**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****where*

* ***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 is supported*
    - *Decide on the value of Mv, e.g. Mv=2,  in RAN1# 104bis-e*
  + *Working assumption:  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 for configuring/indicating to the UE and/or mechanism for selecting/reporting 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 UPT 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) |
| Apple | We are fine with this FL proposal |
| Samsung | OK, with two additional clarifications in blue  **Possible Agreement**  *For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay, support codebook structure* ***W=W1W2 WfH****where ~~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 is supported*     - *Decide on the ~~value~~ value(s) of Mv, e.g. Mv=2,  in RAN1# 104bis-e*   + *Working assumption:  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~~ value(s) of R, mechanism for configuring/indicating ~~of Configured/indicated~~ to the UE and/or mechanism for selecting/reporting ~~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~~ UPT gain* |

***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. |

# 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 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 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. 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*
    - *N=M, 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=M^2*
* *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 |

***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*
    - *Yes:*
    - *No: QC*
  + *Alt. 1: X = 1*
    - *Yes: QC, MediaTek*
    - *No:*
  + *Alt. 2: X=0, 1*
    - *Yes:CATT, DOCOMO, MediaTek*
    - *No:*
  + *Alt. 3: X = 0, 1, 2*
    - *Yes: CATT, Ericsson, Futurewei*
    - *No:QC*
  + *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) | Option 1 only (12): QC (1st), Lenono/MotM, 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)  Based on above review, from Moderator perspective, 7 companies plus Vivo have very strong preference over Option 2 only. So it is hardly to see a majority view.  Therefore, I would recommend to support both. However if the group disagree the assessment, we will continue discussing until next GTW session (Tuesday) to make final decision. |
| Apple | Fine with the FL proposal |
| Lenovo/MotM | Support Option 1, Alt 3 |

***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) | 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  Option 2: a new solution, as above, is needed in Rel-17.  DOCOMO, MediaTek, LG, Intel, Spreadtrum,  Based on the review, the discussion and preference are a little complicated. Clearly there is no companies suggesting that RAN1 shall support both mechanisms in Rel-17. On the other hand, the priority/preference, Proposal 9 versus WA agreed in RAN1 103, become less clear with slight favor over WA design, for example Nokia prefer WA firstly before P9, DC prefer P9 firstly before WA, Oppo prefer none of them.  Therefore, from Moderator perspective, let us have further discussion for technical pros and cons, if any, until next Thursday (last MIMO session). Note that by default, neither Proposal 9 is supported, nor WA is to be confirmed this meeting. |
| Apple | Support the proposal  It clear that we will support a solution of single CSI-ReportConfig, it is preferable to allow mDCI mTRP reporting to be supported for single CSI-ReportConfig configuration. We do not see a strong reason not allowing mDCI mTRP report to be supported for single CSI-ReportConfig  One the other side, we are not against confirming the WA. But it is irrelevant, i.e., confirming the WA does not mean that this proposal cannot be supported.  CSI-ReportConfig just configures the CMR/IMR, and the association rule of CMR from different TRP, and the potential interference measurement assumption. In terms of whether it is sDCI or mDCI reporting, it is uncorrelated. In other words, we should not force NW to use one solution for sDCI and one solution for mDCI for no fundamental reason. |
| Lenovo/MotM | We do not support the proposal. Prioritizing single-DCI design should not preclude multi-DCI solution. We can discuss later but we shouldn’t favor one solution over the other based on a prioritization note. |

**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) | 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 |