021)

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| Huawei (Moderator) | Option 1: WA (if confirmed) is sufficient in Rel-17 so that new solution is not needed.  [QC], Lenono/MotM, CMCC, Samsung, Ericsson, Vivo, Nokia, CATT  Option 2: a new solution, as above, is needed in Rel-17.  DOCOMO, MediaTek, LG, Intel, Spreadtrum,  I don’t see there is strong chance to agree with Proposal 9 or confirm WA this meeting. But since Proposal 9 has been proposed by more than 4 companies this time and WA is to address similar issue, at least we can conclude to mitigate concerns of time line and high level scope.  Here I don’t talk about priority here but just be clear that they will be discussed in RAN1 106e, assuming that basic design are stable enough. |
| QC | Support the conclusion with the following suggestion:  ***Conclusion:***   * Strive to mitigate the spec impact by ~~discussing~~ supporting at most one of the following options   + Option 1: 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   + Option 2: The design was agreed by Working Assumption in RAN1 103e. * The time of decision is RAN1 106e (August 2021) |
| Nokia/NSB | Support the FL’s conclusion and QC’s revision. |

**Appendix**

# 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.* |
| Samsung | Not support  We are not sure why we are discussing this proposal due to the following reason:   1. We have the following in the proposal (on basic CB structure) we are currently discussing on the RAN1 reflector. That proposal has not been agreed yet. Then why we are discussing it (an FFS from another agreement yet to be agreed) here.    * *FFS other candidate values of R, mechanism of Configured/indicated to the UE and/or mechanism of selected/reported by UE for Wf* 2. If the proposal on the reflector is agreed, then we are agreeing to the above FFS. The FFS means that companies will study the issue and come back to the issue and discuss (based on their study) next meeting. So, from the procedural perspective, we should not be discussing this proposal.   So, in short, we don’t need to discuss this issue in this meeting. |
| Qualcomm | We are not sure what’s the difference between option 1 and option 2? I have 3 different understandings:   * Is Wf in option 1 is configured/indicated by gNB and no need UE reporting, while option 2 means UE needs to report Wf within the size N window? * Wf in option 1 is not a window, while Wf in option 2 is a window. Whether UE report Mv bases within the configured Wf is FFS? * Or are they just different by signaling? Option 1 is MACCE/DCI, option 2 is RRC?   @vivo, would you explain what does K stands for? And why you need K windows?  @FL, we prefer the removed option 3 to be an FFS point of proposal 5. |
| LG | We are generally fine with CATT’s version of proposal with the following modification.  If my understanding is correct, it seems that option 1 assumes indication/configuration of FD bases used for Wf and a UE does not need to report information related to selected FD bases. RRC/MAC CE based configuration can be considered for further discussion in this stage. So, we would like to modify option 1 as follows.   * *Option 1: gNB can configure/indicate FD bases used for Wf quantization ~~via dynamic signaling~~* |
| vivo2 | @QC: your understanding in the second sub-bullet on Option 1 and 2 is same as ours. In our opinion, the difference between option 1 and option 2 is whether UE needs to select Mv DFT vectors from the candidate DFT vectors indicated by gNB. Option 1 means all (Mv) DFT vectors are selected to report, while Option 2 needs UE selection.  We think Wf plays two roles: One is to increase precision when reciprocity doesn’t hold perfectly as mentioned by Fraunhofer and timing misalignment, and the other one is to decrease CSI-RS ports consumption by moving partial FD information to the FD indication. gNB can indicate exact K=Mv delay offsets corresponding to the CSI-RS port for UE to report in Option 1, which is analogous to K times of CSI-RS ports with Mv = 1. In Option 2, gNB can indicate K≥Mv windows for UE to select Mv FD bases to provide more accurate FD bases selection when the network is not sure whether the delay reciprocity holds or not. That is, K windows can be indicated and UE can select from a union of K windows. Of course, the value of K is FFS.  We think Option 1 is a special case of Option 2 with K=Mv and Nk=1. Therefore, we recommend a merged proposal of the two options. |
| Nokia/NSB | We support this proposal but prefer to remove the brackets as in the previous formulation  ***Proposal 5:*** *Study following mechanisms of gNB configured/indicated to the UE for Wf , which are to be decided in RAN1 104bis-e:*  The reason is the window concept with is an interesting option to study also in the case with , as a mechanism for the NW to share CSI-RS ports between 2 or more UEs without added UE complexity. For example, with R=2, the network may configure one UE with , and a second UE with . With R=4, up to 4 UEs may share the same ports in this way.  The wording of the options can be improved depending on whether we want to provide design options at high level or list more specific alternatives for down selection at the next meeting. We are fine either way.  In our understanding, at high level we can distinguish between:   1. The NW configures/indicates FD components and UE does not report . The components can be:    1. Consecutive starting from 0    2. Consecutive starting from    3. Any set with dynamic indication 2. UE reports within a window of parameters configured/indicated by the network   In cases a2 and b, vivo’s proposal is to consider such windows. In the current formulation of proposal 5, Option 1 covers case a3, Option 2 covers all the others. |
| Sony | We support the proposal.  Further, option 1 and option 2 need not be mutually exclusive. In our understanding, option 2 serves a purpose when , e.g., because a relatively small number of CSI-RS ports have been configured. This might be the case when (i) the UE enters NLOS (or the LOS is partially blocked), in which case reciprocity ebbs out; (ii) a few UEs are being served simultaneously and therefore the number of available UE-specific CSI-RS ports is limited. In these situations, is desired. To keep CSI feedback overhead to reasonable levels, UE selection of beams is restricted to a certain window, according to option 2, based on the delay reciprocity gained from UL.  Option 1, can then be used to adapt this window depending on changing propagation conditions and/or load offered by the UEs. |

# 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) | Thanks all for valuable input. After reviewing all preference, it seems to be quite clear that the most popular ones are Alt 1 and Alt 3. So Let us more discussion between Alt 1 and Alt 3 firstly.  My general plan is to strive to make a decision between Alt 1 and Alt3, until next GTW session (Tuesday).  Based on explanation from Nokia and other companies, I have updated some text for Alt 3 which seems to have more details now. I reformat Nokia’s preference as Option 1.5 (^-^) for which I, personally, think that it is something between option 1 and 2 and can be interesting. If any text polish is required, please be free to comment.  Alt 1: QC (1st), ZTE, Docomo, Intel, CMCC, Samsung  Alt 2: Nokia, QC (2nd)  Alt 3: Vivo, CATT, Oppo, NEC, Intel, Docomo, MediaTek, LG, Lenovo/MoM, CMCC, Samsung, Ericsson (2nd), Futurewei (2nd), Fraunhofer IIS/Fraunhofer HHI, Nokia (2nd)  Alt 4: Futurewei (1st)  Alt 5: Ericsson (1st) |
| Apple | We are fine with either alternative 1 or 3 |
| Lenovo/MotM | Support Alt3 |
| QC | We are fine with the direction of FL proposal to focus on Alt 1 and Alt3.  It seems that Alt3 still does not provide the flexibility that for some of the CMR pairs, they are not also used for sTRP hypotheses. Is it correct to say that if M>0, we always reuse the first M CMRs for both NCJT and sTRP hypotheses?  If yes, then it is not clear how Case 3 in Nokia’s examples in the previous round can be supported with this unless if we consider this together with X=0 of Proposal 8. As mentioned before, Alt1 allows for this (only NCJT hypotheses) w/o requiring additional reporting configuration enhancements (i.e., w/o requiring configuring X=0 in Proposal 8).  With respect to reusing sTRP CMR for NCJT hypotheses in FR2: This depends on multi-panel implementation. Here is one example for illustration (whether this implementation will be used in practice is a different story): When receiving CMR0 that is configured for sTRP hypothesis, UE may select to use both panels simultaneously to receive the same Tx beam (using two Rx beams or one effective Rx beam). However, if this CMR0 is also used together with CMR1 for NCJT hypothesis, UE has to use panel 0 to receive CMR0 and panel 1 to receive CMR1. In this case, the Rx beam on panel 0 cannot be optimized for the one effective Rx beam in the former case, which may be slightly different than this case that only panel 0 is used to receive CMR0. There could be other examples depending on specific multi-panel implementation.  In addition, Alt3 in its current format assumes 2 TRPs. It is not clear where this is coming from. Single-DCI based mTRP is not designed for only 2 TRPs in the cluster. For example, when MAC-CE maps each of the 8 TCI codepoints to one or two TCI states, there is no grouping of TCI states. Alt3 cannot support FR1 use case where {TRP1,TRP2}, {TRP2,TRP3}, and {TRP1,TRP3} are 3 different NCJT hypotheses while Alt1 can support this.  With respect to overhead of Alt1 when sTRP CMRs are reused for NCJT hypotheses, we would like to point out that this is only about configuring the same CSI-RS resource ID two times in the resource set. This is not about actual CSI-RS overhead. Furthermore, depending on the signaling details of Alt3, the RRC overhead of Alt3 can be even larger and more complicated than Alt1 (e.g. bitmap, configurations related to grouping the resources into two groups, etc.).  One last point: When it comes to down-selection, we think i) signaling mechanisms of Option 1 and Option 1.5 should be first clarified ii) down-selection should not be based on Alt1 and Alt3, but should be based on {Alt1, Alt3-Option1, Alt3-Option1.5, Alt3-Option2}. This is because Alt1 is already clear, but Alt3 have different variants and some FFS for signaling aspects. |
| OPPO | Support to further discuss between Alt.1 and Alt.3. |
| ZTE | We are fine to focus on Alt 1 and Alt 3.  However, in the next round discussion, the following issues should be clarified.   * CPU occupation for CSI calcaultion. For Atl. 1, the number of CPUs O is the same as Rel-15/16 where O is equal to the number of CMRs Ks within the set. For NCJT, one pair CMR needs two CPUs. However, what is the number of O for Alt 3? * The down-selection should be based on {Alt1, Alt3-Option1, Alt3-Option1.5, Alt3-Option2} as QC mentioned. All the signaling details should be clear for each sub-options of Alt 3.   As QC mentioned in FR2, for STRP, UE can use the same two receiving beams on two panels. However, for NCJT, UE will use different receive beams. If one CMR can be configured for both STRP and MTRP, UE can only use single panel for STRP. The CSI estimation accuracy will be impacted for STRP. |
| CATT | In FR2, if we assume that a CMR for sTRP hypothesis is receive with two panels jointly while single panel is assumed in receiving the same CMR for mTRP hypothesis, different measurements will be obtained in the two cases. In such sense, one may argue that a resource for sTRP measurement cannot be used for mTRP hypothesis.  Even in Alt.1, if the same resource is configured for both sTRP and mTRP hypotheses, the same issue as illustrated above exists in both Alt.1 and 3.  Furthermore, to address the concerns to Alt 3 from some companies, one solution could be to configure a subset of resources for sTRP hypothesis only. |
| NEC | We are fine with the proposal, and support Alt 3. |
| DOCOMO | Fine to further discuss Alt.1 and Alt.3.  In Alt.3, we suggest following revision for the ‘Note’ since we have not fully discussed it.   * + *Note that the first M CMRs in each CMR group can be used for ~~both~~ NCJT ~~and Single-TRP~~ measurement hypotheses, the remaining CMRs are only used for single-TRP measurement hypotheses.*     - *FFS whether the first M CMRs in each CMR group can be also used for single-TRP measurement hypotheses.*   With above revision, we think Alt1 and Alt3-Option1 can achieve the similar configuration results. The only differences are signalling format and grouping in Alt3 to distinguish the CMR from each TRP for single-TRP measurement hypotheses. |
| Intel | At this stage it seems for us that it is hard to understand pros and cons for Alt 1 and Alt 3. The alternatives are very flexible and support a variety of use cases.  Our first preference is Alt. 1 for the following reasons   * Alt 1 support >2 TRP in coordination for the CSI   + It is explicitly stated that 2 TRP are supported for Alt 3 in the proposal * Alt 1 is clean and clear without multiple options and FFS   For Alt 3 there are more supporters but it is more fragmented (i.e. multiple options), it requires more RAN1 efforts and discussions comparing to Alt 1. |
| LG | We are fine with FL’s suggestion, and support Alt3.  Regarding Alt3, if my understanding is correct, the main motivation of Alt3 is to support CMR grouping in the same resource set, and it seems that majority wants to support it. We think options for signalling mechanism can be discussed further if we decide to support Alt3. And different options can also be supported together (e.g., Option 1 + Option 1.5, etc) instead of selecting only one option according to discussion.  And to support only NCJT hypotheses in Alt3, disabling/enabling CMR(s) for STRP hypothesis can be considered together with disabling/enabling CMR pair(s) for NCJT hypothesis(i.e., Option 1.5). |
| CMCC | We are fine with this proposal.  And we prefer Alt 3-Option2, which has more flexibility than other Options. Furthermore, if the number of CMRs in each CMR group is limited to a low value, like 4, the overhead of CRI is also acceptable. |

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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)* |
| OPPO | We support Alt 3.  Considering the beam group reporting enhancement being discussed in 8.1.2.3, we think Alt 3 can work also for FR2. Also, enhancement for IMR can also be considered for Alt.3 for FR 2. |
| Futurewei | Our first preference is Alt. 4, but we can also accept Alt. 3. |
| Intel | We are fine with the list of the alternatives.  One point which we should discuss in order to do downselection, as we mentioned previously, is the use cases and scenarios considered for this feature. We identified at least the following scenarios.   * Ks = 2   + 2 TRP in coordination in FR1 with 1 CMR per TRP   + 2 TRP in coordination in FR2 with 1 CMR per TRP     - Downselection of beams is done using beam management (L1-RSRP or L1-SINR) * Ks > 2   + >2 TRP in coordination in FR1 with 1 CMR per TRP   + 2 TRP in coordination in FR1 with >1 CMRs per TRP (e.g. sectorization)   + 2 TRP in coordination in FR2 with >1 CMRs per TRP (multiple beams)   As we already commented some alternatives are optimized for particular cases with Ks > 2, so in our understanding we may have further discussion on the use cases and scenarios or specify the most flexible alternatives (which is Alt. 1 in our understanding). |
| LG | We are generally fine with FL’s proposal and support Alt3.  I cannot fully understand the reason why Alt 3 cannot work for FR2. For example, if we assume two CMRs with different QCL-TypeD reference RSs, e.g., CMR0 with TRS#1, CMR1 with TRS#2 and {CMR0,CMR1} can be used for NCJT measurement hypothesis, then CMR0 with TRS#1 can also be used for single-TRP measurement hypothesis. It seems that the problematic case is that the same CMR is used for multiple NCJT measurement hypotheses with different CMRs such as {CMR0 with TRS#1,CMR1 with TRS#2}, {CMR0 with TRS#1,CMR2 with TRS#3}. This situation can be avoided, e.g., by one-to-one mapping between CMRs in different CMR groups, so we think Alt3 can work for FR2. |
| Fraunhofer IIS  Fraunhofer HHI | Support the FL proposal and ALT3. |
| Nokia/NSB | @vivo: in our understanding in Alt 3 description, the fact that a UE is configured “with 2 CMR groups wherein each CMR group corresponds to one out of two TRPs” does not necessarily imply that there is explicit TRP association to the group. TRP association to CMR or CMR groups is a separate issue than CMR pairing discussed in this Proposal and is only relevant in the case of a configuration where 2 STRP CSIs are reported. So, we suggest considering this aspect after we downselected in P8.  In our view, after some useful clarification, Alt 2 can be considered a special case of Alt 3 where some issues are still left open, such as a mechanism for the network to restrict/control the STRP measurements and/or the NCJT pairs based on UE’s CPU capability and other scheduling conditions and that is flexible enough to allow for the same or different CMRs to be measured in STRP and NCJT hypotheses. The solution provided by Alt 2 is along the lines of vivo’s added text.  @Moderator. We provide here a rewording of Alt 2 to clarify this aspect. Please feel free to combined it with Alt 3 as ‘Option 3’. Our preference is Alt 2-Alt 3   * *Alt.2: 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 determined from two CMR groups*    + *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.*   * + *K1 and K2 are the number of CMRs in two groups respectively. FFS K1=K2 or different K1/K2.*   In our understanding, the main difference between Alt 1 and Alt 2 is that in Alt 2 the CMR pairs for NCJT measurement are not listed in the resource set, but they are configured/indicated by the NW by pointing to CMRs resources in the set. So, there is no need, for example, to duplicate resources in the resource set list if the same resource is used for both STRP and NCJT measurement. In other words, with Alt 2 the CMR resource set has two groups of resources with each group corresponding to one of the two TRPs, like in Alt 3.  A default bitmap can be configured in the report setting, but it can be overridden by MAC-CE indication, so the network can adjust the NCJT pairs more dynamically without an RRC reconfiguration and by taking UE CPU capability in to account.  Maybe an example can help clarify. Say a UE is capable of 4 simultaneous CSI calculations and the network configures a CMR resource set with 4 CMR resources for S-TRP measurements: one group, CMR 0,2 for TRP 0 and one group, CMR 1,3 for TRP 1. So, the CMR resource set is: {CMR 0, CMR 1, CMR 2, CMR 3}. The natural ordering of CMR pairs for NCJT is fixed, for example, as follows: (0,1), (0,3), (2,1), (2,3), so if the network wants to configure the pair (0,1) for NCJT measurement, the 4-bit bitmap is [1 0 0 0].  Case 1) The network triggers a report with both STRP and NCJT measurements and no additional bitmap indication. Then, CMR 0 and 1 will be measured for both S-TRP and NCJT hypotheses.  Case 2) The network triggers a report with both STRP and NCJT measurements and with bitmap indication [0 0 0 1]. Then, CMR 0 and 1 will be measured for STRP and the pair (2,3) for NCJT  Case 3) The network triggers a report with only NCJT measurements and indicates the bitmap [0 1 0 1]. Then, the two pairs (0,3) and (2,3) will be measured for NCJT.  Case 4) The network triggers a report without NCJT measurements and indicates the bitmap [0 0 0 0]. Then, CMR 0,1,2,3 will be measured for STRP only  …  In comparison, in this example, with Alt 1, the CMR resource IDs in the configured set are: {CMR 0, CMR1, CMR 0, CMR 1}, with the last N=1 CMR pair intended for NCJT measurement. This configuration is redundant and can only be used to trigger Case 1) report above. |

***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. |
| OPPO | Support Option 2.  For Option 1, the flexibility of X=2 can be achieved via current CSI reporting. |
| Futurewei | Support Option 1. For Option 1, we prefer Alt. 3. |
| Intel | Support Option 1. In our evaluation results it was shown that performance gain can be achieved for option 1.  To address comment from OPPO, option 1 cannot be fully achieved with current CSI reporting since there is no NCJT CSI currently. If we agree on Option 2 and configure CSI report for STRP separately there will be redundancy in CSI reporting and also increased complexity at the UE since CSI reports are handled separately. |
| LG | The first preference is Option 2, and the second preference is Option 1 with Alt2 + Option 2.  Regarding X=0, it is included in the previous agreement as follows.   * 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 |
| Spreadtrum | First preference is option 2;  Second preference is option 1+ option 2 |
| Fraunhofer IIS  Fraunhofer HHI | Support the FL proposal and option 2. |
| Nokia/NSB | We support Option 1 with preference for Alt 3 for similar reasons of network scheduling flexibility already mentioned by Ericsson |

***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. |
| OPPO | Generally we think both proposal 9 and the WA can be achieved via legacy CSI reports. We don’t need either one. For option 1 in WA, it can be easily implemented by gNB via current CSI report mechanism. As suggested by Ericsson, currently we should strive to finalize the NC-JT CSI targeting single-DCI multi-TRP first, and this discussion should have low priority. |
| Futurewei | We share the same view as moderator that only one solution should be chosen. |
| Intel | In our view suggestion from the Moderator to combine the discussion on WA and proposal 9 may be good way to go. If we would do downselection among WA and proposal 9 at this stage, our preference is to support proposal 9 since it requires less RAN1 effort since all other details does not require separate discussion (i.e. the same design as for singl-DCI NCJT CSI can be used). |
| LG | We are fine with FL’s suggestion, and prefer to support Proposal 9. |
| Spreadturm | We prefer proposal 9. One unified framework for S-DCI and M-DCI is preferred. |
| Nokia/NSB | We agree with the Moderator’s assessment, we only need one solution in Cat 2, and the choice should be clear after we finalise the single reporting setting case. Our preference is to defer discussion of P9 after discussing the WA for Cat 2 |