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

**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 4)**

**Document for: Discussion and Decision**

# Summary of CSI enhancement for FDD

***Proposal 2 [Working Assumption]:*** *For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay,*

* *Alt 3-0, i.e. W1 ∈ N^{PCSI-RS × K1} (K1 ≤ PCSI-RS ) is a port selection matrix in order to freely select K1 ports out of PCSI-RS CSI-RS ports or K1/2 ports out of PCSI-RS/2 CSI-RS ports* 
  + *Lenono/MotM, Oppo, Ericsson, Intel, Vivo, Sony, QC, LG, Ericsson, Apple, MTK, NTT DOCOMO,CATT*
* *Note that PCSI-RS is the number of CSI-RS ports.*

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| Company | Comments |
| Huawei (Moderator) | It seems to be the majority view but a few companies may still have concerns. Let us try to agree with WA if possible. |
| OPPO | Support FL’s proposal |
| vivo | Support |
| NTT DOCOMO | Support FL’s proposal |
| Lenovo/MotM | Support |
| Qualcomm | Prefer an agreement for progress as there is a clear majority view. Without an agreement, it seems that P3 does not hold. |
| CATT | Support |
| LG | Support FL’s proposal |
| Fraunhofer IIS,  Fraunhofer HHI | Support |
| ZTE | Although we think it is more technically correct to discuss and agree on P3 first, we can compromise to agree on P2 and P3 together for the sake of progress. Otherwise the reason to choose Alt 3-0 over Alt 5 is not clear to us, since UE-specific CSI-RS overhead is a critical issue.  More details are given in the comments for P3. |

***Proposal 3:*** *For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay, study following options (or combinations) for CSI-RS configurations associated with Rel-17 PS codebook [for supporting of low CSI-RS overhead]:*

* + *Option 1: Support configuring a lower CSI-RS density per CSI-RS resource, e.g. 0.25*
    - *Nokia/NSB, Apple, Sony, SS (2nd)*
  + *Option 2:Support configuring one or multiple CSI-RS patterns per CSI-RS resource associated with Rel-17 PS codebook* 
    - *Yes: Nokia/NSB, Ericsson*
    - *No: SS*
  + *Option 3:Support configuring multiple CSI-RS resources per CSI reporting configuration associated with Rel-17 PS codebook* 
    - *ZTE, Ericsson, Sony, ~~Lenovo/MotM (2~~~~nd~~~~) ,~~ SS (2nd)*

*Note that no further enhancement is the baseline of study.*

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| Company | Comments |
| Huawei (Moderator) | The wording is relaxed to elaborate a few options, which are common practice in RAN1, so that interesting companies can provide further input accordingly, based on available options on the table. Whether any of them can be agreed will be discussed and determined by evaluations and next meetings.  Option 4 is removed to make things slightly clear. However, if I misunderstand companies’ positions, please suggest. |
| OPPO | Support FL’s proposal |
| vivo | The proposal is not needed.  We think Rel-17 enhancement should be under the baseline, i.e., no enhancement on CSI-RS. |
| Lenovo/MotM | Agree with VIVO |
| Qualcomm | Agree with vivo and Lenovo/MotM, and also flexible to study simple solutions to reduce CSI-RS overhead if there is a majority view (considering P2 is agreed).  Besides, the scope should be reducing CSI-RS overhead rather than increasing total number of ports especially for option 2 and 3. So, if there is a majority view of supporting this proposal (and conditioned on P2 agreed), prefer to adding a note for deprioritizing total number of ports > 32, or keeping the sentence in the bracket. |
| CATT | Support the proposal. |
| LG | We are generally fine with FL’s proposal if there is a majority view.  We have similar view with QC. Before we agree this proposal, it is better to clarify the purpose of this proposal for further study and discussion. |
| Fraunhofer IIS,  Fraunhofer HHI | Share the same view as VIVO. We believe that CSI-RS enhancements are not needed. |
| ZTE | We think it should be agreed in one proposal together with P3.  Further, Option 1 itself cannot solve the issue of reducing CSI-RS overhead completely. It restricts gNB’s resource allocation on CSI-RS for different UEs, or reduces performance from system level perspective (as the number of UEs multiplexed in one slot may be reduced due to restricted resource allocation). Hence, we agree with Nokia’s previous suggestion of converting the three options to two alternatives as follows, and RAN1 shall select one from these two in future meetings.   * + - Alt 1: Option 1 + 2     - Alt 2: Option 1 + 3 |

***Proposal 5:*** *Study following mechanisms*

* *With regarding to mechanism of configuring/indicating Wf to the UE (if supported)*
  + *Option 1: The FD bases used for Wf quantitation are limited within a single window/set with size N and initial point Minitial, which can be fixed/configured/indicated by gNB.* 
    - *FFS: whether/how to support more than one windows/sets*
    - *FFS: candidate values and value ranges for N, Minitial, includingwhether Minitial can be fixed to be, e.g. 0*
    - *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*
    - *[Other enhancements are not excluded].*
* *With regarding to mechanism of selecting/reporting Wf to the gNB (if supported)*
  + *Option 1: UE selects all FD components configured/indicated by the NW without reporting them*
  + *Option 2: UE selects and reports the index of FD components configured/indicated by the NW within a window of size N*
  + *[Other enhancements are not excluded].*

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| Company | Comments |
| Huawei (Moderator) | @Lenovo: update accordingly.  @ZTE: For option 1, it is just a way how to handle UCI reporting, by which a UE can report nothing if there is a clear rule. So the wording is generalized as “mechanism” in the title.  @Intel: I am fine to remove “other enhancement” as long as the group is in the same page. So they are in brackets now.  @SS @ Apple: as far as I can see, companies may be beneficial from certain clarifications, at least no harm I assume. |
| OPPO | We are fine with FL’s proposal |
| vivo | Support |
| NTT DOCOMO | Support FL’s proposal. However, since the *Mv* FD components selection is associated with the second bullet point (selecting/reporting *Wf* to the gNB), following minor modification is proposed for the consistency:     * *With regarding to mechanism of configuring/indicating Wf to the UE (if supported)*   + *Option 1: The FD bases used for Wf quantitation are limited within a single window/set with size N and initial point Minitial, which can be fixed/configured/indicated by gNB.*      - *FFS: whether/how to support more than one windows/sets*     - *FFS: candidate values and value ranges for N, Minitial, includingwhether Minitial can be fixed to be, e.g. 0*     - *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~~*     - *[Other enhancements are not excluded].* * *With regarding to mechanism of selecting/reporting Wf to the gNB (if supported)*   + *Option 1: UE selects all FD components configured/indicated by the NW without reporting them*   + *Option 2: UE selects and reports the index of Mv FD components configured/indicated by the NW within a window of size N*   + *FFS: The number of CSI-RS ports and the value of Mv is jointly configured per codebook parameter combination*   + *[Other enhancements are not excluded].* |
| Lenovo/MotM | Support |
| CATT | Support the proposal in principle.  Suggest to remove the following FFS:   * + - *FFS: The number of CSI-RS ports and the value of Mv is jointly configured per codebook parameter combination*   It is not related to the proposal at all. In addition, we don’t think the number of CSI-RS ports can be jointly configured with Mv. CSI-RS port number would be configured per CSI-RS resource, but not configured with codebook parameters.  We aslo suggest refine wording of Option 2 in following way. The original wording can be interpreted as that UE would report the FD components configured/indicated by network. But actually, UE should select FD components within a window and report the selected FD component.   * + *Option 2: UE selects and reports the index of FD components within a window of size N configured/indicated by NW.* |
| LG | We are generally fine with FL’s proposal, but we would like to propose minor modification for the consistency as follows.   * + *Option 2: UE selects and reports the index of FD components configured/indicated by the NW within a window/set of size N* |
| Fraunhofer IIS,  Fraunhofer HHI | Support FL’s proposal. |
| ZTE | We are fine with the current formulation of this proposal. It should be understood that the two main bullets are not mutually exclusive. Instead, the first bullet is the foundation or precondition of the second bullet. |

# Summary of CSI enhancement for Multi-TRP

**Possible Agreement**

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

* Alt.3: Configure UE with two CMR groups with  Ks = K1+K2 CMRs. 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 (if any or need) are only used for single-TRP measurement hypotheses
  + N CMR pairs are RRC configured by selecting from all possible pairs
    - K1=M1, K2=M2, signalling mechanism can be discussed further, e.g. using a bitmap
    - FFS: Whether MAC CE indication is supported as well
  + Starting from M1=M2=1
* Support N=1 and Ks =2,FFS other maximal values of N>1 and Ks>2
* Note: for CPU resource/port occupation, NCJT hypothesis is considered separately from single TRP hypothesis

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| Company | Comments |
| Huawei (Moderator) | From FL perspective, I don’t see how much agreements or further details can be worked out by now, after lengthy email discussion and online compromise.  Therefore, my general plan is to agree/confirm the possible agreement by email (by Wed), except for minor text polishing, only if there is strong need. It is not preferred to be discussed by last GTW. |
| MediaTek | Support |
| OPPO | Support the agreement to discuss the details in following meetings. |
| vivo | Support the proposal in principle.  But there are some places ambiguity and more things to be FFS. For example,   * whether all the CMRs for NCJT can be used for STRP CSI measurement, as some companies commented that it may not be the case for FR2. * K1=M1, K2=M2 conflicts with “the remaining CMRs (if any or need) are only used for single-TRP measurement hypotheses” * “Starting from M1=M2=1” seems identical to “Support N=1 and Ks =2”   So we propose to update the possible agreement as follows:  **Possible Agreement**  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   * ~~Alt.3:~~ Configure UE with two CMR groups with  Ks = K1+K2 CMRs. 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~~ FFS: the first M1 (or M2) CMRs in each CMR group can be used for both NCJT and Single-TRP measurement hypotheses, the remaining CMRs (if any or need) are only used for single-TRP measurement hypotheses   + N CMR pairs are ~~RRC configured by~~ selected ~~ing~~ from all possible pairs     - ~~K~~~~1~~~~=M~~~~1~~~~, K~~~~2~~~~=M~~~~2~~~~,~~ FFS: signalling mechanism ~~can be discussed further~~, e.g. using a bitmap     - ~~FFS: Whether MAC CE indication is supported as well~~   + Starting from M1=M2=1, N=1 and Ks =2 * ~~Support N=1 and K~~~~s~~ ~~=2,~~FFS other maximal values of N>1 and Ks>2 * Note: for CPU resource/port occupation, NCJT hypothesis is considered separately from single TRP hypothesis |
| Lenovo/MotM | We prefer changing the last note related to CPU/resource/report occupation to FFS. We are OK with the other elements of the proposal |
| Ericsson | We have some questions on the current proposal listed above by FL.   1. In the first sub-bullet, we have UE being (RRC) configured with two CMR groups. Then, in the 3rd sub-bullet under Alt 3, we have N CMR pairs being RRC configured. We don’t see the motivation for adding 2 levels of RRC configuration. Such 2 levels of RRC configuration results in redundant signaling. Plus, it is quite inflexibly as updating the pairs would require RRC reconfiguration. 2. if K1 = M1 and K2 = M2, then what is the reason for introducing M1 and M2? Seems all K1 and K2 resources in the two CMR groups can be used for selecting CMR pairs. Then, M1 and M2 can be removed altogether. 3. The above agreement is for N=1 and Ks = 2. In this case, there is only one CMR pair, and RRC configuration of N CMR pairs is not needed. 4. There has been very limited discussion on the last Note added in the proposal. It is better to discuss such design details later.   Hence, for this meeting, we suggest to make a minimal agreement with only the Ks = 2 and N = 1 values. The remaining details can be discuss after we resolve FFS on other maximal values of N>1 and Ks>2. So, we suggest the following revision:  **Possible Agreement**  For CSI measurement associated to a reporting setting CSI-ReportConfig for NCJT, the UE can be configured with Ks NZP CSI-RS resources in a CSI-RS resource set for CMR and N NZP CSI-RS resource pairs whereas each pair is used for a NCJT measurement hypothesis   * Support N=1 and Ks =2,FFS other maximal values of N>1 and Ks>2   It appears that this would be the minimum progress we can make for this meeting. |
| LG | We are generally fine with FL’s proposal. But, regarding the last Note for CPU resource/port occupation, we have the same view with Lenovo/Ericsson. In this meeting, there was no time to discuss that issue, so we also think the last Note should be FFS. |
| NTT DOCOMO | We can support the proposal in principle but have following comments for clarification.  - First, the ‘Note’ part is ambiguous and should be further study, especially for FR2.  - Second, the N CMR pairs may be additionally indicated by RRC according to different measurement purposes or frequency ranges. So, the N CMR pairs can be FFS.  - Third, the CPU resource/port occupation can be FFS  Hence, we are generally okay with vivo’s revision, with FFS for the last note. |
| Futurewei | We share Ericsson’s view and are ok with Ericsson’s revision. |
| CMCC | We are fine with FL’s proposal in principle.  But, there are some places ambiguity. If K1=M1, K2=M2, does this mean that there is no remaining CMR only used for single-TRP measurement hypotheses? If that is the case, all the CMRs are used for NC-JT measurement hypotheses, then it is hard to use these CMRs for single-TRP measurement hypotheses in FR2. |
| QC | We are fine with FL’s proposal in principle and generally ok with vivo’s revisions.  Regarding the last Note: We compromised to this proposal for progress and because we understand the difficult situation. One of our concerns was that UE may be unreasonably forced to increase its complexity by not properly counting CPU’s/resources/ports. The note is already inline with the Rel. 15 principle that if the same CMR is configured N times within same or different report configs, it should be counted as N times:  “If a CSI-RS resource is referred *N* times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted *N* times”  When a NCJT hypothesis is evaluated, CSI processing is not the same as sTRP hypothesis even when the same CMRs are reused. This was naturally addressed in Alt1, but for Alt3, we would not be comfortable w/o acknowledging this issue at least in a note as we requested.  Hence, we suggest keeping the note and not make it FFS. |
| Samsung | We are generally fine with FL’s proposal and okay with vivo’s revision to make proposal clearer. |

***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*
    - *If X=2, two CSIs are associated with two different single-TRP measurement hypotheses*
  + *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*

Proposal 8 (17): Nokia/NSB, Lenovo/MotM, Ericsson (1st), Vivo, CATT, Spreadtrum, LG (2), NTT DOCOMO (2nd), CMCC (2nd), Intel (2nd), Futurewei, Huawei/HiSicon, Fraunhofer IIS, Fraunhofer HHI

* QC, OPPO, ZTE, LG (1): only if removing X=2

Proposal 8’ (7): QC (1st), NTT DOCOMO (1st), Ericsson (2nd), Intel (1st), CMCC (1st), Oppo (2nd)

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| Company | Comments |
| Huawei (Moderator) | From FL perspective, I don’t see how far we can go for down-selecting among different combinations by email since companies will not change minds at all, even there is the majority of view.   * My general plan is to stabilize some text, if any further changes are required. * We will make a down-selection by GTW. |
| MediaTek | Our first preference is Proposal 8’. Proposal 8 is acceptable only if removing *X* = 2. |
| OPPO | Considering the situation in GTW, we prefer proposal 8’ which is easier to make progress.  With proposal 8, actually all the three alternatives are supported. We doubt whether we need so many types of CSI report for M-TRP. |
| vivo | Support Proposal 8.  We need to clarify that If X=2, two CSIs are associated with two different single-TRP measurement hypotheses with CMRs from different TRPs. Otherwise it is non-sense to report two single-TRP CSI for a single TRP.  ***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*     - *If X=2, two CSIs are associated with two different single-TRP measurement hypotheses with CMRs from different TRPs*   + *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* |
| Lenovo/MotM | We support Proposal 8. We are also OK with the additional wording proposed by VIVO. Just a reminder that Proposal 8 in itself was presented as a compromise solution for the three original alternatives in RAN1#103e, we do not think that omitting support of X=2 would qualify as a compromise anymore |
| Ericsson | Our first preference is Proposal 8. We are fine with the clarification from vivo.  We can accept Proposal 8’ if X=0 is added instead of X=1. Let us explain the reasoning for proposing X=0. In our view, X=2 would provide good scheduling flexibility. With X=2, the gNB receives one NC-JT CSI and 2 single TRP CSIs. Hence, if one of the TRPs corresponding to the NC-JT CSI is unavailable, then the UE can schedule using the single TRP CSI of the other TRP.  But with X=1, this scheduling flexibility may be lost. Assume that the UE receives NC-JT CSI corresponding to TRP1 and TRP2, and single-TRP CSI corresponding to TRP2. If TRP2 is unavailable, then the gNB cannot use either of these CSIs as it cannot schedule from TRP2.  Hence, instead of supporting X=1 in Proposal 8, it is much better to go for X=0. Note that X=0 is the simplest CSI case where the UE reports one NC-JT CSI. X=0 should simplify UE complexity compared to X=1. Rather than support X=1 which provides limited or no scheduling flexibility, we think it is better to go with X=0. Our suggestion is as follows:  ***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 = 0*   *FFS omission of CSI associated with NCJT measurement hypothesis* |
| LG | We have the same view with vivo, and support the clarification from vivo. |
| NTT DOCOMO | Our first preference is Proposal 8’.  Although X=0 in addition to X=1 is also useful, in our understanding. |
| Futurewei | We support Proposal 8 and is ok with Vivo’s revision. |
| CMCC | We could accept Proposal 8 as a comprise, and also fine with the clarification from vivo. |
| Samsung | We support Proposal 8 and are also fine with vivo’s added sub-bullet for the case of X=2. |

***Conclusion:***

* Strive to mitigate the spec impact by supporting at most one of the following options, if needed
  + Option 1: The design ~~was agreed~~ by Working Assumption in RAN1 103e.
  + Option 2: 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
* The time of decision is RAN1 ~~106e (August 2021)~~ 105e (May 2021)
* [Note: The WA is the default assumption without further decision on this issue]

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| Company | Comments |
| Huawei (Moderator) | For above conclusion, my general plan is to agree with it by email (by Wed). Therefore it is not preferred to be discussed by last GTW.  Let us have a try to stabilize text asap. Thanks. |
| MediaTek | Support the conclusion |
| OPPO | We support the conclusion.  Suggest deleting “was agreed” in option 1, since the working assumption has not been confirmed yet. |
| vivo | Actual we don’t see very strong need to downselect one out of Option1 and Option2. If we have to downselect, we think we cannot only strive to mitigate the spec impact, but also need to consider other aspects such as performance, applicable scenarios. In our opinion, Option 2 can work for ideal backhaul, while Option 1 can work for both ideal-backhaul and non-ideal backhaul. Some modifications for conclusion as follow:  ***Conclusion:***   * Strive to ~~mitigate the spec impact by~~ support~~ing~~ at most one of the following options~~, if needed~~   + Option 1: The design was agreed by Working Assumption in RAN1 103e.   + Option 2: 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 * The time of decision is RAN1 ~~106e (August 2021)~~ 105e (May 2021) * ~~[~~Note: The WA is the default assumption without further decision on this issue~~]~~ |
| Lenovo/MotM | We support the conclusion provided by the moderator |
| Ericson | Ok with FL conclusion. |
| LG | We are fine with FL’s conclusion. |
| NTT DOCOMO | We do not accept the Note. We have not fully discussed the issue, and the WA is not confirmed yet, how does it become default assumption? We can also say that since single CSI reporting has been supported, Option2 should be default assumption. Let's avoid such further debating on this and delete the note.  Without the note, we can be supportive.  ***Conclusion:***   * Strive to mitigate the spec impact by supporting at most one of the following options, if needed   + Option 1: The design ~~was agreed~~ by Working Assumption in RAN1 103e.   + Option 2: 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 * The time of decision is RAN1 ~~106e (August 2021)~~ 105e (May 2021)   ~~[Note: The WA is the default assumption without further decision on this issue]~~ |
| Futurewei | Support FL’s conclusion. |
| CMCC | Support FL’s conclusion. |
| Samsung | We are fine with FL’s proposed conclusion in principle but the wording seems that this down-selection considers mitigating the spec impact only, hence we prefer vivo’s one. |

**Appendix**

# 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 (2nd preference),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.*
    - *Vivo (1st preference)*

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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. |
| Qualcomm | Support Alt3-0. P3 can be discussed/studied after P2. We prefer to add the default option (no enhancement) in P3. |
| ZTE | We still support Alt 5 in P2.  We think P3 should be studied and discussed before P2. The reason why we choose Alt 3-0 or Alt 5 should depend on whether we consider or which solution we consider in P3. Otherwise, we perform down-selection in P2 based on what? In terms of supporting companies, it is clear the companies supporting Option 4 in P3 should support Alt 5 in P2.  Another way to move forward can be to discuss P2 and P3 together. These two are trying to solve a common issue in W1 design essentially. |
| Intel | We support current version of P2 (i.e. Alt 3-0).  Regarding P3, in our view it is not necessary to agree that we need to do enhancement at this stage. We prefer to add Option 0: No enhancement    We see some performance gain for reduced CSI-RS density (Option 1), but we need further study on Option 2,3 –benefits are not clear at this stage and the corresponding changes in the spec are more significant comparing to Option 1. For option 4, it seems that it contradicts with Alt 3-0 (first bullet under option 4), so if we consider P3 with option 4 then there is no sense to discuss P2. |
| vivo | Support Proposal 2.  We think Proposal 3 is not needed, as W1 is to be discussed in Proposal 2, and Wf is to be discussed in Proposal 5. |
| LG | Regarding proposal 2, we also support Alt3-0.  Regarding proposal 3, we are generally fine with the way of this proposal. But, the purpose of this proposal should be clarified for discussion. And whether to support option(s) for enhancement should also be discussed further. So, we propose the following modification.  ***Proposal 3:*** *For PS codebook enhancements utilization DL/UL reciprocity of angle and/or delay, ~~support~~study ~~one or a combination of~~ following options for CSI-RS configurations associated with Rel-17 PS codebook for supporting of low CSI-RS overhead and to be decided in RAN1 104bis:*  And, can I ask more details about Option 2? ‘Multiple CSI-RS patterns per CSI-RS resource’ is not clear to us. |
| Nokia/NSB | In our view P2-Alt 5 and P3 are clearly linked and tackle the same issue, which is the total CSI-RS overhead of scheduling multiple UEs for reporting, when configuring up to 32 ports per UE  What is important to us is the ability to reduce CSI-RS overhead and being able to have a simple and efficient (for PDSCH throughput) scheduler implementation so the gNB can schedule multiple UEs, for example with 32 ports, in the same slot, in a similar fashion as for “cell-specific” resources.  From this point of view, Option 1+2, Option 1+3 and Option 4 in P3 achieve the same RS overhead reduction and simple and efficient scheduler implementation. Option 1+3, however, has the drawback, compared to Option 1+2, of requiring multiple resources for a single Type II CSI measurement. This creates a complication in handling UE’s capability for number of resources/ports. Also, currently Type II CBs can only be configured with a single resource.  From our perspective, we prefer to discuss P3 first or both P2-P3 together, so if we can agree on one of Option 1+2 or Option 1+3, P2 will be also resolved. |
| Ericsson | Support the new version of P2 (i.e. Alt 3-0)  Support Option 2 and 3 in P3 as they allow for reduced UE and gNB complexity or improved pipelining by distributing CSI-RS ports across a larger number of OFDM symbols. |
| Samsung | Re P2, what is new in Alt 3-0 (compared to the agreement we made this meeting)?   * How is it different from the agreement (copied below) which says that W1 is a port selection matrix? * We agreed that it is FFS whether the selection is pol-common and pol-indep. Then, why the size of W1 is P\_CSIRS x K1?   ***W1****is a free selection matrix, with identity matrix as special configuration*  o   *FFS polarization-common/specific selection*  Re P3, same view as Intel, and our current preference is Option 0 (no enhancement). Among other options, we have strong concerns about enhancements related to CSI-RS resource. In particular, we can’t accept Option 2 and 4. Other options (1 and 3) require more study. |
| Lenovo/MotM | We support Proposal 2 (Alt3-0)  For Proposal 3, we support no enhancement (A new Option 0) as a first preference, and Option 3 as a second preference. |
| Apple | Regarding proposal 2: We are fine to agree on Alt3-0  Regarding proposal 3:  We want another option that there is no CSI-RS enhancement in Rel-17 which is the default outcome if companies cannot converge on at least one of the enhancement |

***Proposal 5:*** *Study following mechanisms,*

* *With regarding to mechanism of configuring/indicating Wf to the UE (if supported)*
  + *Option 1: 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: whether/how to support more than one windows*
    - *FFS: candidate values and value ranges for N, Minitial, includingwhether Minitial can be fixed to be, e.g. 0*
    - *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*
    - *Other enhancements are not excluded.*
* *With regarding to mechanism of selecting/reporting Wf to the gNB (if supported)*
  + *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 N*
  + *Other enhancements are not excluded.*

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| Huawei (Moderator) | The intention of P5 is to provide high level description to clarify the FFS in the agreement so that we can see any solutions/variations on the table, to help companies to understand each other. After checking comments, it seems that most of companies refer to the same thing, at least conceptually.  @All: It seems that most companies think that the motivation of K windows/sets is unclear, so I use Fraunhofer words so that proponent company may elaborate more. Also, I have taken a few comments to make proposals to be less “aggressive”.  @Vivo: I add a FFS for K windows, but please strive to explain to RAN1 that it is a valid/good option to try.  @QC: add M\_initial to be fixed as FFS  @Spreadtrum: FFS is required by QC. Let’s keep it as it is.  @Apple @ SS: “other enhancements” are limited to the discussion of Wf here. I have no intention to across proposals.  @Intel, @Ericsson: I have used Nokia’s wording. It seems to be in your preference/thinking I assume. |
| 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. |
| Lenovo/MotM | We appreciate Nokia’s detailed comments which provide more clarity to the proposal bullet points. We are generally fine with the proposal, however we suggest the following minor wording changes for consistency, as follows    ***Proposal 5:*** *Study following mechanisms for downselection in RAN1#104bis-e,*  *With regarding to mechanism of configuring/indicating Wf to the UE (if supported)*   * + *Option 1: 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: whether/how to support more than one windows*     - *FFS: candidate values and value ranges for N, Minitial, includingwhether Minitial can be fixed to be, e.g. 0*     - *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*     - *Other enhancements are not excluded.* * *With regarding to mechanism of selecting/reporting Wf to the gNB (if supported)*   + *Option 1: UE selects all FD components configured/indicated by the NW without reporting them*   + *Option 2: UE selects and reports ~~the index of~~  FD components within a window of size N*   *Other enhancements are not excluded* |
| Qualcomm | @Nokia, thanks for the reply. I understand the intention is to use FD precoding to multiplex ports intended for different Ues. But if not clarified in CSI-RS pattern, the UE will see two ports (intended for itself and another UE) mixing together, and will misunderstand it as the channel of its own. Mini and Wf is about the reported PMI, not related to CSI-RS estimation and CSI measurement.  Not sure this proposal is essentially needed. Interested companies can provide more concrete proposals in their contribution next meeting. |
| ZTE | We are okay to discuss this issue. This formulation is more clear than last version. We thank FL for the effort.  But still, there is one unclear part for us, which is Option 1 under UE reporting bullet. If UE uses all the Wf vectors configured by NW, it should be same as Option 1 in the NW configuration bullet. It’s not clear to us why we need to have this option 1 under UE reporting while there is no UE reporting at all. |
| Intel | This version is much better comparing to the previous one – thanks to feature lead other companies for discussion and elaboration.  In our view this proposal reflects the main direction for further study with the main sub-bullets. However, there are multiple redundant FFS points in our view, also “other enhancements are not excluded” is not needed here since, in our view the proposal covers pretty much all the directions for Wf. |
| Vivo | Support updated Proposal 5.  We think multiple windows can be FFS.  Most companies think more SD-FD bases are good to performance, if the number of SD-FD bases conveyed by the CSI-RS ports is limited, indicating more FD information by gNB is necessary. Multiple windows are used for more information indication.   * Need of K: in enhanced Type II codebook in R16, K (e.g., Mv) FD bases are selected from a window of size N (e.g., 2Mv or N3 when N3<19). If the gNB is able to measure the delay and indicate the exact K delay taps to the UE, FD bases reporting by the UE will not be needed with reduced feedback overhead. In a word, K windows corresponding to each CSI-RS port are for K FD bases indication and UE can obtain K times SD-FD bases. * Need of window size N­k: for each tap indicated by gNB, to counteract the non-ideal FDD reciprocity and timing mismatch, each tap can be expanded to a window of size Nk around the k-th delay location starting from Minital, k, enabling precise FD basis selection within a limited window.   Anyway, this is a general model to accommodate all options. When K=1, N=1, Minital=0, then it turns out to be the case of Mv=1. If the overhead of CSI-RS ports is more essential, K>1 can be indicated for UE to measure. The candidate values and value ranges for K, Nk, Minitial,k are FFS. |
| LG | We are generally fine with FL’s proposal.  However, it seems that ‘window’ and ‘set’ in the previous wording of the proposal have different meanings, i.e., ‘window’ for continuous FD bases and ‘set’ for non-continuous FD bases. So, we think it is better to keep ‘set’ as well as ‘window’ as follows.  ***Proposal 5:*** *Study following mechanisms,*   * *With regarding to mechanism of configuring/indicating Wf to the UE (if supported)*   + *Option 1: The FD bases used for Wf quantitation are limited within a single window/set with size N and initial point Minitial, which can be fixed/configured/indicated by gNB.*      - *FFS: whether/how to support more than one windows/sets*     - *FFS: candidate values and value ranges for N, Minitial, includingwhether Minitial can be fixed to be, e.g. 0*     - *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*     - *Other enhancements are not excluded.* * *With regarding to mechanism of selecting/reporting Wf to the gNB (if supported)*   + *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/set of size N*   + *Other enhancements are not excluded.* |
| Nokia/NSB2 | We support this proposal and we think the FL’s reformulation is very clear.  @ZTE: the second bullet is about UE selecting and/or reporting, and option 1 in that bullet has no reporting. The first bullet is about NW’s configuration/indication of the restriction on FD components for the UE to calculate, a UE may further select and report a subset of components within this window (option 2) or select all with no reporting (option 1).  @QC: a UE is oblivious of the precoding applied at the NW side on a port, so from UE’s perspective, the CSI calculation is assumed to be the same as for a port with additional FD components in a window starting from 0. The only difference is that the window starts from , for example. It is the NW’s responsibility to ensure that when scheduling two Ues on the same port, there is good separation in the delay domain such that the two channel impulse responses do not overlap. |
| Samsung | We prefer to discuss this after we have some understanding/agreement about Wf. We have already agreed with the two main bullets (cf. agreement made this meeting, copied below). We don’t need to rush and list signaling/reporting aspects of Wf.   * *FFS candidate value(s)  of R, mechanism for configuring/indicating to the UE and/or mechanism for selecting/reporting by UE for* ***Wf*** |
| Apple | Again, we do not see the need to have this study because the uncertainty of Mv and the size of the subbands.  Companies can still study but there is no need to agree on it since it is discussed in the wrong order. |
| Fraunhofer IIS  Fraunhofer HHI | Support of the FL proposal. |

# 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*
    - *K1=M1, K2=M2, 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 (3): QC (1st), ZTE, Intel (1st),  Alt 3 (16): Vivo, CATT, Oppo, NEC, Intel(2nd), MediaTek, LG, Lenovo/MoM, Ericsson (2nd), Futurewei (2nd), Fraunhofer IIS/Fraunhofer HHI, Nokia/NSB (2nd), CMCC (option 2)  Either Alt 1 or Alt 3: Apple, Docomo, Samsung  @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. |
| ZTE | We still support Alt.1.   * **Comment for option 2:**   Here, we would clarify one import thing is  **Observation:** One CMR cannot be configured/assumed within two or more CMR pairs in FR2  For instance, UE has to use two simultaneous receive beam r1, r3 to measure CMR pair {1, 3} , meanwhile, UE has to use two simultaneous receive beam r1, r4 to measure CMR pair {1, 4}. So to measure CMR1, how could UE simultaneously use both r1, r3 and r1, r4? In such case, option 2 of alt.3 will not work.  If companies don’t agree with the observation above, please share your views.   * **Comment for option 1.5:**   MACCE cannot be used for periodic CSI since UE will average measurement instances. If only RRC configuration is used, there is no much difference between Alt.1 and option 1.5.  @Nokia, for the comment ‘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’, for sTRP, why doesn’t gNB configure Ks =3 ?  For CPU assumption, in the case CPU is over occupied, you actually prioritize NCJT CSI than sTRP which may not be reasonable.   * **Comment on the last bullet:**   Regarding the last bullet ‘Support N=1 and Ks =2, FFS other maximal values of N>1 and Ks>2’, we have strong concern since Ks can even be 8 in Rel-15. We can not accept a backward design in Rel-17. We are fine with either removing the bullet or following revision  *- Maximum Ks value should not be smaller than Rel-15/16, the maximum N is equal to or smaller than Ks/2*   * **General comment:**   Alt 3 is getting more complicate and hard understandable. Option 1 actually has no much difference with Alt.1. Option 2 is completely different with Option 1.5. In Option 1.5, only NCJT is allowed, but Option 2 cannot. In option 1.5, MACCE may be used, but option 2 will not. In option 1.5, K1, K2 seem fixed as Nokia clarified, but Option 2 is unclear.  Based on the above, we propose to split Alt.3 into some parallel alternatives. |
| Lenovo/MotM | We support Alt 3, Option 2.  @ZTE: In our view, Alt3 is more flexible for FR1, since flexible CMR pairing (i.e., different CMR group sizes and free CMR pairing) is allowed. In our opinion Alt1 is too restrictive for FR1. We have previously suggested adding FFS under Alt3 to address whether special FR2 considerations are needed (e.g., one-to-one CMR pairing in FR2), which we are still fine with to address ZTE’s concerns on Alt3 under FR2. Also, we believe it is important to set upper limits for supported *N*, *Ks* values for better comparison of the different alternatives and easier assessment of overall complexity/overhead. |
| NTT DOCOMO | We understand the concerns from QC and ZTE on CMR pairing in FR2. But Alt.3 – Option1 can achieve the similar CMR pairing as Alt.1 for FR2, and ZTE also agreed on it. Can we assume ZTE is also okay with Alt.3 – Option1 (if FFS to use NCJT CMRs for sTRP hypotheses)?  For Alt.3-Option2, it is more suitable for FR1, considering CMR pairing restrictions in FR2. However, on the other hand, it also requires further study whether such flexibility on CMR pairing is necessary or not. Because before CSI reporting configurations, gNB already obtains several good beam pairs from UE based on beam measurement/reporting. Hence, gNB just needs to configure a limited number of beam pairs for CSI measurement/reporting, which means that such flexibility on CMR pairing in Alt.3-Option2 may be not needed.  In MTRP BM, enhancement on group-based beam reporting is also discussed. No matter which grouping method is supported in MTRP BM, grouping of CSI-RS resources and association with each TRP is needed. To make the CSI signaling framework consistent, we slightly prefer Alt.3 even though we think Alt.1 and Alt.3-Option1 can achieve similar configuration results. For the options in Alt.3, Option1 can be considered at least for FR2. |
| Ericsson | Support Alt 3, Option 2.  First, we should make a clarification that in Alt 3 Option 2: UE freely select CMR pairs from two groups. Hence, the following note should not be applicable to Alt 3 Option 2.   * + *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*   We suggest the following modification:   * + *FFS Option 2: UE freely select CMR pairs from two groups (without one-to-one mapping)*      - *M1 = K1, M2 = K2, N= M1M2*   Note that in FR1 where the number of ports in the CMR can be large (e.g., 16 or 32), then configuring separate CMRs for single TRP hypothesis is really inefficient from RS overhead perspective. If we use, a 16-port CMR1 and a 16-port CMR2 for NC-JT hypothesis, and then another two 16-port CMRs (CMR 3 and 4) for single TRP hypothesis as proposed in Alt 1, the RS overhead will be very high.  Plus, for the basic setting of Ks = 2 and N=1, most of these alternatives will be simplified.  After resolving the FFS on other maximal values of N>1 and Ks>2, we can discuss how much to optimize the CSI resource configuration for FR2 and thereafter downselect one option under Alt 3. |
| OPPO | We are fine with the proposal.  Firstly, we don’t think there is any issue for Alt3 to support FR2. When a CMR is used for both single TRP and NC-JT measurements, it should be measured twice with different measurement hypotheses, potentially with different panels. It is similar to Alt1 to configure a CMR twice. Furthermore, based on beam group reporting supported in 8.1.2.3, it is sufficient to support N=1 and Ks =2 for CSI report. More than 2 TRPs can be naturally supported by the beam reporting enhancement for M-TRP. We are open to discuss a larger number if companies think more flexibility is needed. |
| Intel | We feel that it is not fair to compare the supporters of Alt 1 and Alt 3 since Alt 1 is clean and clear while there are a lot of options and FFS for Alt 3.  Since Alt 3 is still not finalized yet in our view it is better not to preclude Alt 1 at this stage. |
| ZTE2 | We have the same view with QC, Intel. Alt.3 is too broad and uncertain.  @E///, in FR1, one resource can be configured both for NCJT and sTRP. For your comment ‘If we use, a 16-port CMR1 and a 16-port CMR2 for NC-JT hypothesis, and then another two 16-port CMRs (CMR 3 and 4) for single TRP hypothesis as proposed in Alt 1, the RS overhead will be very high.’, actually two CMRs are enough for Alt 1, that is CMR {1, 2, 1, 2} with N=1. The only overhead is duplicate CMR ID of RRC signaling. The RS overhead is not increased.  @DOCOMO, Option 1 is the same as Alt.1 while Alt.1 is simpler than Option. Let’s see other companies views.  @OPPO, for aperiodic CMRs in FR2, one resource can only be transmitted once. How could UE measure it twice with different analog beams ? As I commented above, one CMR cannot be paired with more than one CMRs in FR2. That is, in alt.1, a CMR for sTRP should not be one of CMRs for NCJT in FR2. In FR1, there is no such restriction.  @Lenovo, Do we need separate solution for FR1 and FR2 ? |
| vivo | We support Alt3.  We show some understanding about Proposal 6 as follows:   1. Firstly, we think grouping CMRs is necessary for UE to tell which TRP that a CMR belongs to, which is the same as in MTRP beam reporting. Whether to support more TRPs can be FFS and we think Alt3 is ready to support more TRPs. 2. Proposal 6 and Proposal 8 are related and Proposal 6 should work for the CSI hypotheses reporting alternatives considered in Proposal 8    1. If X=2 is supported, the UE cannot tell which TRP the CMR for two single-TRP CSI measurement belongs to and may report two STRP CSIs corresponding to one TRP if Alt1 is assumed. While this can’t happen with Alt3. 3. On reusing CMR for NCJT for STRP,    1. First of all, the CMR for NCJT hypothesis can also be used for STRP hypothesis at least FR1.    2. In FR2, we agree with QC’s comment that it depends on multi-panel implementation. In Alt3, it is also possible to configure dedicated CMRs only for STRP measurement. Even if the CMR for NCJT is also used for STRP CSI calculation where one of the Rx panel using the beam for another TRP, in our opinion performance loss may not be very large. Evaluations can be conducted and can be FFS. |
| CATT | Support Alt.2, Option 2.  We don’t think Alt.2 is only applicable to two TRPs case. So, the following revision of Alt.3 is recommended:   * *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).*   Besides, as pointed out by Ericsson, the difference between different alternatives is also related to the values of N and Ks. For the case N=1 and Ks=2, all the alternatives and options are actually the same. |
| CMCC | We support Alt 3-Option 2.  We have the same view with Ericsson and CATT, if the number of CMRs in each CMR group could be limited to a low value, like 2, the overhead of CRI is also acceptable. |
| LG | We support Alt3.  Alt1 can cause redundant signaling to configure NZP CSI-RS resource associated with both single-TRP and NCJT measurement hypotheses at least in FR1 because the same NZP CSI-RS resource should be configured twice in the same reporting setting. However, this kind of redundant signaling can be avoided when Alt3 is supported.  Regarding multi-panel implementation issue in FR2, it seems that impact of reusing a CMR for both single-TRP and NCJT measurement hypotheses is not clear. This is because how to receive STRP PDSCH (or STRP CMR) depends on UE implementation. UEs can receive STRP PDSCH based on multi-panel in order to maximize performance, while other UEs can receive STRP PDSCH based on single panel in order to save battery consumption. So, even if CMR for STRP hypothesis and CMR for NCJT hypothesis are configured separately, the UE can receive CMR for STRP hypothesis based on single panel. In this case, the benefit of configuring CMRs separately for STRP and NCJT hypotheses is not clear. |
| Nokia/NSB2 | Support Alt 3, Option 1.5  Whether there is any issue to support FR2 from Alt3 by comparing to Alt 1  In our view, Option 2 is not well suited for FR2 because the same CMR is always configured, by construction, in multiple NCJT pairs when , as pointed out by ZTE. Option 2 also has the problem that a UE has to perform too many NCJT measurements, , so the NW can only configure NCJT measurements for  Option 1, on the other hand, is not well suited for FR1 because the same CMR is never configured in multiple NCJT pairs, by construction, unless the same CMR appears multiple times in the set.  Option 1.5 does not have these two limitations and can offer flexible configuration for both FR1 and FR2, similarly to Alt1, but without a redundant RRC configuration and with the extra flexibility of allowing the network to restrict the NCJT pairs more dynamically for semi-persistent reporting.  Whether/how to support more than 2 TRPs?  In our view, the discussion on CMR pairing for NCJT does not require any assumption on the TRP association to CMR/CMR groups. All alternatives in the proposal can support more than 2 TRPs. In particular, in Alt 3 the two CMR groups are only for pairing purpose, so a NW can associate CMRs from more than 2 TRPs in each of the two groups.  We propose to clarify this aspect by removing the following part, as it doesn’t seem needed   * ***Alt.3: Configure UE with two CMR groups with Ks = K1+K2 CMRs. CMR pairs are determined from two CMR groups by following method(s).***   @ZTE: we agree that for periodic reporting Alt1 and Option 1.5 are very similar. There is still some difference in the configuration, for example, in a simple case where the NW wants to configure two CMR resources for both sTRP and NCJT measurements, with Alt1 the configuration requires , with CMR resource set: {CMR 0, CMR1, CMR 0, CMR 1}. For Option 1.5, the configuration can be done with , with CMR resource set: {CMR 0, CMR 1} and, for example NCJT pairing bitmap [1].  Regarding our previous comment on the assumption of in Alt1, of course NW can configure or any other value. The intention was to raise the issue of the definition of in relation to . The last bullet point: , can work with different assumptions on |
| Futurewei | We support Alt. 3 Option 2 and share the same view as Ericsson, CATT, and CMCC. |
| Fraunhofer IIS  Fraunhofer HHI | Support of the FL proposal and ALT3. |

***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 |
| ZTE | We still have concern to support X=2.  We are fine with proposal 8 with X=1.  Note that, option 2 has been adopted in LTE FeCoMP where only one best CSI among sTRP and NCJT is selected.  Further, the current wording of proposal 8 with X=2 is more high level than previous agreement. Why two single TRP CSI is needed for sDCI based MTRP in which there is no TRP differentiation. |
| Lenovo/MotM | We support Proposal 8. We further elaborate on the motivation to support X=2 as follows.  For a UE configured with NCJT CSI from TRP1 and TRP2, the network may need to fall back to single-TRP transmission due to change in traffic demands, e.g., falling back from NCJT to single-TRP transmission with TRP2 in case TRP1 needs to be scheduled with other UE(s). A UE configured with X=1 that reports single-TRP CSI for TRP1 along with NCJT CSI fails to support such fallback scenario. Supporting X=2 would resolve this issue, regardless of whether TRP1 or TRP2 has higher traffic, which cannot be fully predicted when configuring/reporting CSI. In light of that, we think Proposal 8 provides a good compromise by addressing network flexibility concerns (via supporting X=2), as well as overhead concerns (via supporting Option2 in Proposal 8). |
| NTT DOCOMO | First preference: support Proposal 8’.  Second preference: support Proposal 8. |
| Ericsson | As a compromise, we can accept Proposal 8.  But, if companies want to downselect, then we prefer to support **only one** solution which is captured by Proposal 8’.    @ZTE: Not sure what you mean by no TRP differentiation. The network knows which TRP transmits which CMR, so based on which CMR was used by the UE for the single-TRP CSI, the network has the flexibility to schedule from either TRP. |
| OPPO | We agree with QC that Alt1 of Option1 + Option 2 can be a better choice. As a second choice, we are also fine with proposal 8’. |
| Intel | We support Proposal 8’.  We can accept proposal 8 as a compromise. |
| vivo | We support proposal 8.  In our view, Option1 and Option2 both are useful and suitable to various scenarios.   * X=2 is beneficial for the network scheduling flexibility by increasing a UE’s opportunity to be scheduled which may occur with ideal-backhaul at higher RU. If a UE only reports one STRP CSI from TRP1, the network is unable to schedule the UE with another TRP when TRP1 decides to schedule another UE with higher scheduling priority. * Option 2 is more suitable to low RU cases for both ideal and non-ideal backhaul scenarios. When there are very few UEs in a network, as an extreme example, only one UE, UE’s recommendation is the best choice for network to follow. Option 2 can achieve the best performance with least CSI feedback overhead.   Anyway, we can allow the Network to configure multiple reporting hypotheses to increase the scheduling flexibility. |
| CATT | We support Proposal 8. |
| CMCC | We support Proposal 8’, as a compromise between Option 1 and Option 2 in Proposal 8. And it’s also a balance between CSI overhead and scheduling flexibility. |
| LG | We are generally fine with proposal 8 for the progress.  However, if X=2 is supported for option 1, 2 CSIs associated with single-TRP measurement hypotheses should be associated with CMRs from two TRPs based on the previous agreement. So, it seems that more clarification is needed in proposal 8 as commented by ZTE. And, in this case, a UE should know about association between CMRs and TRPs in order to report 2 CSIs related to different TRPs. So, such association should be considered in discussion in proposal 6. If Alt1 in proposal 6 is supported, then it is not clear how to differentiate TRPs from CMRs for single TRP measurement hypotheses.  As a result, we would like to propose the following modification for the clarification.  ***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*     - *If X=2, two CSIs associated with single-TRP measurement hypotheses are associated with CMRs from two TRPs.*   + *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* |
| Spreadtrum | We support Propsoal8. |
| Futurewei | We support Proposal 8. |
| Fraunhofer IIS  Fraunhofer HHI | Support of Proposal 8. |

***Conclusion:***

* Strive to mitigate the spec impact by 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)

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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. |
| Lenovo/MotM | We are fine with the FL version of the conclusion |
| NTT DOCOMO | Based on Moderator’s comments, Option 1 is to confirm WA, and Option 2 is to enhance single CSI reporting. It seems not consistent with the Option1/2 in Conclusion. Better to exchange Option1/2 in Moderator’s comments.  For the conclusion, we are supportive of FL’s conclusion. |
| Ericsson | In the current FL conclusion, ‘supporting’ may be a bit too strong in the main bullet. Option 1 has a WA, and Option 2 still needs to be discussed. Thus, replacing ‘supporting’ with ‘discussing’ is suggested. |
| OPPO | Support the modification from Ericsson |
| Intel | Support the conclusion |
| vivo | First of all, we think the WA should be confirmed since the better performance for non-ideal backhaul scenario compared to Option1, i.e., Cat1. In the RAN1#103-e, we agreed to prioritize Cat1 and strive for commonality for NC-JT CSI measurement between Cat2 (WA) and Cat1. So, confirming the WA will do no harm to the progress of future work. Some observations and reasons for confirming the WA are as follows:   1. Multi-DCI is mainly used for non-ideal backhaul scenario. 2. We think it is indeed hard for network to ensure that resources are always completely non-overlapping or completely overlapping, as what we observed in our simulation. Due to overlapping uncertainty, the UE may assume fully overlapping when it wants to joint transmission to avoid the CQI mismatch. Besides, for lower RU case where the probability of PDSCHs overlapping is obviously high, if UE selects NCJT as the optimal transmission scheme, it is the best choice for network to follow as there is no other competing UEs in the area. 3. In our simulation, as shown below, Cat1 has a large performance loss than Cat2.   Some evaluation results in non-ideal backhaul scenarios (with 5ms and 50ms backhaul delay) are as following for reference. From the results, UE recommendation of transmission scheme to different TRPs would help the different TRPs to schedule independently and make the feature more usable in real deployment.  Table 1: Indoor Hotspot with non-ideal backhaul   |  |  |  |  | | --- | --- | --- | --- | | FR1, RU for STRP (16%) | Mean UPT | 5% UPT | 50% UPT | | STRP | -32.52% | -28.20% | -25.33% | | DPS | -24.41% | -6.58% | -13.85% | | Legacy CSI | -4.49% | -8.37% | -6.67% | | Cat2 | 0.00% | 0.00% | 0.00% | | Cat1 (5ms) | -4.69% | -6.96% | -7.57% | | Cat1 (50ms) | -21.51% | -37.50% | -29.88% |  |  |  |  |  | | --- | --- | --- | --- | | FR1, RU for STRP (38%) | Mean UPT | 5% UPT | 50% UPT | | STRP | -31.63% | -35.61% | -30.45% | | DPS | -14.43% | -13.14% | -7.06% | | Legacy CSI | -12.31% | -13.41% | -15.24% | | Cat2 | 0.00% | 0.00% | 0.00% | | Cat1 (5ms) | -12.43% | -15.91% | -13.79% | | Cat1 (50ms) | -35.44% | -45.29% | -38.42% |   Table 2: Dense Urban with non-ideal backhaul   |  |  |  |  | | --- | --- | --- | --- | | FR1, RU for STRP (14%) | Mean UPT | 5% UPT | 50% UPT | | STRP | -13.33% | -13.85% | -9.61% | | DPS | -12.11% | -6.53% | -9.61% | | Legacy CSI | -5.36% | -11.18% | -7.84% | | Cat2 | 0.00% | 0.00% | 0.00% | | Cat1 (5ms) | -2.52% | -5.85% | -4.08% | | Cat1 (50ms) | -10.38% | -33.48% | -14.92% |  |  |  |  |  | | --- | --- | --- | --- | | FR1, RU for STRP (25%) | Mean UPT | 5% UPT | 50% UPT | | STRP | -8.53% | -13.78% | -4.05% | | DPS | -6.51% | -7.41% | -1.22% | | Legacy CSI | -4.66% | -11.56% | -4.05% | | Cat2 | 0.00% | 0.00% | 0.00% | | Cat1 (5ms) | -3.66% | -8.60% | -4.28% | | Cat1 (50ms) | -16.34% | -36.95% | -21.17% |   Some illustration of evaluated schemes:   |  |  |  |  | | --- | --- | --- | --- | | Scheme | CSI report | Scheduling | UE’s working mode | | STRP | STRP CSI report to the serving TRP | UE scheduled by serving TRP | STRP | | DPS | Cat2 framework: DPS CSI report to both TRPs | Independent scheduling | DPS | | Legacy CSI\* | Two CSI report settings in legacy CSI framework: each with a STRP CSI report to its corresponding TRP | Independent scheduling | DPS or NCJT | | Cat2 | Cat2 framework: UE selected NCJT CSI or DPS CSI report to both TRPs | Independent scheduling | DPS or NCJT | | Cat1 (5ms) | Cat1 framework: UE selected NCJT CSI or DPS CSI report to a single TRP, CSI exchange with 5ms latency | Independent scheduling | DPS or NCJT | | Cat1 (50ms) | Cat1 framework: UE selected NCJT CSI or DPS CSI report to a single TRP, CSI exchange with 50ms latency | Independent scheduling | DPS or NCJT |   Secondly, we don’t see very strong need to downselect one out of Option1 and Option2. If we have to downselect, we think we cannot only strive to mitigate the spec impact, but also need to consider other aspects such as performance, applicable scenarios. In our opinion, Option 1 can work for ideal backhaul, Option 2 can work for both ideal-backhaul and non-ideal backhaul. Besides, the down-selection can be earlier if possible. Some modifications for conclusion as follow:  ***Conclusion:***   * Downselect from the following to support one of the options for M-DCI based NCJT enhancement ~~Strive to mitigate the spec impact by 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 105~~6~~e (May ~~August~~ 2021) * Note: The WA is the default assumption without further decision on this issue. |
| CATT | Support FL’s conclusion. |
| CMCC | Support the modification from Ericsson. |
| LG | We are fine with FL’s conclusion. |
| Nokia/NSB2 | It may be worth clarifying in this conclusion what is the main difference between the two options. In our understanding:   * Option1: a single reporting setting with two PUCCH/PUSCH resources for CSI reporting. 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: two reporting settings with one PUCCH/PUSCH resource for CSI reporting (WA in RAN1#103e) |
| Spreadtrum | We are fine with both option 1 and option 2. They could be applied for different scenarios,  e.g., option 1 more for ideal backhaul, and option 2 more for non-ideal backhaul.  But we agree with FL’s assessment that it is difficulty to make decision at this stage. We are  fine with FL’s conclusion.  Re Nokia’s question, in our understanding:   * + Option1: a single reporting setting with one or two PUCCH/PUSCH resources for CSI reporting. 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: two reporting settings with one or two PUCCH/PUSCH resource for CSI reporting (WA in RAN1#103e) |
| Futurewei | Support FL’s conclusion. |