**3GPP TSG RAN WG1 #118 R1-2407279**

**Maastricht, The Netherlands, August 19th – 23rd, 2024**

**Agenda item:** 9.2.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#2 on Rel-19 CSI enhancements: Round 2

**Document for:** Discussion and Decision

## Introduction

The scope given in the Rel-19 NR MIMO Phase 5 WID pertaining to CSI enhancement is as follows:

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| 1. Specify CSI support for up to 128 CSI-RS ports, targeting FR1    1. Type-I codebook refinement supporting up to a total of 128 CSI-RS ports across all resources, assuming legacy CSI-RS resources (with up to 32 CSI-RS ports per resource), based on extension of legacy codebooks    2. Type-II codebook refinement supporting up to a total of 128 CSI-RS ports across all resources, assuming legacy CSI-RS resources (with up to 32 CSI-RS ports per resource), based on extension of legacy codebooks, **without modifying any codebook parameter other than** introducing additional values for the number of ports codebook parameter(s)    3. Extension of CRI(s)-based CSI reporting (CQI/PMI/RI calculated per CRI for ≥1 CRIs) for hybrid beamforming supporting up to a total of 128 CSI-RS ports across all resources, with up to 32 CSI-RS ports per resource, without new codebook design 2. Specify UE reporting enhancement for CJT deployments under non-ideal synchronization and backhaul, targeting FR1, both FDD and TDD 3. Inter-TRP time misalignment and frequency/phase offset measurement and reporting, assuming legacy CSI-RS design, with stand-alone aperiodic reporting on PUSCH |

## Summary of companies’ proposals and views

***Ground rules in sharing your inputs:***

* **Please do NOT input anything in Tables 1A, 2A, and 3A**
  + **Including company names - appreciate your trying to save me some work, but …**
  + **For some reason, most likely due to poor MS Word inter-platform/version compatibility support (if any), the formatting of the FL proposals will change (for the worse) if you do so. This has happened several times in Athens and Changsha ☹**
* **Please input your comments ONLY in Tables 1C, 2C, and 3C, thanks! 😊**

### Issue 1 (WID objective 2a and 2b): Type-I and Type-II codebook refinement for up to 128 CSI-RS ports

Table 1A Summary: issue 1

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| **#** | **Issue/proposal** | **Companies’ views** |
| 1.2.1 | **Proposal 1.B.1**: For the Rel-19 Type-I SP and Type-II codebook refinements (except based on Rel-18 Type-II Doppler) for 48, 64, and 128 CSI-RS ports, active resource counting is:   * FFS: For Capability 1 timeline: 1 vs K * For Capability 2 timeline: 1   **FL assessment**: This was discussed OFFLINE [2].  Since Capability 2 is quite (too) relaxed, there is no reason to further relax both OCPU and ARC for Capability 2.  For ARC, since the increase in the total # antenna ports (to up to 128) will be addressed in the ‘triplet’, there doesn’t seem any need to double-book this (mostly relevant to measurement buffering) in ARC (hence 1 should be more fitting, and K is excessive). Hence legacy in FG 2-33 can be interpreted as “Ks=1” (post aggregation) rather than “Ks=K”(pre-aggregation) | **1:**  **Support/fine:** Ericsson, Nokia/NSB, ZTE, Fraunhofer IIS/HHI, Intel, TCL, Samsung, vivo, Google, CATT, Qualcomm, NTT DOCOMO, Xiaomi, HONOR, Lenovo/MotM (Cap2), Spreadtrum, CMCC, Sharp, OPPO, MediaTek, NEC, New H3C, KDDI, Kyocera,  **Concern:** Huawei/HiSi, Fujitsu (Cap1), Apple (Cap1)  **K:**  **Support/fine:** Huawei/HiSi, Fujitsu (Cap1), Apple (Cap1), Samsung (2nd), vivo, OPPO, Google (Cap 1), Lenovo/MotM (Cap1),  **Concern:** Qualcomm  **1 and K (UE indicates):**  **Support/fine:** Apple, Fujitsu, Qualcomm,  **Concern:** Huawei/HiSi, Samsung, Ericsson, CMCC, vivo, |
| 1.3.1 | **[117] Agreement**  For the Rel-19 Type-I codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=v=1, support the following:   * for each group of SD basis vectors, a 3-bit scaling factor can be NW-configured via higher-layer (RRC) signalling, where the scaling factors are defined as scalings on the power control offset configured for the associated CSI-RS resources   + The values of and for this feature are separately configured from those for CBSR   + Separate configuration (RRC signalling) from CBSR   + The candidate values of and are the same as those agreed for CBSR * The codepoints of each of the group-specific 3-bit scaling factors are mapped to values of * Note: This feature is a separate UE capability   FFS: Whether this can be extended to RI=v>1 …  **Question 1.C.1**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding the 3-bit scaling factor, please share your view whether this can be extended to RI=v>1 (and provide justification)  **Yes**: Ericsson, Nokia/NSB,  **No**: IDC, TCL, OPPO, Xiaomi, Huawei/HiSi, ZTE, Fujitsu,  **Need more discussion/study**: Qualcomm, CMCC, Samsung, Apple, NTT DOCOMO, Xiaomi (ok), HONOR, Google, Lenovo/MotM, Fraunhofer IIS/HHI,  **FL assessment**: This FFS needs resolution | |
| 1.3.3 | **[117] Agreement**  For the 3-bit scaling scheme for Type-I codebook, the following (X1, X2) values are supported: (2,1), (2,2), (4,1), (4,2), (4,4),   * FFS: … (8,1)   **Proposal 1.C.3**: For the 3-bit scaling scheme for Type-I SP codebook, support, in addition, (X1, X2)=(8,1)  **FL assessment**: This FFS needs resolution. | **Support/fine:** Ericsson, Samsung, Apple, ZTE (ok), Google,  **Not support:** TCL, Nokia/NSB, HONOR |
| 1.3.4 | **Proposal 1.C.4**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, conditioned in UE capabilities, a UE can be configured with either the group-based hard CBSR, or the 3-bit SD basis group-based scaling factor, or both, or none of the two  **FL assessment**: Since the two are separate UE features, it is natural that they can be configured together. | **Support/fine:** ZTE, Google, Qualcomm, Ericsson, Lenovo/MotM Huawei/HiSi,  **Not support:** MediaTek |
| 1.5.2 | |  |  |  | | --- | --- | --- | | First SD basis vector selection indicator | Part 2  Wideband | *v*=5-8: Decide (by RAN1#118) Alt1 vs Alt2  Alt1. Same as legacy Rel-15 Type-I SP, separate (i1, i2) indicators of bits and bits, respectively    Alt2: Separate (i1, i2) indicators of bits and bits, respectively; and separate (q1, q2) indicators of bits and bits, respectively. |   **Question 1.E.5**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding first SD basis vector selection indicator for Scheme-A for RI=5-8, please share your preference:   * Alt1: * Alt2: Tejas, ZTE   **FL assessment**: Since Alt1 can be perceived as the baseline per legacy design | |
| 1.5.3 | **[117] Agreement**  For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports with RI=5-8, support the following schemes:   * The same O1=O2 value(s) as RI=1-4 are supported * Scheme-A (based on Scheme3 described in RAN1#116bis):   + W1 structure:     - The 1st SD basis vector is freely selected and subsequent 2 (RI=5-6) or 3 SD basis vectors (RI=7-8) are freely selected such that they are orthogonal in at least one dimension (horizontal or vertical).     - …   **Proposal 1.E.3**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, for Scheme-A RI=5-8, by RAN1#118, decide, from the following alternatives, the second SD basis vector selection scheme (in Part 2 UCI, wideband):   * Alt1: -bit () and -bit () indicators for each of the *nSDBV* other selected SD basis vectors, and the (q1,q2) for the *nSDBV* other selected SD basis vectors is indicated via a 1-bit flag f∈{0,1}, and a q2 (if f=0) or q1 (if f=1)   + f=0 indicates q1 is same as the first SD basis vector   + f=1 indicates q2 is same as the first SD basis vector * Alt2: -bit indicator for each of the *nSDBV* other selected SD basis vectors * Alt3: -bit indicator, selecting *nSDBV* SD basis vectors from the beams orthogonal to first beam * Alt4: -bit () and -bit () indicators for each of the *nSDBV* other selected SD basis vectors, and One-bit orthogonal beam group indicator, and separate indicator per SD basis vector, with   + , , if , or   + , , if   Other alternatives are not precluded  Note (from previous agreement): *nSDBV*=2 (*v*=5-6) or 3 (*v*=7-8)  **FL assessment**: This needs to be resolved. The previous agreement leaves the details on indication open. While there are other slightly different alternatives, the above represent the ones that are aligned with the previous agreement and specific enough not to leave any open issue.  Alt1: ZTE, Qualcomm, Ericsson, MediaTek, Fujitsu, Google, Lenovo/MotM, Fraunhofer IIS/HHI, Tejas, Intel,  Alt2: Xiaomi, vivo  Alt3: Huawei/HiSi, Samsung, vivo   * Concern (combinatorial memory): Qualcomm, MediaTek, Fraunhofer IIS/HHI,   Alt4: Nokia/NSB, | **Support/fine**: Huawei/HiSi, vivo, Xiaomi, ZTE, Nokia/NSB, Qualcomm, Samsung, Ericsson, MediaTek, Fujitsu, Google, Lenovo/MotM, Fraunhofer IIS/HHI, Tejas,  **Not support**: |
| 1.5.4 | **Proposal 1.E.4**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, the UCI parameters are captured in the tables below for Scheme-B for RI=5-8:   * Note: The second column includes the location of the parameters when reported with two-part UCI   **Scheme-B**   |  |  |  | | --- | --- | --- | | Parameter | UCI | Details/description | | SD basis oversampling (rotation) factor q1, q2 | Part 2  Wideband | *v*=5-8: Values of q1, q2 follow Rel-16 eType-II, bit indicator | | SD basis vector selection indicator for each layer | Part 2  Wideband | *v*=5-8: bit indicator, where *LG*=3 for *v*=5-6, and 4 for *v*=7-8 | | Inter-pol co-phase selection indicator for each layer | Part 2  Wideband or Subband (\*\*) | *v*=5-8: QPSK: 2-bit indicator per layer group *l=*1*, …,* |   (\*): Not included when CQI reporting granularity is set to ‘wideband’  (\*\*): Wideband when PMI reporting is set to ‘wideband’, Subband when PMI reporting granularity is set to ‘subband’  **FL assessment**: This list is to complete UCI design for Type-I SP Scheme-B RI=5-8 | **Support/fine**:  **Not support**: |
| 1.9 | **Proposal 1.I**: For the Rel-19 Type-I SP and MP codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=*v*>1, for each PMI sub-band, UE shall select a recommended *P*-by-*v* precoder matrix (associated with the reported PMI) with *v* orthogonal columns.  **FL assessment**: This is to ensure orthogonality constraint for Type-I is maintained. It is argued that this is especially crucial for SU-MIMO where the gNB typically follows the recommended PMI. | **Support/fine:** Qualcomm,  **Not support:** |
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Table 1B SLS results: issue 1

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| **Company** | **SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| Huawei/HiSi | Other (SRS port grouping) | Normalized throughput (LLS) | *It is observed in Figure 4 that 43% performance gain can be achieved by PDSCH reception with SRS port grouping compared to max Rank-4. The performance of 8R rank-8 is also shown in the figure as an upper bound, which is difficult to be implemented due to the high complexity currently.* *Moreover, it can be observed from figure 9 that the performance of low complexity receiver (two antenna groups) without SRS port grouping enhancement is very poor even at high SNR.*    Figure 4 Performance of 8Rx UE with different receiver schemes under practical interference |
| Samsung | Other (SRS port grouping) | Avg UPT gain | *The case of low complexity 8 RX receiver w/o SRS port grouping incurs 65% UPT loss com-pared to 4RX scenario. This basically implies that it is not possible to work for RI>4 without SRS port grouping assumption for low-complexity 8RX receiver* |
| Ericsson | 1.3.1 | Mean user throughput gain, 5%-tile throughput gain | *The table below shows the relative throughput gain of different schemes at 50% and 70% resource utilization. As seen in the result, such an approach provides large throughput gains.* |
| 1.3.3 | Mean user throughput gain, 5%-tile throughput gain | *In the table below, it is shown that the impact of using a group size larger than 1 along the dimension, i.e., . As seen in the results, the mean and 5th-percentile throughput decrease with increasing group sizes along the dimension.* |

Table 1C Additional inputs: issue 1

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| **Company** | **Input** |
| Ericsson | **Question 1.C.1**  @OPPO: Some replies regarding your comment ‘Prefer RI=1 only. The signaling overhead and performance impact to RI>1 is more significant than RI=1.’, There is no additional signaling overhead for supporting this feature for RI>1. The 3-bit scaling factors are signaled per groups of beams once, and the same ignallin per groups of beams are used for the cases of RI=1 and RI>1. Regarding performance, we showed performance gains of 20-25% in mean throughput gain for using this feature with RI>1 over a baseline solution based on network implementation (results copied below).    @Qualcomm/Samsung: If the beams corresponding to different layers for RI>1 are chosen from the same beam group, then the power between layers will still be equal. But if the beams corresponding to different layers are chosen from different beam groups, the power between layers may be different. As shown in our paper, one way to determine the power scaling factor to be applied for the beam is , where denotes the amplitude scaling factor signalled for the beam and is the number of layers that are transmitted using the beam. But how exactly to do this can be left to UE implementation. If there are concerns with implementation deviating from legacy approach, we suggest to make support of this feature for RI>1 as a UE capability.  **Question 1.C.3**:  We hare evaluation results showing the benefit of supporting which are copied below. Supporting gives the network to ignalling the scaling factor to be signalled with finer resolution in the second dimension when compared to for example . Based on the results, we suggest to support . |
| Ericsson2 | **Question 1.C.1**  Some responses to Google’s question. In our understanding, the sqrt(v) is excluded from the signaled 3-bit scaling factors. Regarding power boosting, we are not considering any power boosting for layers without power scaling.  **Question 1.C.4**:  In our understanding, the group-based hard CBSR and the 3-bit SD basis group-based scaling factors are independent features. If a UE is capable of supporting both, then it should be possible to configure the UE with both. |
| Samsung | **Proposal 1.E.3**  Support the proposal.  In our view, feedback overhead should be prioritized to decide the indicator, since Scheme-A is designed aiming for an ‘eco’ mode and the ordering info isn’t really beneficial in companies’ previous results.  Based on the overhead analysis below, we prefer Alt3 which has the smallest overhead for all configurations of (N1,N2) among all alternatives.     |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | (N1,N2) | (8,3) | (6,4) | (16,2) | (8,4) | (16,4) | (8,8) | | Alt1 | 22 | 22 | 22 | 22 | 25 | 25 | | Alt2 | 24 | 24 | 24 | 24 | 27 | 27 | | Alt3 | 19 | 19 | 20 | 21 | 24 | 24 |      |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | (N1,N2) | (8,3) | (6,4) | (16,2) | (8,4) | (16,4) | (8,8) | | Alt1 | 15 | 15 | 15 | 15 | 17 | 17 | | Alt2 | 16 | 16 | 16 | 16 | 18 | 18 | | Alt3 | 14 | 14 | 14 | 15 | 17 | 17 |   Regarding the combinatorial indicator, there are implementation ways to design large combinatorial values using small combinatorial values only in the current table of the spec (via Vandermonde identity). So, a large table is not needed and it shouldn’t be an issue, in terms of both memory and computational complexity. |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 1A**  **Please check the counter-arguments from Ericsson re 1.C.x and Samsung re 1.E.3** |
| Fraunhofer IIS/HHI | **Proposal 1.E.3**:  Re proposal 1.E.3, we think Alt 1 is incomplete as the details related to the indication of the selected SD basis vector (not from the orthogonal beam group) is not included.  Re Alt 1/Alt 4, we think there is no need to indicate the selected SD basis vectors per dimension separately (as in Alt 4 or in Alt 1) or jointly using a bit indicator per SD basis vector (as mentioned by Mediatek), as both options result in higher feedback overhead compared to Alt 3. However, Alt 3 is complex due to the large number of combinations. To overcome the complexity concerns of Alt 3 and overhead concerns of Alt 1/Alt 4, we propose the following joint (compromise) proposal combining Alt1/Alt 4 and Alt 3, where a single joint indicator (as in Scheme B) is used to indicate the *nSDBV SD* basis vectors jointly.  **Joint proposal:**  A -bit indicator to indicate the *nSDBV* selected SD basis vectors, and the (q1,q2) for the *nSDBV* selected SD basis vectors is indicated via a 1-bit flag f∈{0,1}, and a q2 (if f=0) or q1 (if f=1)   * + f=0 indicates q1 is same as the first SD basis vector   + f=1 indicates q2 is same as the first SD basis vector   and a -bit indicator to indicate the rotation factor where if and if .  We request FL to consider this joint proposal for further discussion. |
| vivo | **1.C.4**  This proposal has no specification impact, correct? This is just to confirm that these two RRC parameters can work independently.  **1.E.5**  We support Alt 1, which is same as legacy approach. We are not sure about the reason to have a new design.  **1.E.3**  On the detailed alternatives, we are wondering the reasoning or motivation to have Alt1 and Alt 4.  If the goal is to save overhead, we should go for Alt 3 as it has the smallest overhead.  If several bits overhead is not an issue, we should go for Alt 2, which is the simplest and straight-forward one.  **1.I**  Our view is inter-layer orthogonality is not essential. Further, it is not needed to have such restriction for UE implementation. It is anyway up to UE what to select as PMI. |
| Ericsson3 | **Question 1.C.1**  We’d like to share some new results that we have in our revised contribution R1-2407308. New results have been added in Table 2 of R1-2407308 and shows the performance difference between the following cases:   * Case 1:  applying the 3-bit scaling factor to only RI=1 at the UE side * Case 2:  applying the 3-bit scaling factor to both RI=1 and RI>1 at the UE side   Our results (copied below) show that Case 1 does not provide gains over the network implementation based solution.  Case 2 provides the expected gains, and hence supporting our proposal to extend application of the 3-bit scaling factor to both RI=1 and RI>1 at the UE side.    As for the proposal, we can consider the following as a starting point.  Proposal:  For the Rel-19 Type-I codebook refinement for 48, 64, and 128 CSI-RS ports, for RI= >1, apply the 3-bit Scaling factor(s) as agreed in RAN1#117, where the scaling factor applied to the selected SD basis vector is given by , where is the scaling factor associated with the beam, and is the number of layers transmitted using the SD basis vector.   * Note: This feature is a separate UE capability |
| OPPO | **Question 1.E.5**:  We prefer to reuse legacy mechanism, i.e. Alt1.  **Proposal 1.E.3**:  Fine. Alt2 is not preferred due to unnecessary overhead |

### Issue 2 (WID objective 2c): CRI-based CSI for hybrid beamforming (HBF)

Table 2A Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.2.2 | **[118] Agreement**  For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding CBSR and RI restriction, support resource-specific specific CBSR   * FFS (by RAN1#118): Whether RI restriction is resource-common or resource-specific   **Proposal 2.B.2**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, support resource-common RI restriction  **FL assessment**: The above proposal is based on the majority view in [1]:   * *Resource common (same as legacy): vivo, Tejas, OPPO, CATT, Intel, Lenovo/MotM, CATT, Xiaomi NTT DOCOMO, Spreadtrum, Qualcomm* * Resource specific: Samsung, MediaTek, Ericsson, NEC, Huawei/HiSi, ZTE, Fujitsu, | **Support/fine:** vivo, Tejas, OPPO, CATT, Intel, Lenovo/MotM, CATT, Xiaomi, NTT DOCOMO, Spreadtrum, Qualcomm  **Not support:** Samsung, MediaTek, Ericsson, NEC, Huawei/HiSi, ZTE, Fujitsu, |
| 2.3.1 | **Question 2.C.1**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding UCI omission for the UCI reported *in CSI part-2*, other than priority 0 (G0), the 2M consecutive priority levels are defined w.r.t the M CRIs (including the non-reported MR CRIs).  Please share your **preference** between the two following alternatives:  as follows:   * Alt1. 2M consecutive priority levels (higher to lower):   + **Even sub-bands (G1)** associated with the **lowest CSI-RS ID** among the non-reported MR CRIs, **odd sub-bands (G2)** associated with the **lowest CSI-RS ID** among the non-reported MR CRIs,   + ...,   + **Even sub-bands (G1)** associated with the**highest CSI-RS ID**among the non-reported MR CRIs, **odd sub-bands (G2)** associated with the **highest CSI-RS ID** among the non-reported MR CRIs,   + **Even sub-bands (G1)** of the **1st reported CRI**, **odd sub-bands (G2)**of the **1st reported CRI**,   + ...,   + **Even sub-bands (G1)** of the **(M-MR)th reported CRI**,  **odd sub-bands (G2)** of the **(M-MR)th reported CRI**. * Alt2. 2M consecutive priority levels (higher to lower):   + **Even sub-bands (G1)** associated with the **lowest CSI-RS ID** among the non-reported MR CRIs, …, **even sub-bands (G1)** associated with the**highest CSI-RS ID**among the non-reported MR CRIs,   + **Odd sub-bands (G2)** associated with the **lowest CSI-RS ID** among the non-reported MR CRIs, …, **odd sub-bands (G2)** associated with the **highest CSI-RS ID** among the non-reported MR CRIs,   + **Even sub-bands (G1)** of the **1st reported CRI**, …, **even sub-bands (G1)** of the **(M-MR)th reported CRI**,   + **Odd sub-bands (G2)**of the **1st reported CRI**, …, **odd sub-bands (G2)** of the **(M-MR)th reported CRI**.   Note: For UCI fields in wideband (G0), even sub-bands (G1), and odd sub-bands (G2), legacy design is fully reused.  **Alt1** (legacy even-odd extendion): Qualcomm, Huawei/HiSi, vivo, Samsung, Intel, Fujitsu, NTT DOCOMO, Lenovo/MotM, [Ericsson]  **Alt2**: ZTE  **FL assessment**: Since UCI omission is an emergency procedure, over-optimization deviates from its design goal. Keeping this in mind, unless a design based on the legacy principles result in catastrophic failure(s), there is no reason to redesign UCI omission for this purpose. The above proposal is based on the legacy principles (Rel-15 CRI-based and Rel-17 NJCT) with the necessary modifications to accommodate M and MR. | |
| 2.3.2 | **Proposal 2.C.2**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding UCI omission for the UCI reported *in CSI part-1 (only applicable to PUCCH-based reporting and Rel-15 Type-I codebook)*, M consecutive priority levels are defined w.r.t the M CRIs (including the non-reported MR CRIs) as follows:   * (M-MR) consecutive priority levels (higher to lower): CSI part-1 of the 1st reported CRI, CSI part-1 of the 2nd reported CRI, …   + The UCI associated with the non-reported MR CRIs is assigned the highest MR priority levels, ordered based on their MR CSI-RS resource IDs (the smaller ID is reserved the higher priority level)   **FL assessment**: Since UCI omission is an emergency procedure, over-optimization deviates from its design goal. Keeping this in mind, unless a design based on the legacy principles result in catastrophic failure(s), there is no reason to redesign UCI omission for this purpose. The above proposal is based on the legacy principles (Rel-15 CRI-based and Rel-17 NJCT) with the necessary modifications to accommodate M and MR. | **Support/fine:** vivo, Qualcomm, Huawei/HiSi, Samsung, Lenovo/MotM, NTT DOCOMO, ZTE, Ericsson,  **Not support:** |
| 2.4.1 | **Proposal 2.D.1**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding timeline:   * Multiply legacy Z’ by a factor of max(M,2). * Z is increased by max(M–1),1)\*Z’ to match the increase in Z’   **FL assessment**: This proposal is a synthesis between proposals from vivo and Qualcomm | **Support/fine**: vivo, Qualcomm, Huawei/HiSi, Apple, NTT DOCOMO, LG, IDC, Spreadtrum, Qualcomm, Nokia/NSB, CMCC, Samsung, Ericsson (as long as Alt3 OCPU), Sharp, MediaTek, Lenovo/MotM (ok),  **Not support**: MediaTek (legacy), Intel (legacy), Xiaomi (legacy), HONOR (legacy), ZTE (Ks.Z’), Google (legacy), |
| 2.4.2 | **Proposal 2.D.2**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, OCPU = KS  **FL assessment**: Reusing the legacy OCPU =Ks is reasonable as long as Z/Z’ is adjusted accordingly (2.D.1) considering the extra computations needed for M>1. I is also a middle ground between Alt4/5 (less than legacy) and Alt2/6 (more than legacy).  **Question 2.D.2**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, please share your preference on the following alternatives and justify your choice:   * Alt2: OCPU = M + KS – 1 * Alt3 (legacy): OCPU = KS * Alt4: OCPU = M + 1 * Alt5: OCPU = X.M where X={1,2,3} based on UE capability * Alt6: OCPU = Ks + X.(M-1), where X={0,1} based on UE capability   **Alt2**: vivo,  **Alt3 (legacy)**: ZTE, TCL, Xiaomi, Apple, NTT DOCOMO, Qualcomm, NEC (2nd), OPPO, Spreadtrum (if 2.D.1), Nokia/NSB, Intel, CMCC, Samsung, Ericsson, HONOR, Fujitsu, Sharp,  **Alt4**: Huawei/HiSi, NEC (1st), MediaTek,  **Alt5**: Google,  **Alt6**: LG | **Support/fine**: ZTE, TCL, Xiaomi, Apple, NTT DOCOMO, Qualcomm, NEC (ok), OPPO, Spreadtrum (if 2.D.1), Nokia/NSB, Intel, CMCC, Samsung, Ericsson, HONOR, Fujitsu, Sharp, MediaTek (ok), Lenovo/MotM (ok),  **Not support**: Huawei/HiSi, LG, vivo, Google |
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Table 2B SLS results: issue 2

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Table 2C Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 2A** |
| OPPO | **Proposal 2.B.2**  Support.  **Question 2.C.1**:  We cannot see any issue to reuse the UCI omission of Rel-17 NCJT CSI, which also includes multiple CRIs and multiple CSIs. So our preference is Alt2 (but there is ambiguity on the number of consecutive priority levels, 2M or 4?). |
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### Issue 3 (WID objective 3): CJT calibration reporting for non-ideal synchronization and backhaul

Table 3A Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | **[117] Agreement**  For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), if >1 (sub-band reporting) is supported, select **one** from option 1 and option 2, by RAN1#118, from the following:   * A sub-band size is selected from {8,16} PRBs   + The sub-band size is NW-configured via higher-layer (RRC) signalling * Denoting the number of sub-bands within the configured CSI reporting band as NSB-P, and the sub-bands are indexed as {0, 1, …, NSB-P –1}, decide, by RAN1#118, from the following reporting options:   + Opt1: {(n,, n), n=0, 1, …, NTRP – 1, n≠nref}, where n,is the phase offset corresponding to sub-band 0 and the phase offset for sub-band  can be calculated as n, + n     - , where ={64, 128}   + Opt2: = NSB-P, i.e. {(n,, n,, n,NSB-P), n=0, 1, …, NTRP – 1, n≠nref}     - The alphabet for n, follows the previously agreed alphabet for =1, including the ‘invalid’ state     - The maximum NSB-P is [4]   + FFS: For all the above reporting options, the UE performs measurement over the entire configured CSI reporting band * FFS: Further restriction on CSI-RS (e.g. RE density)   Note: Companies to report whether their evaluation is based on precoded or non-precoded CSI-RS  **Proposal 3.A.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), regarding the support of sub-band reporting (>1):   * Denoting the number of reported sub-band phase-offset values as NSB-P, and the sub-bands are indexed as {0, 1, …, NSB-P –1}, support reporting, in one CSI reporting instance, {(n,, n,, n,NSB-P), n=0, 1, …, NTRP – 1, n≠nref}   + The alphabet for n, follows the previously agreed alphabet for =1, including the ‘invalid’ state * FFS (by RAN1#118):   + Supported sub-band size(s), e.g. following the legacy CSI sub-band definition, vs {4, 8, 16 PRBs}   + Whether the UE performs measurement over the entire configured CSI reporting band WCSI   + If needed, mechanism to limit CSI reporting overhead (e.g. maximum NSB-P)   Note: UE is not required to perform DO/FO compensation for sub-band phase offset calculation  **FL assessment**: This issue was discussed OFFLINE [2]. Supporting BOTH Opt1 and Opt2 have been precluded in RAN1#117 agreement – see above (therefore I will not accommodate such proposal – kindly please don’t re-propose this again 😊). | **Support/fine:** CATT, Samsung, NTT DOCOMO, Ericsson, OPPO (ok), Lenovo/MotM, Intel (ok), Apple, Fujitsu, TCL, Huawei/HiSi, Google, Sharp, KDDI, CMCC, NEC (ok), NICT, Nokia/NSB (ok), New H3C, Xiaomi (ok),  **Not support:** ZTE (Opt1), Qualcomm (Opt1), Sony (Opt1), IDC (no sub-band), vivo (no sub-band), |
| 3.2.3 | **Question 3.B.3**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), on the selection of PSRS=1 SRS port corresponding to the ‘reference UE antenna port’ (out of available port(s)), please share your preference on the following (and preferably, provide your justification):   * Scheme1: NW-configured via higher-layer (RRC) signalling   + **Support/fine**: ZTE, Apple, Huawei/HiSi, TCL, Xiaomi, IDC, CMCC, OPPO, ETRI, Samsung, Lenovo/MotM,   + **Not support:** * Scheme1B: NW dynamic selection via MAC CE or A-CSI triggering (DCI)   + **Support/fine**: Google   + **Not support:** * Scheme2: UE-selected, the selection included in the phase offset report   + **Support/fine**: vivo, ETRI,   + **Not support:** Samsung, ZTE, Lenovo/MotM, * Scheme3: Fixed rule, selecting the first (the lowest SRS port ID) out of available port(s)   + **Support/fine**: Ericsson, Samsung, Intel, Lenovo/MotM, CMCC,   + **Not support:** ZTE   **FL assessment**: This issue needs resolution | |
| 3.2.4 | **[117] Agreement**  For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset),   * For a given phase offset reporting configuration, the UE can be configured (via higher-layer/RRC signaling) with Q associated SRS resource(s) for antenna switching * … * Regarding the number of configured associated SRS resource(s) (=Q) for antenna switching xTyR, support at least Q=1 where:   + the configured associated SRS resource is selected from all the y/x SRS resources and all the configured resource set(s)   + … * Regarding how to determine the SRS port corresponding to the ‘reference UE antenna port’, support PSRS =1 SRS port selected from all the ports from the configured Q associated SRS resource(s)   + …   **Question 3.B.4**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset) and xTyR SRS , on the selection of PSRS=1 SRS port corresponding to the ‘reference UE antenna port’ (out of available port(s)), please share your view on *the available port(s)* (and preferably, provide your justification):   * The number of available port(s) = x:   + **Support/fine**:   + **Not support:** * The number of available port(s) = y:   + **Support/fine**: Qualcomm,   + **Not support:**   **FL assessment**: This issue needs resolution | |
| 3.2.5 | **Question 3.B.5**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), regarding the configured associated SRS resource, please share your view on the supported time-domain behaviour(s):   * Periodic   + **Support/fine**: CMCC,   + **Not support:** * Semi-persistent   + **Support/fine**: CMCC,   + **Not support:** * Aperiodic:   + **Support/fine**: CMCC,   + **Not support:**   **FL assessment**: This issue needs resolution before we can decide on the need for special provisions on timing relationships | |
| 3.3 | **Proposal 3.C.1**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, to facilitate UE-specific delay offset pre-compensation on PDSCH by the NW, *decide*, by RAN1#118, whether to support configuring a UE (via RRC signaling) to perform PMI calculation for the Rel-18 eType-II CJT CSI report assuming pre-compensation using the UE-reported delay offset (when ReportQuantity is ‘cjtc-Dd’). And if supported, whether any of the following is additionally supported or not:   * NW indicates the delay offset value to be compensated for the Rel-18 eType-II CJT CSI report, and/or * The two separately configured reports (i.e. Rel-18 eType-II CJT CSI report and the CJTC delay offset report) are always jointly triggered and carried on a same PUSCH (hence on a same slot) * The delay offset value to be compensated is the latest reported DO before the DCI triggering the CJT CSI reporting   Only AP-CSI-RS can be configured for the Rel-18 eType-II CJT report  The above only applies when the CMRs do not share common QCL source for average delay indication  **FL assessment**: The above proposals further enhance the utility of delay and frequency offset reporting by co-configuration with Rel-18 Type-II CJT. This was included in Round-1 summary for RAN1#117 but only discussed briefly. Assuming that companies have looked into this issue, we will discuss more in RAN1#118 and aim for decision whether to support or not, also in RAN1#118.  **UE-specific PDSCH delay offset compensation:**   * **Support/fine:** vivo, ZTE, Qualcomm, Ericsson, CATT, Nokia/NSB, IDC, Samsung (ok), Huawei/HiSi (ok), Xiaomi, * **Not support:** MediaTek, OPPO, Intel, Apple (too early),   **UE-specific PDSCH frequency offset compensation:**   * **Support/fine:** vivo, ZTE, Ericsson, Samsung (ok), Xiaomi, * **Not support:** MediaTek, CATT, OPPO, Qualcomm, Nokia/NSB, Intel, Apple (too early), Huawei/HiSi (ok), | **Support/fine:** vivo, ZTE, Qualcomm, Ericsson, CATT, Nokia/NSB, IDC, Huawei/HiSi, MediaTek, Samsung, OPPO, Intel, Apple, Xiaomi, Sony, Fujitsu, Google, Sharp, Lenovo/MotM,  **Not support:** |
| 3.4.2 | **Any change of view from ‘not support’ to ‘support/fine’ per the resolution of issue 3.1?**  **Proposal 3.D.2:** For the Rel-19 aperiodic standalone CJT calibration reporting, support joint Dd + phase offset (PO) reporting as follows:   * Only wideband (=1) PO is supported * No further optimization of CSI reporting format, e.g. configurability of not reporting {dn} * The UCI parameters are captured in the table below   *When ReportQuantity is ‘cjtc-Dd-P’ (joint Doffset+d and PO)*   |  |  | | --- | --- | | Parameter | Details/description | | nref1 | Reference TRS resource set index for Doffset+d, based on the ordering from RRC configuration:  bits | | nref2 | Reference TRS resource set index for FO, based on the ordering from RRC configuration: bits | | {Dn,offset,  n=0, 1, …, NTRP – 1 n≠nref1} | Delay offset for CSI-RS resource n:  bits | | {dn,  n=0, 1, …, NTRP – 1, n≠nref1 } | 1-bit inside/outside indicator for CSI-RS resource set n: bits | | {POn ,  n=0, 1, …, NTRP –1, n≠nref2} | Wideband phase offset for CSI-RS resource n:  bits |  * The UCI mapping order is as follows:   + nref1,   + nref2,   + {Dn,offset, n=0, 1, …, NTRP – 1, n≠nref} ordered from the lowest to highest CSI-RS resource set ID,   + {dn, n=0, 1, …, N TRP – 1, n≠nref} ordered from the lowest to highest CSI-RS resource set ID   + {POn, n=0, 1, …, NTRP – 1, n≠nref} ordered from the lowest to highest CSI-RS resource ID,   **FL assessment**: This issue was discussed OFFLINE [2] and since RAN1#117. The situation hasn’t changed (even more opposing companies)  Summary:  Joint Dd + wideband PO reporting:   * Support/fine: OPPO (if SB PO not supported), vivo, Qualcomm, Sony (if SB PO not supported), Samsung (ok), * Not support: Huawei/HiSi, Lenovo/MotM, MediaTek, NTT DOCOMO, Ericsson, NEC, Intel, Apple, Fujitsu, TCL, Huawei/HiSi, Xiaomi, IDC, Sharp, KDDI, CMCC, ETRI, | **Support/fine:** Qualcomm, OPPO, vivo, Sony, Samsung (ok), Google,  **Not support**: Huawei/HiSi, Lenovo/MotM, MediaTek, NTT DOCOMO, Ericsson, NEC, Intel, Apple, Fujitsu, TCL, Huawei/HiSi, Xiaomi, IDC, Sharp, KDDI, CMCC, ETRI, |
| 3.4.3 | **Proposal 3.D.3:** For the Rel-19 aperiodic standalone CJT calibration reporting, support reporting, in one CSI reporting instance, L1-RSRPs associated with the configured NTRP CSI-RS resources and the following CJT calibration report type:   * ReportQuantity is ‘cjtc-Dd’ (delay offset), or * ReportQuantity is ‘cjtc-F’ (frequency offset), or * ReportQuantity is ‘cjtc-Dd-F’ (delay+frequency offset), or * ReportQuantity is ‘cjtc-P’ (DL/UL phase offset)   Regarding the L1-RSRP:   * The legacy L1-RSRP is fully reused, where the L1-RSRP associated with nref is the reference for the other (NTRP-1) differential L1-RSRP(s)   + The NTRP CRI(s) are not reported * FFS: Whether this is supported via a new ReportQuantity or a joint CSI request/triggering   **FL assessment**: This proposal is an optimization primarily for TRP selection (which utilizes both RSRP and CJTC report) | **Support/fine:** NEC  **Not support**: |
| 3.5.2 | **Proposal 3.E.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the resolution for delay offset reporting Dn,offset, additionally support MD = {128, 256}  **FL assessment**: This proposal is to enable higher delay offset resolution | **Support/fine:** Qualcomm  **Not support**: |
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Table 3B LLS/SLS results: issue 3

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| **Company** | **LLS/SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| ZTE | 3.3 | Average UPT and cell-edge UPT | *The figure below shows the SLS performance evaluation results for non-compensated CJT and UE-specific DO/FO pre-compensated CJT. It is observed that, the UE-specific DO/FO pre-compensation provides 56.41% throughput gain for cell-edge UE and 17.81 throughput gain in average.* |
| vivo | 3.1 | Cell mean SE | *The following observation can be obtained by the simulation results below.*   * *For 8Tx per TRP and 2Rx per UE, when residual TE is 20ns and residual PE is 0.05pi, there is more than 5% performance loss. And, with the increase of residual error, the performance loss also increases.* * *When the number of Tx per TRP and the number of Rx per UE are doubled, even if the residual TE is 80ns, the performance loss is less than 5%.*     *The comparison of SE performance for different maximum residual phase errors and maximum residual timing errors*    *The comparison of SE performance for different maximum residual phase errors and maximum residual timing errors* |
| 3.3 | Cell mean SE | *The following observation can be obtained by the simulation results below.*   * *UE compensation achieves larger performance gains of mort than 7% compared to the baseline.* * *gNB compensation using UE-specific CSI-RS has the worst performance gain. Compared to UE compensation, the performance loss is about 11% at 30k SCS and about 30% at 15k SCS. This is mainly due to the impact of more RS overhead on the data transmission.* * *gNB compensation of the average DO value does not result in a significant performance gain, compared to no DO compensation.*     *The comparison of SE performance for different approaches*  *The comparison of SE performance for different approaches* |
| CATT | 3.1 | Average throughput gain vs overhead | *The performances of different reporting options versus overhead in precoded/non-precoded CSI-RS scenario, with ideal/realistic channel estimation are shown in Figure 1 to Figure 4 below, respectively. It is observed that Opt2 with 4 reporting subbands outperforms Opt1 and baseline scheme in all cases.*    ***Figure 1 Performances of different reporting options in precoded CSI-RS scenario with ideal channel estimation***    ***Figure 2 Performances of different reporting options in non-precoded CSI-RS scenario with ideal channel estimation***    ***Figure 3 Performances of different reporting options in precoded CSI-RS scenario with realistic channel estimation***    ***Figure 4 Performances of different reporting options in non-precoded CSI-RS scenario with realistic channel estimation*** |
| Sony | 3.1 | Average throughput | *As shown in the figure below, 4% throughput gain of SB PO is observed over WB PO in a LLS simulation.* |
| Samsung | 3.1 | Avg UPT gain vs overhead | *For (a) non-precoded CSI-RS transmission approach:*   * *Even in an intra-site inter-cell scenario where channel frequency-selectivity across TRPs is very mild, the performance degradation of option 1 is significant (6% loss from the ideal case) whereas option 2 incurs only 1% loss from the ideal case when Nsb=8.*   *For (b) BFed CSI-RS transmission approach,*   * *option 1 (6~7% loss at 0-6 dB SNR regime) is vulnerable to measurement error compared to option 2 (2-5% loss at 0-6dB SNR regime), due to the underlying assumption of linear phase drift for option 1 being broken at low SNR regime.*       *For (a) non-precoded CSI-RS transmission approach, in an inter-site inter-cell scenario,* *UPT loss for option 1 is observed, in the figure below, compared to WB PO reporting due to large difference of channel frequency selectivity across TRPs, which results in that the underlying assumption of linear phase drift in FD for option 1 does not hold.* |
| Nokia/NSB | 3.3 | Mean UE throughput vs overhead | *It is shown in the SLS results below that ~4% performance loss is encountered in the one-sided case compared to no delay compensation, due to the mismatch between the channel seen by the PDSCH (after precoder compensation at gNB side) and the PMI actually calculated at UE side.*    ***Performance comparison with and without delay compensation of CSI-RS resources at the UE side for CSI calculation. Delay compensation is also applied at the gNB to calculate PDSCH precoder.*** |
| 3.1/3.2 | Average UE throughput and cell-edge UE throughput | *Simulation results below comparing wideband and subband phase offset calibration reporting for a non-MRT-precoded CSI-RS network implementation show that wideband PO calibration reporting allows to recover virtually all the performance loss caused by inter-TRP PO misalignment and subband reporting does not provide any additional benefit.*   |  |  | | --- | --- | |  |  |   ***Comparison between wideband and subband PO measured from one receive antenna. Network implementation with non-MRT-precoded CSI-RS for calibration measurement*.**  *Simulation results below comparing wideband phase offset calibration reporting with multiple UE receive antennas, for a non-MRT-precoded CSI-RS network implementation, show that a single antenna wideband PO calibration reporting allows to recover virtually all the performance loss caused by inter-TRP PO misalignment if the UE antenna radiation patter is assumed isotropic and without blockages*    ***Comparison between wideband PO calculation measured from one or more UE antennas. Network implementation with non-MRT-precoded CSI-RS for calibration measurement.***  *The performance by reporting subband PO calibration measurement averaged over multiple UE antennas was also evaluated, by using a non-MRT-precoded CSI-RS network implementation. The combination of these two features does not provide any significant improvement in performance, as shown in the figures below.*    ***Comparison between subband PO calibration measured from one or more receive antennas. Network implementation with non-MRT-precoded CSI-RS for calibration measurement.*** |
| Ericsson | 3.3 | Throughput vs SNR | *Comparing the CJT performance with and without UE side DO/FO pre-compensation, the simulation results below demonstrate a 15% performance gain at SNR 10 dB with DO/FO pre-compensation.*    *The figure below provides simulation results which illustrate that synchronizing CJT PMI reporting periodicity and DO/FO reporting periodicity does not provide any meaningful performance gain over the case when CJT PMI reporting periodicity and DO/FO reporting periodicity are different.* |
| 3.1 | Throughput vs SNR | *The figure below shows the performance impact by selecting two sets of subbands for subband phase offset reporting with subband size=8RBs. It can be seen that there is a large performance degradation when a wrong set of subbands are selected for subband phase offset reporting.*    ***Option 2 subband phase reporting with two different sets of subbands {2,3,4,5} vs {1,2,3,4}. Subband size = 8.*** |
| Qualcomm | 3.1 | Relative UPT vs DL SNR | *From the LLS results below, the following observations can be made:*   * *For CJT-TDD Scheme-A (FD-precoded CSI-RSs), Opt1 (phase+delay/TAE) outperforms the case of all 16 subbands (which is with massive UCI overhead).* * *For the proposed “artificial” restriction on # subbands, it may not work for some large-BW case.* * *For CJT-TDD Scheme-B (FD-non-precoded CSI-RS), the benefit of Opt1 (phase+delay/TAE) over Opt2 (subband phase) is reduced.*   A graph of different types of data  Description automatically generated with medium confidence |
| 3.2 | Relative UPT vs DL SNR | *From the LLS results below, the following observation can be made.*   * *For CJT-TDD Scheme-A (FD-precoded CSI-RSs), UE combining of >1 antenna ports provide performance gain over single antenna port.* * *For CJT-TDD Scheme-B (FD-non-precoded CSI-RSs), UE combining does not provide significant benefit over single antenna port.*   A graph of different colored lines  Description automatically generated with medium confidence |
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Table 3C Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 3A** |
| vivo | 3.B.3  We are okay with Alt 1, which is NW configured, as well.  3.C.1  On the detailed mechanism to achieve linkage, we think the first step is to link the CJT PMI report config and CJTC DO report in RRC, for example, gNB can configure the linked CJTC DO report config in the CJT PMI report config. Then a basic way is to trigger these two CSI reports separately. Then UE will use a latest CJTC DO reporting before the reference resource of the CJT PMI reporting for the calculation of CJT PMI. With this as a baseline, we can further discuss whether some further enhancement on triggering of these two reports can be supported. For example, if one CJTC DO report and one CJT PMI report are jointly triggered, the calculation of CJT PMI reporting is based on the reported DO of the CJTC report. |
| OPPO | **Question 3.B.3**:  We are fine with either Alt1 or Alt3  **Question 3.B.4**:  Since only Q=1 was agreed by now, available port(s) = x should be a natural choice.  **Proposal 3.D.2:**  With current proposal 3.A.1, we don’t think it is needed. |
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# References

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| 1 | RP-240087 | Revised WID: NR MIMO Phase 5 | Samsung (Moderator) |
| 2 | R1-2406643 | Moderator Summary for OFFLINE discussion on Rel-19 CSI enhancements | Moderator (Samsung) |
| 3 |  |  |  |
| 4 |  |  |  |