**3GPP TSG RAN WG1 #117 R1-2405484**

**Fukuoka, Japan, May 20th – 24th, 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** |
| 1.1.1 | **Proposal 1.A.1**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, Scheme-A and Scheme-B are two separate UE features, where Scheme-A is a basic UE feature of Rel-19 Type-I SP CSI  **FL assessment**: This seems to be a common understanding and can be agreed now. | **Support/fine**: Qualcomm, Samsung, OPPO, NTT DOCOMO, Fujitsu, MediaTek,  **Not support:** ZTE, Huawei/HiSi |
| 1.1.2 | **Proposal 1.A.2**: For a UE configured with a total of PSRS=6 or 8 ports across ≥1 SRS resources for antenna switching intended for xT6R or xT8R, respectively, support the following fixed SRS port grouping where (with the PSRS ports indexed in an ascending order according to SRS resource ID and port number within each SRS resource):   * SRS port group 0, corresponding to CW0, comprises the first PSRS/2 out of PSRS ports; and * SRS port group 1, corresponding to CW1, comprises the second PSRS/2 out of PSRS ports   No other spec enhancement is introduced, e.g. new CW-to-layer mapping, DL resource allocation, DCI format  This feature applies when reportQuantity = ‘cri-RI-CQI’  Note: The above grouping assumption is to align NW and UE on the association between SRS ports and reported CQIs for the two CWs.  Note: different SRS ports are associated with different UE antenna ports.  Note: if one single CW is scheduled, both SRS port groups can correspond to the same CW  Note: This feature is a separate UE capability and, for UEs supporting this capability, configured via RRC (FFS details on the extend of RRC configuration)  **FL assessment**: This was discussed OFFLINE [2]. | **Support/fine**: Huawei/HiSi, Samsung, ZTE, Ericsson, Nokia/NSB, Fujitsu, Tejas, Xiaomi, vivo, NTT DOCOMO, NEC, OPPO, TCL, KDDI, Sharp, MediaTek, Google, Apple (ok), New H3C, CATT, HONOR (ok), Spreadtrum, CMCC  **Not support**: Qualcomm |
| 1.1.5 | **[116bis] Agreement**  For the Rel-19 Type-I single-panel (SP) codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=1-4, O1=O2 is 4   * FFS: Additional support for O1=O2 is 2 when RI=1-4 (including separate UE capability)   **Conclusion 1.A.5**: For the Rel-19 Type-I single-panel (SP) codebook refinement for 48, 64, and 128 CSI-RS ports, there is no consensus on additionally supporting O1=O2=2  **Question 1.A.5**: For the Rel-19 Type-I single-panel (SP) codebook refinement for 48, 64, and 128 CSI-RS ports, please share your view whether O1=O2=2 is additionally supported as a separate UE capability (from O1=O2=4)  **Support/fine**: Tejas, Lenovo/MotM, Google, ZTE,  **Not support**: Spreadtrum, Samsung, NTT DOCOMO, OPPO, Fujitsu, MediaTek, Xiaomi,  **FL assessment**: This FFS needs resolution to finalize codebook and UCI design | |
| 1.1.6 | **Question 1.A.6**: For the Rel-19 Type-I single-panel (SP) codebook refinement for 48, 64, and 128 CSI-RS ports, regarding Scheme-B for RI=5-8, please share your view on the following two FFS points:   * FFS1: mapping between the orphan layer and its selected SD basis vector and, if needed, UE reporting of the selection [fixed vs UE indication] * FFS2: (additional) support of 4 selected SD basis vectors for RI=5-6 * FFS3: (additional) support of 'x' selected SD basis vectors for ranks 5-8, x not equal to ceil(v/2)   FFS1: Fixed mapping (last SD basis vector 🡪 last/orphan layer) vs UE indication (1 out of 3 or 4, i.e.3 bits) of selected SD basis vector for the orphan layer   * **Fixed**: vivo, Xiaomi, OPPO, NTT DOCOMO, Fujitsu, MediaTek, * **UE indication**: Intel, ZTE,   FFS2: additional support for 4 selected SD basis vectors for RI=5-6 (note that 3 is already agreed)   * **Support/fine**: Huawei/HiSi, Xiaomi, NEC, CEWiT, * **Not support**: ZTE, Intel, Samsung, OPPO, NTT DOCOMO, MediaTek,   FFS3: additional support of 'x' selected SD basis vectors for ranks 5-8, x not equal to ceil(v/2) (note that 3 is already agreed)   * **Support/fine**: CEWiT, * **Not support**: Samsung, OPPO, NTT DOCOMO, ZTE, MediaTek,   **FL assessment**: This FFS needs resolution to finalize codebook and UCI design | |
| 1.4 | **Proposal 1.D.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, regarding CPU occupation   * For Capability 1 timeline: OCPU = ceil(P/32)   **Proposal 1.D.2**: For the Rel-19 Type-I SP and Type-II codebook refinements (expect based on Rel-18 Type-II Doppler) for 48, 64, and 128 CSI-RS ports, active resource counting is:   * For Capability 1 timeline: 1 * For Capability 2 timeline: 1   **FL assessment**: 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.D.1:**  **Support/fine:** Huawei/HiSi, Ericsson, Nokia/NSB, Intel, TCL, Samsung, vivo, Google, OPPO, Fraunhofer IIS/HHI, CATT, Qualcomm, MediaTek, Xiaomi, ZTE, HONOR, Lenovo/MotM, Spreadtrum, CMCC, Sharp, NTT DOCOMO, Apple  **Not support:** Fujitsu (Cap1 ceil(P/32)^X)  **1.D.2:**  **Support/fine:** Ericsson, Nokia/NSB, ZTE (ok), Fraunhofer IIS/HHI, Intel, TCL, Samsung, vivo, Google, CATT, Qualcomm, NTT DOCOMO, Xiaomi, HONOR, Lenovo/MotM, Spreadtrum, CMCC, Sharp, OPPO, MediaTek,  **Not support (K):** Huawei/HiSi, Fujitsu, Apple |
| 1.5.1 | **[116bis] Agreement**  For the Rel-19 Type-I multi-panel (MP) codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=1-4, decide, by RAN1#117, whether to support Type-I multi-panel (MP) codebook refinement in Rel-19.  If supported, decide from the following alternatives:   * Scheme1. Based on Rel-15 Type-I MP design directly extended with Ng=K (2, 3, and 4), and new (N1, N2) values * Scheme2. Based on Scheme4/6 as described in the RAN1#116 agreement   + W1 structure: Reuse legacy Rel-15 Type-I SP SD basis selection with L=1 independently for each of the K NZP CSI-RS resources   + W2 structure:     - Legacy Rel-15 Type-I inter-polarization co-phasing rules independently in each resource,     - Layer-common inter-resource M-PSK co-phasing, where M is further down-selected from {2,4}       * FFS: Whether inter-resource co-phasing is wideband or per subband.   If so, decide, by RAN1#117, whether port mapping scheme similar to, e.g. Rel-18 Type-II CJT, needs to be specified.  …  **Proposal 1.E.1**: For the Rel-19 Type-I multi-panel (MP) codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=1-4, support the following (compromise between Scheme1 and Scheme2 described in RAN1#116bis):   * W1 structure: Common SD basis selection across all the Ng=K NZP CSI-RS resources, reusing legacy Rel-15 Type-I SP SD basis selection rules with L=1 for RI=1-4   + Ng = *K* = {2, [3], 4} denotes the number of NZP CSI-RS resources associated with the Ng panels * W2 structure:   + Legacy Rel-15 Type-I inter-polarization co-phasing rules independently in each resource,   + Layer-common sub-band inter-resource QPSK co-phasing   **FL assessment**: This was discussed OFFLINE [2]. The proposal is a compromise between Scheme1 and Scheme2 (resource-common SD basis instead of resource-specific, just as Scheme1).  The majority of companies supporting/ok with 1.E.1 are also supportive of/ok (neutral)with Scheme2, e.g. MediaTek, Ericsson, Samsung, NTT DOCOMO, Nokia/NSB, Huawei/HiSi, vivo, ZTE, Qualcomm, OPPO, CATT, HONOR, Fujitsu  Note that **all the available SLS results show that Scheme2 outperforms Scheme1 (cf. Table 1B).** | **Support/fine (panel-common SD basis, compromise between Scheme1 and 2)**: MediaTek, Qualcomm, Ericsson, Nokia/NSB, vivo (ok), Samsung, Tejas (ok), NTT DOCOMO, CMCC, ZTE, Huawei/HiSi, OPPO, CATT, Intel (ok), HONOR, Fujitsu, LG (ok)  **Prefer resource-specific SD basis, i.e. Scheme2**: Fraunhofer IIS/HHI, CEWiT, New H3C, NEC, KDDI, IDC,  **No T1 MP**: Apple, TCL, Xiaomi, Spreadtrum, Google, Lenovo/MotM, Fraunhofer IIS/HHI (2nd) |
| 1.6.1 | **[116bis] Agreement**  For the Rel-19 Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, on CBSR, refine the legacy CBSR as follows:   * …   + FFS: Value(s) of X1 and X2 and detailed design/spec impact   **[116bis] Agreement**  For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding CBSR design:   * …   + FFS: Value(s) of X1 and X2 and detailed design/spec impact   **Question 1.F.3**: For the Rel-19 Type-I SP and Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, on CBSR, below is the list of applicable (X1, X2) values for a given (N1, N2). Please share your views on which (X1, X2) value(s) of are applicable to a given (N1, N2) value   * Note: X1/X2=8 or 16 are still in brackets  |  |  |  | | --- | --- | --- | | **New P** | **New (N1,N2)** | **Supported (X1, X2) value(s)** | | 48 | (8,3) | (1,1), (1,2), (1,4),  (2,1), (2,2), (2,4),  (4,1), (4,2), (4,4),  [(8,1), (8,2), (8,4),]  [(16,1), (16,2), (16,4)] | | (6,4) | (1,1), (1,2), (1,4), [(1,8),]  (2,1), (2,2), (2,4), [(2,8),]  (4,1), (4,2), (4,4), [(4,8),]  [(8,1), (8,2), (8,4), (8,8),] | | 64 | (16,2) | (1,1), (1,2), (1,4),  (2,1), (2,2), (2,4),  (4,1), (4,2), (4,4),  [(8,1), (8,2), (8,4),]  [(16,1), (16,2), (16,4),] | | (8,4) | (1,1), (1,2), (1,4), [(1,8),]  (2,1), (2,2), (2,4), [(2,8),]  (4,1), (4,2), (4,4), [(4,8),]  [(8,1), (8,2), (8,4), (8,8)]  [(16,1), (16,2), (16,4), (16,8),] | | 128 | (16,4) | (1,1), (1,2), (1,4), [(1,8),]  (2,1), (2,2), (2,4), [(2,8),]  (4,1), (4,2), (4,4), [(4,8),]  [(8,1), (8,2), (8,4), (8,8),]  [(16,1), (16,2), (16,4), (16,8),] | | (8,8) | (1,1), (1,2), (1,4), [(1,8), (1,16),]  (2,1), (2,2), (2,4), [(2,8), (2,16),]  (4,1), (4,2), (4,4), [(4,8), (4,16),]  [(8,1), (8,2), (8,4), (8,8), (8,16),]  [(16,1), (16,2), (16,4), (16,8), (16,16),] |   Remove X1/X2=8, 16: Samsung, ZTE, NEC  Remove X1/X2=16: NTT DOCOMO  Remove everything except (2,2), (2,4), (4,4), i.e. no dependence on (N1,N2): ZTE  Remove everything except (2,2)), i.e. no dependence on (N1,N2): NEC  **FL assessment**: It’s clear that the supported (X1, X2) values depend on (N1,N2). | |
| 1.6.4 | **Conclusion 1.F.4**: For the Rel-19 Type-I codebook refinement for 48, 64, and 128 CSI-RS ports, on the agreed 3-bit group-based scaling factor for RI=v=1, there is no consensus on supporting this feature for codebooks other than for Rel-19 Type-I SP codebook refinement  **Question 1.F.4**: For the Rel-19 Type-I codebook refinement for 48, 64, and 128 CSI-RS ports, on the agreed 3-bit group-based scaling factor for RI=v=1, **other than for Rel-1 Type-I SP codebook refinement (assumed to be supported by previous agreement)**, please share your view whether the scheme should also be applicable for following codebook types:   * Rel-19 Type-I MP codebook refinement (if supported):   + Support/fine:   + Not support: Samsung, OPPO, NTT DOCOMO, MediaTek, Xiaomi, * Rel-19 Type-II codebook refinement based on Rel-16 eType-II   + Support/fine:   + Not support: Samsung, OPPO, NTT DOCOMO, MediaTek, Xiaomi, * Rel-19 Type-II codebook refinement based on Rel-17 FeType-II   + Support/fine:   + Not support: Samsung, OPPO, NTT DOCOMO, MediaTek, Xiaomi, * Rel-19 Type-II codebook refinement based on Rel-18 Type-II Doppler   + Support/fine:   + Not support: Samsung, OPPO, NTT DOCOMO, MediaTek, Xiaomi,   **FL assessment**: This FFS needs to be resolved (codebook type) then we can proceed to whether to support RI=v>1 | |
| 1.8.3 | **Proposal 1.H.3**: For the Rel-19 Type-II codebook refinement for 48, 64, and 128 CSI-RS ports based on the Rel-18 Type-II Doppler codebook, support the following constraints of m:   * If the CSI-RS resources in a resource group span two consecutive slots, m is 2. * If the CSI-RS resources in a resource group are located in one slot, m can be configured from {1, 2}   **FL assessment**: This FFS needs to be resolved | **Support/fine**:  **Not support:** Samsung, Fujitsu, ZTE, Xiaomi, |
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Table 1B SLS results: issue 1

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| **Company** | **SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| IDC | 1.5.1 | Normalized average throughput | From the result above, it is observed that 8-PSK and 4-PSK based co-phasing in Scheme-2 MP with 32 ports on each panel can achieve a reasonable performance. As shown in the result above, Scheme-2 MP achieves higher performance than the legacy Rel-15 Type-I MP with 32 ports albeit having smaller throughput performance than Rel-19 Type-I SP Scheme-A with 64 ports. |
| MediaTek | 1.5.1 | Avg UPT gain vs feedback overhead | It is seen that the compromised proposal 1.E.1 shows 1~2 % UPT degradation compared to Scheme 2. This is because Scheme 2 offers flexibility to compensate the angle difference (however small) between panels due to large array size. In case there is no angle difference between panels, Scheme 2 does not preclude the UE report of common SD bases, thereby offering the best performance in either case. Further, we anticipate that the flexibility of Scheme 2 will be more beneficial in non-co-located/mixed deployments.  Based on the above observations, we support Rel-19 Type I MP codebook enhancement up to 128 ports based on Scheme 2. |
| Huawei/HiSi | 1.1.2 | Normalized throughput vs SNR | cid:image001.png@01DAA8B6.C9E20CC0  The performance of low complexity receiver (two antenna groups) with SRS port grouping enhancement, each of which contains 4 different UE antenna ports, is only 10% less than the performance of full 8Rx receiver with Rank-8.  The performance of low complexity receiver ( two antenna groups ) without SRS port grouping enhancement is almost 0 for high SNR. This is because the serious interference between codewords since gNB does not perform interference cancellation between codewords. |
| Samsung | 1.1.5 | Avg UPT Gain vs overhead | For Rel-19 Type-I for RI=1-4, it is shown in SLS results that the case of O1=O2=2 incurs 2% UPT loss compared to the case O1=O2=4 for both Scheme A and Scheme B. |

Table 1C Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 1A**  **For proposals 1.A.2, 1.D.1/2, and 1.E.1, @companies who oppose the proposals, please discuss offline with other companies and see if you can converge** |
| Samsung | Proposal 1.A.1  Ok.  Proposal 1.A.5  We don’t support O1=O2=2 since we do not see any benefit over the legacy O1=O2= 4:   * UPT losses were shown for both the schemes A and B in all companies’ SLS results including ours as shown in the figure below * Compared to O1=O2= 4 (legacy), the resulting overhead reduction is very small (only 2-bit) for AP-CSI. For P-CSI even if the 2-bit overhead is reduced, the need is unclear since all the allowed PUCCH formats (2, 3, 4 with 768, 5376, and 336 bits, respectively) has way enough capacity for Scheme A and Scheme B.   Question 1.A.6  We don’t support FFS2/FFS3, since the benefit is unclear from UPT/overhead tradeoff perspective. Also, in our view, what FFS2/FFS3 describe is quite different scheme from what Scheme-B describes (there will be no orphan layer).  Question 1.F.2.  We suggest to remove the cases that X1/X2 = 8 or 16.  Question 1.F.3.  We don’t support T1-MP, Rel-16 T2, Rel-17 T2, and Rel-18 T2 Doppler for the power scaling method. In contrast to T1-SP, for T2, it is unclear how UE to select PMI with satisfying what the power scaling method is aiming for. Also, for T2 the precoder is redesigned from the reported PMI to support MU-MIMO in most case, which is different from a usual case of T1 PMI feedback.  Proposal 1.H.3  We don’t support. Two bullets are not needed since this can be left to NW implementation. It’s quite obvious that m=1 is not feasible when the aggregated resources are across 2 slots. It’s also obvious that when the aggregated resources span 1 slot, both m=1 and 2 are feasible. |
| OPPO | **Proposal 1.A.1**:  Fine.  **Proposal 1.A.2**:  We are generally fine with the proposal. However, as discussed in Round 1, we propose to add a FFS part for the supported report quantity for this feature. We interpret it is mainly applied for No-PMI based transmission.   * FFS: the applicable report quantity.   **Proposal 1.A.5**:  Not support. Based on our previous evaluation, the performance and overhead is similar for 2 and 4.  **Question 1.A.6:**  Support fixed mapping for FFS1. Not support FFS2 and FFS3.  **Proposal 1.D.1/2**:  Fine.  **Proposal 1.F.3**:  We don’t think extension to other codebook types are not needed. |
| NTT DOCOMO | **Proposal 1.A.1**:  Support  **Question 1.A.5**:  Not support. It is not necessary to introduce different values for O1 and O2.  **Question 1.A.6**:  FFS1: Fixed mapping is sufficient, like legacy.  FFS2: Since 4 selected SD basis vectors have been supported for RI=4, it seems fine to also support 4 selected SD basis vectors for RI=5-6. On the other hand, if it is common understanding that 3 selected SD basis vectors for RI=5-6 have been agreed, it is also simple to not have additional scheme. Thus, with this common understanding as prerequisite, we do not support additionally support 4 selected SD basis vectors for RI=5-6.  FFS3: Additional scheme is not preferred, thus, FFS3 is not supported.  **Proposal 1.D.1/2**:  Support  **Question 1.F.2**:  At least X1/X2 = 16 is not needed.  **Question 1.F.3**:  We donot see strong need to consider other codebook types.  **Proposal 1.H.3**  OK |
| Fujitsu | **Proposal 1.A.1**:  Fine.  **Proposal 1.A.5**:  We think O1=O2=4 as legacy is sufficient.  **Question 1.A.6:**  Support fixed mapping for FFS1.  **Proposal 1.D.1**:  As we commented before, at least for Type II, SVD for 128 ports is not 4 times by SVD for 32 ports, because the computation complexity of SVD is from O(n^2) to O(n^3). Thus, for capability 1, our suggestion is following.  ***Proposal 1.D.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, regarding CPU occupation*   * *For Capability 1 timeline: OCPU = ceil(P/32) for Type I codebook, and OCPU = ceil(P/32)^x for R19 Type II codebook（x is up to UE capability）*   **Proposal 1.H.3**:  As we commented before, considering fast time-varying channel for medium/high speed for R19 Doppler Type II, all K CMRs should be configured in one slot. If two slots are configured, one 128 ports channel based on 4 CMRs will be not aligned and accurate, which can obviously decline the performance. Thus, the first bullet is not needed. |
| ZTE | 1.A.1:  It could be too early to discuss which scheme should be the basic feature and which scheme should be the optional feature, because both schemes are not finalized yet. From implementation perspective, scheme-B is less complex with lower overhead when the PMI is wideband. So, scheme-B could also be the basic feature.  1.A.5:  OK.  1.A.6:  For the 1st FFS, we do not have the definition of the last SD basis. In the previous agreement, the last SD basis means the SD basis except those applied to layer pairs. Indication of the SD basis mapped to the orphan layer is definitely needed (only 2 bits are needed, not 3 bits). From implementation perspective, the stronger SD bases should be applied to layer pairs, and the weakest SD basis should be applied to the orphan layer, to maximize the throughput. The SLS simulation is shown as below. The throughput is improved by applying the weakest SD basis to the orphan layer. Note that, this is the average throughput with adaptive RI from 1-8. If we look at the throughput for RI = 5 or 7 only, the gain is more significant. Besides, reporting the order of the power of SD baes does not help improving the throughput.    1.F.3:  The (1, 1) and X1/X2 = 8 or 16 should be removed. Besides, we prefer one (X1, X2) for one (N1, N2). For example, X1/X2 = 2/4 for N1/N2 <= 4 and N1/N2 > 4, respectively. Then only (2, 2), (2, 4), and (4, 4) are needed.  1.H.3:  Do not support. This can be handled by gNB implementation. |
| MediaTek | **Proposal 1.A.1** Support  **Question 1.A.5** Prefer not to have two different values of O1, O2, given the slight performance loss and negligible overhead saving with O1=O2=2.  **Question 1.A.6** Support FFS1 only. Do not support FFS2 and FFS3.  **Proposal 1.D.1 and 1.D.2** Support  **Proposal 1.E.1** 1st preference is to support resource specific SD bases selection as shown by available simulation results. Angles across large number of antenna elements can slightly decorrelate, making specific selection helpful. Further, although we understand that co-located multiple panels with same orientation could use resource common SD bases, specific selection makes it suitable for more general deployments.  2nd preference is to have the proposal in current form, which is extending Rel-15 Type I MP Mode 2.  **Question 1.F.3**  Rel-19 Type I MP: Do not support. The interference issue can be solved by a combination of NW panel deployment and MP codebook enhancement with resource specific SD bases selection.  Do not support for any of the Type II codebooks, since it is not clear how UE needs to optimize linear combination coefficients based on the configured offsets and SVD computation. |
| NEC | **First Question 1.F.3**: (seems two Question 1.F.3)  We also think (1,1) and X1/X2 = 8 or 16 should be removed. And we don’t think so many combinations of (X1,X2) are needed, which will lead to quite variable RRC signalling. As the agreed new (N1,N2) are both larger than 1, a 2D group (X1,X2) = (2,2) is sufficient for CBSR. |
| Xiaomi | **Proposal 1.A.1**:  Support  **Question 1.A.5**:  We prefer to unified values of O1 and O2 considering that there are no much difference on feedback overhead.  **Question 1.A.6**:  We suggest to firstly discuss FFS2. Then, how to map SD basis to layers are discussed.  **Question 1.F.3**:  Fine  **Question 1.F.3**:  Do not support to extent to other type II or Type-I MP. It needs to justify why should extent to other codebook type.  **Proposal 1.H.3**:  The second sub bullet is not needed, since it have been supported according to achieved agreement in the past meeting. |
| Mod V11 | **1.A.2: Added reportQuantity = ‘cri-RI’CQI’**  **Revision per inputs, added conclusions 1.A.5, 1.F.4** |
| CEWiT | **Proposal 1.A.1:** Support  **Conclusion 1.A.5:** Support  **Question 1.A.6:**  We feel that since Scheme-B is proposed to be an advanced scheme, all possible avenues should be explored for the effective usage of the proposed scheme. In this regard, we feel that supporting one SD basis vector to map up to 3 layers should be beneficial. For example, for a given channel conditions, if there is one strong SD basis vector, then reusing that SD basis vector for up to 3 layers should be more beneficial than forcing the UE to select a different SD basis vector which is not strong enough.  In the figure below, the number of instances that one SD basis vector is selected for up to 3 layers is shown when the UE is given the liberty of selecting up to 4 SD basis vectors for Ranks 5-8. According to the figure below, the number of instances one SD basis vector is selected for 3 layers is lesser but significant enough.  A blue bar graph with white background  Description automatically generatedHence, we feel that both FFS2 & FFS 3 should be supported.  **Proposal 1.E.1:** Support  **Conclusion 1.F.4:** Support  **Proposal 1.H.3:** Support |
| Nokia | **Proposal 1.A.1**  Support  **Question 1.A.6**  In our view, for SD bases indication for Scheme-B and ranks 5-8, we need to evaluate the performance gain of combinatorial indication per codeword as compared to combinatorial indication across codewords. Combinatorial indication per codeword avoids large layer imbalance within a codeword. A second level optimisation that can be evaluated is the performance impact of mapping a specific SD basis to the orphan beam.  So we propose to add an  FF0: combinatorial indication of SD bases per codeword  **Question 1.F.3**  Our preference is for the 3-bit scaling of the Pc ratio per beam group to be applicable only to Type-I SP. For Type-II, this power control per beam is not accurate because the fraction of transmit power on a selected SD basis depends on the nonzero combination coefficients for that basis for all reported layers. Besides, introducing this power scaling has the same effect of introducing different quantisation range and values for different beam groups. |

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

Table 2A Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1.1 | **RAN1#116bis discussion + OFFLINE**  **Question 2.F.2:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M>1, please share your view on whether the following overhead reduction schemes should be supported:   * CRI/resource-common RI value (indication):   + *Support/fine*: NTT DOCOMO (1st), Xiaomi, TCL, Huawei/HiSi, CATT   + *Not support (CRI/resource-specific RI)*: vivo, Samsung, NEC, Qualcomm, NTT DOCOMO (2nd), Lenovo/MotM, Ericsson, Nokia/NSB, Google, Intel, CMCC, MediaTek, Fujitsu, Sharp, OPPO * Differential WB CQI (the wideband CQI(s) associated with the 2nd, …, M-th CRI(s) is calculated differentially with respect to the 4-bit largest wideband CQI(s) associated with the 1st CRI into Bd<4 bits):   + *Support/fine*: NTT DOCOMO (1st), ZTE, Huawei/HiSi   + *Not support (No differential, Bd=4)*: vivo, Samsung, Qualcomm, Lenovo/MotM, Ericsson, Nokia/NSB, Google, Intel, TCL, CMCC, MediaTek, Fujitsu, Sharp, OPPO, NTT DOCOMO (2nd), * 1-bit differential SB CQIs associated with the 2nd, …, M-th CRI(s), calculated differentially with respect to the 2nd, …, M-th WB CQI(s)   + *Support/fine*: Huawei/HiSi   + *Not support (No differential, legacy 2-bit)*: vivo, Samsung, Lenovo/MotM, Ericsson, Fujitsu Nokia/NSB, Google, Intel, TCL, CMCC, MediaTek, Sharp, OPPO   **Proposal 2.A.1:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M>1, support the following:   * Resource-specific RI, i.e. RI is independently calculated and indicated for each of the selected M NZP CSI-RS resources   + FFS: If resource-common RI indication is also supported * 4-bit wideband CQIs are independently calculated and reported across the M selected NZP CSI-RS resources * 2-bit differential SB CQIs are independently calculated and reported across the M selected NZP CSI-RS resource   **FL assessment**: This was already discussed in RAN1#116bis and also OFFLINE [2].   * Whether RI is CRI-common or CRI-specific should be decided first. In this case, the proponents of CRI-common should demonstrate that CRI-common is better than CRI-specific in UPT vs PMI overhead trade-off   + Given the marginal saving in overhead from CRI-common RI, CRI-common RI is justified only if there is practically no loss of UPT relative to CRI-specific RI * If CRI-common is justified, whether differential CQI is supported or not can be decided with the same methodology (UPT vs PMI overhead). Else, the baseline (non-differential) is the natural outcome | **Support/fine**: OPPO, vivo, Samsung, Apple, MediaTek, Intel, CEWiT, Ericsson, NEC, Qualcomm, NTT DOCOMO, Lenovo/MotM, Nokia/NSB, Google, CMCC, Fujitsu, Sharp, Spreadtrum, HONOR, Kyocera, KDDI, Lenovo/MotM, IDC, Xiaomi (ok)  **Not support**: Huawei/HiSi, ZTE, CATT, TCL (CRI-common RI), |
| 2.1.2 | **[116bis] Agreement**  For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M>1, the M CRIs (each with bits) are separated indicated   * FFS: whether to support NW configuring/requesting the UE to report CRI/RI/PMI/CQI associated with *MR* (<*M*) of *KS* CSI-RS resources, including whether further reduction in the number of hypotheses is supported, i.e. reporting (*M* – *MR*) CRIs (each with bits)   **Proposal 2.A.2**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for A-CSI only, the NW can configure *MR* (<*M*) of *KS* CSI-RS resources to be selected as part of reporting the *M* “quadruplets”:   * (*M–MR*) CRIs, each with bits are reported, along with the *M* sets of CQI/PMI/RI/(if applicable) LI * The value of *MR* is NW-configured via higher-layer (RRC) signaling * The *MR* selected resources are NW-configured via higher-layer (RRC) signaling   + In addition, the *MR* selected resources can be updated via DCI (as a part of CSI trigger state)   **FL assessment**: The additional trigger-state-based update offers flexibility. | **Support/fine:** MediaTek,Huawei/HiSi, Ericsson, Nokia/NSB, Samsung, CATT, HONOR, Fujitsu, NEC, Google, ZTE, Qualcomm, IDC, Apple (ok), Intel, Sharp,  **Not support:** Spreadtrum, vivo, NTT DOCOMO, OPPO (no DCI), HONOR (no DCI), Lenovo/MotM, CMCC, Fujitsu (no DCI) |
| 2.1.3 | **Proposal 2.A.3:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M=2, when Rel-16 eType-II codebook is configured, FD basis selection and indication are resource-specific (per resource)  **FL assessment**: This is a proposal from Huawei to reduce overhead. Note that the **baseline is resource-specific**, and resource-specific SD basis has been agreed.  **Question 2.A.3:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M=2, please share your view on the following proposal:   * When Rel-16 eType-II codebook is configured, support resource-common FD basis selection and indication   **Support/fine:** Huawei/HiSi, Xiaomi (if no performance loss)  **Not support (resource-specific):** Google, Samsung, Qualcomm, Ericsson, NTT DOCOMO, OPPO, Apple, vivo | **Support/fine:** Google, Samsung, Qualcomm, Ericsson, NTT DOCOMO, OPPO, Apple, vivo, Intel, HONOR, Lenovo/MotM, MediaTek, Spreadtrum, CMCC, Sharp, Fujitsu, LG,  **Not support:** Huawei/HiSi |
| 2.1.4 | **Proposal 2.A.4:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M=2, when Rel-16 eType-II codebook is configured, RRC configuration of Parameter Combination is resource-common  **FL assessment**: This needs to be resolved for Rel-16 eType-II based HBF. Analogous to Rel-18 Type-II CJT, **the baseline is Alt2.**  **Question 2.A.4:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M=2, when Rel-16 eType-II codebook is configured, please share your preference on the following alternatives:   * Alt1. Resource-specific RRC configuration of Parameter Combination   + Support/fine: Google,   + Not support: Samsung, Qualcomm * Alt2. Resource-common RRC configuration of Parameter Combination   + Support/fine: Samsung, Qualcomm, Ericsson, NTT DOCOMO, OPPO, Apple, vivo, ZTE, CATT, Intel   + Not support: | **Support/fine:** Samsung, Qualcomm, Ericsson, NTT DOCOMO, OPPO, Apple, vivo, ZTE, CATT, Intel, Xiaomi, HONOR, Lenovo/MotM, MediaTek, Spreadtrum, CMCC, Sharp, Fujitsu, LG,  **Not support:** |
| 2.2 | **Proposal 2.B**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding CBSR and RI restriction, for each of the configured KS NZP CSI-RS resources, reuse per-resource CBSR and per-resource RI restriction from the legacy spec as follows:   * KS per-resource Type-I SP CBSRs when Rel-15 Type-I SP is configured * KS per-resource Rel-18 Type-II CJT CBSRs when Rel-16 eType-II is configured   **FL assessment**: No reason not to reuse legacy CBSR | **Support/fine:** MediaTek, ZTE, Samsung, Lenovo/MotM, HONOR, Xiaomi, Google, Qualcomm, IDC, Ericsson, NTT DOCOMO, OPPO, Apple, vivo, CATT, Intel, HONOR, Spreadtrum, CMCC, Sharp, Fujitsu, LG, NEC,  **Not support:** Huawei/HiSi (two-level), ZTE (two-level) |
| 2.4 | **Proposal 2.D**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports:   * Active resource counting = KS (following legacy)   **FL assessment**: Z/Z’ and OCPU will be discussed in later rounds | **Support/fine:** vivo, Google, OPPO, Xiaomi, Samsung, Qualcomm, Huawei/HiSi, NTT DOCOMO, Apple, ZTE, Intel, MediaTek, CMCC, Sharp, Fujitsu,  **Not support:** |
| 2.5 | **[116bis] Agreement**  For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, the following report quantities are supported:   * *‘cri-RI-PMI-CQI ‘* * *‘cri-RI-LI-PMI-CQI’ (only for Type-I)* * *FFS: ‘cri-RI-i1-CQI’ (only for Type-I)* * *FFS: ‘cri-RI-i1’ (only for Type-I)*   **Proposal 2.E**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, the following report quantities are also supported only when Rel-15 Type-I SP codebook is configured [and only for M=1]:   * *‘cri-RI-i1-CQI’* * *‘cri-RI-i1’* * ‘*cri-RI-CQI*’   **FL assessment**: The restriction M=1 only was proposed by Xiaomi (need to check with companies) | **Support/fine:** IDC, MediaTek, Spreadtrum, CMCC, Xiaomi (M=1), Huawei/HiSi, HONOR, Sharp, NTT DOCOMO,  **Not support:** Google, Samsung, Ericsson, Apple, Fujitsu |
|  |  |  |

Table 2B SLS results: issue 2

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| --- | --- | --- | --- |
| **Company** | **SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| Huawei/HiSi | 2.1.2 | Relative Throughput | gNB-assisted reporting beam determination (*M=2, MR*=1*)* provides significant performance gain (~17.5%) over UE-autonomous reporting beam determination(*M=2, MR*=0) |
| 2.1 | Channel Correlation | The normalized power in spatial domain and delay domain of multiple beams are highly correlated |
|  |  |  |  |

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**  **These are all proposals from round-1 (no time to discuss online)**  **We can’t progress on UCI for HBF unless the issues below are concluded:**   * **Proposal 2.A.1: @Huawei, ZTE, CATT, Xiaomi, TCL, I have added FFS to accommodate more discussion. Can you accept majority view?** * **Proposals 2.A.3: @Huawei, can you accept majority view?**     **Proposal 2.B: @Huawei, ZTE, can you accept majority view?** |
| NTT DOCOMO | **Proposal 2.E**:  OK |
| ZTE | 2.A.1:  We still think CRI-common RI and differential CQI can reduce the overhead without significant performance loss. |
| NEC | **Proposal 2.B:**  General fine with the direction of per resource CBSR, while for the first subbullet, we are not sure whether it’s reusing Rel-17 NCJT CBSR, as for Rel-17 NCJT CBSR, there are two groups of CBSR configured, while here we need Ks CBSRs. In addition, besides CBSR, we think RI restriction is also needed, which should also be per resource.    **Proposal 2.B**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding CBSR and RI restriction, for each of the configured KS NZP CSI-RS resources, reuse per-resource CBSR and per-resource RI restriction from the legacy spec as follows:   * KS typeI-SinglePanel CBSRs ~~Rel-17 Type-I NCJT CBSR~~ when Rel-15 Type-I SP is configured * KS Rel-18 Type-II CJT CBSRs when Rel-16 eType-II is configured   **[Mod: Done 😊]** |
| Xiaomi | **Proposal 2.A.1:**  We can fine if majority companies can live with it.  **[Mod: Thanks for your understanding]** |
| Mod V11 | **Revision per inputs** |
| Nokia | **Proposal 2.B**  In Rel17 NCJT, there are two CBSR parameters, one per resource group, i.e. one per TRP. Similarly, for Rel18 CJT, there is one CBSR parameter configurable per TRP. However, for CRI extension, because there is a single TRP, in our view the legacy solution should be to configure a single CBSR parameter for all Ks resources  **Proposal 2.D**  Ok |

### 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, regarding the dynamic range for delay offset reporting Dn,offset, i.e. AD, at least support the following values: {0.5CP, CP}   * Decide, by RAN1#117, whether any of the following candidate values are supported: {0.75CP, 1.5CP, ,   **[117] Agreement**  For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the dynamic range for frequency offset reporting FOn, i.e. AFO, at least support the following values: {0.1ppm, 0.2ppm}   * Decide, by RAN1#117, whether any of the following candidate values are supported: {0.025ppm, 0.05ppm, 1/(8t), 1/(16t), 1/(32t)}   **Question 3.A.3**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the dynamic range for delay offset reporting Dn,offset and frequency offset reporting FOn please share your views on the support of the remaining candidates below   * While having a single unit looks “nice” from spec perspective and uniformity, there is no value in terms of system implementation complexity for both NW and UE. Everyone agrees that having a single unit is preferred, but cannot agree on which unit 😊  |  |  |  | | --- | --- | --- | | **Parameter** | **Value** | **Company view** | | AD | 0.75CP | Support/fine: Intel, Ericsson, NTT DOCOMO, Xiaomi, Google, NEC, Sharp, KDDI, IDC, OPPO  Not support: ZTE, Nokia/NSB, Samsung | | 1.5CP | Support/fine: Samsung, Ericsson, NTT DOCOMO, Fujitsu, NEC, KDDI  Not support: ZTE, Nokia/NSB, Xiaomi, Google, Sharp, IDC, OPPO, | |  | Support/fine: ZTE, Huawei/HiSi, Nokia/NSB, CATT  Not support: Samsung, OPPO, Apple, Intel, Xiaomi, Google, Fujitsu, NEC, Sharp, KDDI, IDC, | |  | Support/fine: **ZTE**, Huawei/HiSi, Nokia/NSB, CATT  Not support: Samsung, OPPO, Apple, Intel, Xiaomi, Google, Fujitsu, NEC, Sharp, KDDI, IDC, | |  | Support/fine: **ZTE**, Huawei/HiSi, Qualcomm, Nokia/NSB, vivo, CATT  Not support: Samsung, OPPO, Apple, Intel, Xiaomi, Google, Fujitsu, NEC, Sharp, KDDI, IDC, | | AFO | 0.025ppm | Support/fine: Qualcomm  Not support: Samsung, OPPO, | | 0.05ppm | Support/fine: Qualcomm  Not support: Samsung, OPPO, | | 1/(8t) | Support/fine: **ZTE**, Huawei/HiSi, CATT  Not support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, NEC, IDC, | | 1/(16t) | Support/fine: **ZTE**, Huawei/HiSi, Nokia/NSB, CATT  Not support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, IDC, NEC | | 1/(32t) | Support/fine: ZTE, Huawei/HiSi, Nokia/NSB, CATT  Not support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, IDC, | | |
| 3.2 | **Proposal 3.B.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), ***support*** >1 (sub-band reporting) as follows:   * A sub-band size is selected from {8,16} PRBs   + FFS: Whether the sub-band size is NW-configured via higher-layer (RRC) signalling or selected (hence reported) by the UE * 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#117, 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 {[32], [64], [128], [256]}   + 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     - FFS: Whether restriction on the maximum payload size is needed   + Note: For all the above reporting options, the UE performs measurement over the entire configured CSI reporting band   **FL assessment**: Based on the arguments from proponents,  Opt1 is suitable when BF CSI-RS is used and the frequency selectivity is caused by TAE (hence linear);  Opt2 is suitable when non-precoded CSI-RS is used and frequency selectivity is mixed with the channel, and possibly additional RF impairments | **Support/fine (Opt1+2)**: ZTE, Qualcomm, CATT, Ericsson, Samsung, Fujitsu, NEC, TCL, Sony, KDDI, Lenovo/MotM, CMCC, NICT, Sharp, MediaTek, Nokia/NSB, Huawei/HiSi, NTT DOCOMO,  **Support only Opt1**: NEC, NICT, Sony, OPPO (2nd),  **Support only Opt2**: CMCC, Sharp, Lenovo/MotM,  **Not support >1 (separate D/d+WB PO enough)**: OPPO, Apple, Intel, vivo, Google, Panasonic |
| 3.3.1 | **[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   + FFS: The supported value(s) of Q * …   **Question 3.C.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), regarding the number of configured associated SRS resource(s) (=Q) for antenna switching xTyR, **other than Q=1 (assumed to be supported by default)**, please share your view on the supported value(s), if any**:**   |  |  | | --- | --- | | **Value of Q** | **Company views** | | 2 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, | | 3 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, | | 4 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, | | 6 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, | | 8 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, | | y/x | Support/fine: NTT DOCOMO,  Not support: Samsung, Fujitsu, ZTE, | | Other | Be specific |   **FL assessment**: This FFS needs to be resolved to give more clarity to proposal 3.C.2.  With the current xTyR SRS for antenna switching, up to 2 resource sets can be configured, each set with y/x sources, and each resource with x ports. This doesn’t preclude the use of a subset of all the available resources. | |
| 3.3.2 | **Proposal 3.C.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), regarding how to determine the SRS port corresponding to the ‘reference UE antenna port’, support the following   * Scheme1. The UE is configured by NW (via higher-layer/RRC signaling) PSRS SRS port(s) selected from all the port(s) from the configured Q associated SRS resource(s) for phase offset reporting   + FFS: Exact details of configuration mechanism   + FFS: Supported value(s) of PSRS * Scheme2. The UE selects PSRS SRS port(s) out of all the ports across Q resources and includes the selection in the phase offset report   + FFS: Supported value(s) of PSRS   FFS: Whether further restriction(s) to limit the time gap between the received CSI-RS and the transmitted associated SRS are needed  **FL assessment**: This proposal is needed so that the UE and gNB know the exact SRS port(s) used for the linkage in 3.C.1. Scheme2 offers an additional freedom for the UE to select the port(s) according to its implementation, while Scheme1 relies on NW configuration. In some Tdocs it was argued that Scheme2 facilitates NW implementation using non-precoded CSI-RS linked with SRS.  Supporting both schemes facilitates more use cases and deployment scenarios for PO report. | **Support/fine:** Qualcomm, Ericsson, Nokia/NSB, Samsung, vivo, MediaTek, IDC, CATT, NTT DOCOMO, [Google]  **Not support:** OPPO (only sch1 needed), Apple, Intel (only sch1 needed), Panasonic (only sch1 needed), Xiaomi (only sch1), |
| 3.3.3 | **Question 3.C.3**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), regarding how to determine the SRS port corresponding to the ‘reference UE antenna port’, please share your view whether only PSRS =1 or ≥1 SRS ports can be selected/configured from all the port(s) from the configured Q associated SRS resource(s):   * Only PSRS =1 SRS port: Samsung, Fujitsu, ZTE, Xiaomi * PSRS ≥1 SRS ports: OPPO (all),   **FL assessment**: To have more focused discussion on 3.C.2, this needs to be decided first. Note that the supported value(s) of PSRS also corresponds the supported number(s) of reference UE antenna ports | |
| 3.4 | **Proposal 3.D.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, the UCI parameters are captured in the tables below:   * FFS: Mapping order   *When ReportQuantity is ‘cjtc-Dd’ (Doffset+d)*   |  |  | | --- | --- | | Parameter | Details/description | | nref | Reference TRS resource set index, based on the ordering from RRC configuration: bits | | {Dn,offset,  n=0, 1, …, NTRP – 1, n≠nref } | Delay offset for CSI-RS resource n:  bits | | {dn,  n=0, 1, …, N TRP – 1, n≠nref } | 1-bit inside/outside indicator for CSI-RS resource n: bits |   *When ReportQuantity is ‘cjtc-F’ (frequency offset)*   |  |  | | --- | --- | | Parameter | Details/description | | nref | Reference TRS resource set index, based on the ordering from RRC configuration: bits | | {FOn ,  n=0, 1, …, NTRP –1, n≠nref} | Frequency offset for CSI-RS resource n:  bits |   *When ReportQuantity is ‘cjtc-Dd-F’ (joint Doffset+d and FO)*   |  |  | | --- | --- | | 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 n: bits | | {FOn ,  n=0, 1, …, NTRP –1, n≠nref2} | Frequency offset for CSI-RS resource n:  bits |   **FL assessment**: PO report will be addressed later after the issue on supporting sub-band PO is resolved | **Support/fine:** NTT DOCOMO, Samsung, OPPO, Fujitsu, ZTE, KDDI, Xiaomi,  **Not support:** |
| 3.5 | **Proposal 3.E.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding timeline, fully reuse those from Rel-18 TDCP reporting  **FL assessment**: This is for a single-type report, either Dd or FO | **Support/fine:** vivo, Samsung, Ericsson, Xiaomi, NTT DOCOMO, ZTE, Apple, Intel, Qualcomm, CATT, IDC, Intel, Xiaomi, Sony, Sharp, Nokia/NSB, OPPO,  **Not support:** Google |
| 3.6 | **[116bis] Agreement**  For the Rel-19 aperiodic standalone CJT calibration reporting, an ‘invalid’ quantization state/hypothesis is supported for frequency offset and phase offset CJT calibration reporting   * Note: already supported as ‘out-of-range’ for the (Dn,offset, dn) reporting * FFS (RAN1#117): The need for a condition/event for ‘invalid’ to be specified as a UE procedure e.g. RSRP-based   **Conclusion 3.F**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the ‘out of range’ or ‘invalid’ quantization state/hypothesis, there is no consensus on specifying a condition/event for such state.  **FL assessment**: Please share your views  **Question 3.F**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the ‘out of range’ or ‘invalid’ quantization state/hypothesis, please share our view whether a condition/event for such state needs to be specified and, if so, please be specific  **Yes (RSRP-based with RRC-configured threshold, e.g. RAN3)**: IDC, CATT, NEC, Google, Nokia/NSB,  **No (UE implementation)**: CMCC, KDDI, Qualcomm, Ericsson, OPPO, Huawei/HiSi, Apple, vivo, ZTE, Intel, Xiaomi, Lenovo/MotM , Fujitsu,  **Need discussion (need for other metrics? Testing?)**: Samsung | |
| 3.8.1 | **[116bis] Agreement**  For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the applicable type(s) of the configured NTRP NZP CSI-RS resources/resource sets when ReportQuantity is ‘cjtc-Dd’ (Doffset+d) or ‘cjtc-F’ (frequency offset), periodic TRS (‘CSI-RS for tracking’) resource set is used for each of the NTRP NZP CSI-RS resource sets   * Extend the maximum allowed number of TRS resource sets to 4 (note: legacy supports max. 3 from Rel-18 TDCP) * FFS: Whether all the resources across the NTRP TRS resource sets are configured with the same bandwidth * FFS: Whether aperiodic TRS resource set can also be used * FFS: Whether CSI-RS for CSI can also be used * FFS: Whether different RE locations (FDM) are supported for the RSs * FFS: additional time separation between RSs * FFS: The exact number of CSI-RS resource(s) within each TRS resource set * FFS: applicable type(s) if joint reporting of both Doffset/d and FO is supported   **Question 3.H.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the applicable type(s) of the configured NTRP NZP CSI-RS resources/resource sets when ReportQuantity is ‘cjtc-Dd’ (Doffset+d) or ‘cjtc-F’ (frequency offset), please share your view on the following (**baseline is NO for all the questions below**):   * Whether all the resources across the NTRP TRS resource sets are configured with the same bandwidth   + Yes:Huawei, Intel, Spreadtrum, CATT, Fujitsu, NTT DOCOMO, Samsung, OPPO, Xiaomi,   + No: CMCC * Whether aperiodic TRS resource set can also be used   + Yes: Intel, Fujitsu, Samsung, Sharp, Ericsson, NTT DOCOMO   + No: Spreadtrum, CATT, OPPO, * Whether CSI-RS for CSI can also be used   + Yes: ZTE   + No: Samsung, NTT DOCOMO, OPPO, Fujitsu, * Whether different RE locations (FDM) are supported for the RSs   + Yes: Huawei, ZTE, CATT   + No: Intel, Spreadtrum, NTT DOCOMO, Samsung, OPPO, Fujitsu,   **FL assessment**: These FFS points need to be resolved | |
| 3.8.2 | **[116bis] Agreement**  For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the applicable type(s) of the configured NTRP NZP CSI-RS resources/resource sets when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), single-port CSI-RS(s) for CSI is used   * FFS: Whether multi-port CSI-RS for CSI can also be used * FFS: Whether all the ‘CSI-RS for CSI’ resources within each resource set follow the legacy pre-Rel-19 rules of CSI-RS resources associated with a same resource set, and whether only 1 or NTRP >1 resource sets are used * FFS: The exact number of CSI-RS resource(s) within each resource set * FFS: Whether different RE locations (FDM) are supported for the RSs * FFS: additional restrictions e.g. time separation between RSs, bandwidth   **Question 3.H.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the applicable type(s) of the configured NTRP NZP CSI-RS resources/resource sets when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), please share your view on the following (**baseline is NO for all the questions below**):   * Whether multi-port CSI-RS for CSI can also be used   + Yes: CATT, Ericsson   + No: Spreadtrum, Samsung, OPPO, Fujitsu, * Whether all the ‘CSI-RS for CSI’ resources within each resource set follow the legacy pre-Rel-19 rules of CSI-RS resources associated with a same resource set   + Yes: Samsung, OPPO, Fujitsu, Xiaomi,   + No: * Whether only 1 or NTRP >1 resource sets are used   + 1 set, NTRP resources: CATT, CMCC, Samsung, OPPO, Fujitsu, Xiaomi,   + NTRP sets: * Whether different RE locations (FDM) are supported for the RSs   + Yes: ZTE,   + No: Samsung, OPPO, Fujitsu, * Whether all the resources across the NTRP CSI-RS resources/resource sets are configured with the same bandwidth   + Yes:CMCC, Samsung, OPPO, Fujitsu, Xiaomi,   + No:   **FL assessment**: These FFS points need to be resolved | |
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Table 3B LLS/SLS results: issue 3

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| **Company** | **LLS/SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| Samsung | 3.2.2 | Avg UPT Gain | For CJTC phase-offset reporting, it is identified that Option 1 can perform sufficiently well and nearly achieve the performance of Option 2 and ideal calibration in the scenario with maxTAE=65ns, when only small measurement errors exist (without additional hardware impairments). However, when large measurement errors exist, Option 1 incurs some performance degradation (2% UPT loss) than Option 2, because the large measurement errors affect the underlying assumption of linear phase drift not working well. |
| Vivo | 3.1 | SE gain vs maximum payload | It is observed in the result above that when the carrier is 2.2GHz, a frequency error of 0.01 ppm (~ 22Hz) results in a performance loss in the range of 3%, but a frequency error of 0.05 ppm results in a loss of 20% in DU scenarios, which is significant. |
| ZTE | 3.1 | Average throughput gain | The figure above shows the SLS results of average throughput gain for MD = 32, AD = CP (baseline) or . It is shown that, the performance of AD = CP and AD = is very close.  The figure above shows the SLS results of average throughput gain for MFO = 16, AFO = 0.2ppm (baseline) or . It is shown that the performances of AFO = 0.2ppm and AFO = are very close. |
| CATT | 3.2.2 | Mean UPT gain | The SLS results above show that the proposed low feedback overhead based calibration scheme with (UE selects some SBs and reports Pos corresponding to the selected SBs 🡺 NW inter/extrapolates missing SBs) can also achieve quite good performance while maintaining a moderate overhead cost.  The SLS results above show that 1) aligned 4 subbands based calibration achieves similar performance to all subbands based calibration, and 2) calibration performance is degraded if misaligned frequency resources in DL and UL are used for phase offset calculation. |
| Sony | 3.2.2 | Average throughput | The LLS simulations show that reporting information about the evolution of the phase offsets in the frequency domain improves the system’s throughput, at least for TAEs of 65 ns or larger. (2% gain over wideband PO reporting) |
| Nokia | 3.6 | Mean cell UPT vs total overhead | A graph with numbers and linesA graph with a line and a chart with numbers   1. (b)   Normalized mean cell UPT (a) without RSRP condition on the invalid state and (b) when an RSRP threshold of 9dB is configured as a condition for invalid state  Configuring an RSRP threshold of 8dB as condition for the invalid state for FO reporting shows average UPT gain of around 5% over not configuring an RSRP threshold. |
| 3.3.1 | Mean spectral efficiency gain | A graph with different colored bars  Description automatically generatedA graph with different colored squares  Description automatically generated  In the left figure, 2 out of 4 antennas at UE side are sounded and the same antennas are used to estimate the phase difference between the CSI-RS signals transmitted by TRP and the reference TRP, and received by antenna , . In the right figure, only 1 SRS antenna port is sounded in UL and all receive antennas are used to compute . We can see how the mismatch between the SRS ports used to compute and the receive antennas used to compute , has impacted the performance greatly as shown in the right figure, where we can see about 60% loss. |
| Qualcomm | 3.2.2 |  | A couple of graphs with lines and numbers  Description automatically generated with medium confidence  As seen in the results above, it is observed that tens of nano seconds can cause nearly 10% UPT loss. Furthermore, it is observed that the UPT loss is still significant, when a small bit, (e.g., 3-to-5 bits, i.e., 8 to 32 quantization levels) is used for TAE quantization. The UPT loss is around 2% to 10%, depending on the exact TAE value – this is due to some TAE value close to certain quantization point by chance. |
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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**  **Proposal 3.B.2: decide (in round-1) 🡪 support (round-2)**  **Proposal 3.C.1/2/3: To have more clarity for 3.C.2, we need some progress of Q and P\_SRS**  **Proposal 3.E.1: @Google, could you please provide a concrete counter-proposal to refine the TDCP timeline (i.e. reuse legacy Z2/Z2’)?**  **Conclusion 3.F: @ proponents of spec-based condition for ‘invalid’, please discuss if you can convince companies who prefer to leave this to UE implementation** |
| NTT DOCOMO | **Question 3.A.3:**  We think at least 1.5 CP for delay offset reporting should be supported. Open for other values (for delay and frequency).  **Proposal 3.B.2:**  Fine with the proposal.  **Question 3.C.1:**  If more than one is supported, then in the spec, we think it is ok to support all possible resources per resource set for antenna switching. Of course the actual combination(s) will be subject to UE capability (on the xTyR support).  **Proposal 3.D.1:**  Support.  **Question 3.H.1:**  One change: we are open to consider AP-TRS additionally. |
| Samsung | Question 3.A.3  Since we agree 0.5CP and CP for dynamic ranges, we first suggest to consider only the candidates of >CP, which are 1.5CP, 1/4f, and 1/12f. If we transform the remaining candidates in CP unit, those are given by: 1.5CP, 3.5CP, and 1.167CP. Among the three candidates, we think that 3.5 CP is too large and no clear use case based on delay distribution results, and 1.167 CP is close to 1 CP we already agreed to support. So, we are still supporting 1.5CP for the use case of >CP.  For AFO, 0.025ppm and 0.05ppm are too small value in our view, and actually we haven’t seen any non-trivial performance degradation in scenarios with such small FO offsets. We prefer to exclude those candidates as well.  Proposal 3.B.2  Support.  Question 3.C.1  We don’t support Q>1. For PO measurement/report, it is sufficient for NW to configure one SRS resource among y/x resources.  Question 3.C.2  We support PSRS=1 only, which is sufficient for UE to calculate/report PO. Introducing Psrs>1 requires additional rule and the benefit is unclear (SNR gain or UPT gain?). At best it is an optimization for the same functionality, which is unnecessary in our view.  Proposal 3.D.1  OK.  Question 3.H.1  We don’t support 3rd and 4th bullets  Question 3.H.2  1st bullet: No  2nd bullet: yes  3rd bullet: 1set, NTRP resources  4th bullet: no  5th bullet: yes |
| OPPO | **Question 3.A.3:**  There is no reason to use two units for similar values.  For remaining values, we are open to new values as long as the use case is justified. For delay offset, we think a value larger than CP may be useless since it would be difficult for CJT between TRPs with large delay offset (which also means large pathloss gap). For frequency offset, the benefit of 0.025ppm and 0.05ppm is still unclear to us.  **Proposal 3.B.2:**  We still think subband phase reporting is not needed. Even if majority companies want it, one option (e.g. Opt.1) can be enough.  **Proposal 3.C.2:**  Prefer Scheme 1. The benefit of Scheme 2 is unclear.  To ensure the accuracy of phase offset reporting, gNB can configure multiple antennae ports for phase offset measurement (averaged offset among RX) regardless of MRT precoding or not.  **Question 3.C.3:**  In case that Q associated SRS resource(s) and P SRS ports are both configured by gNB (Scheme 1), all the ports in configured SRS resource could be used for phase offset measurement. This simplifies the signalling design.  **Proposal 3.D.1:**  Fine**.**  **Proposal 3.F:**  Fine.  **Question 3.H.1:**  Yes.  No.  No.  No.  **Question 3.H.2:**  No.  Yes.  1 set, NTRP resources  No.  Yes. |
| Fujitsu | **Question 3.C.1/3:**  We support Q=1 SRS resource with PSRS =1.  **Proposal 3.D.1:**  Fine**.**  **Conclusion 3.F:**  Ok.  **Question 3.H.1:**  Yes.  Yes.  No.  No.  **Question 3.H.2:**  No.  Yes.  1 set, NTRP resources  No.  Yes. |
| ZTE | 3.A.3:  Prefer to add and for DO, 1/(8t) and 1/(16t) for FO.  3.B.2:  Support.  3.C.1/3.C.3:  Prefer Q = 1, PSRS = 1 only.  3.D.1:  The mapping order of D/d, FO, DO for different TRPs should be further discussed.  3.H.1:  Support CSI-RS for CSI and different RE locations (FDM). The time separation between RSs should be restricted.  3.H.2  Support different RE locations (FDM) for the RSs. The time separation between RSs should be restricted. |
| KDDI | **Question 3.A.3:**  With respect to the discussion regarding dynamic range beyond 1CP, we support 1.5CP. Also, we think that Samsung’s explanation of this dynamic range beyond 1CP makes sense.  **Proposal 3.B.2:**  We are fine with the proposal. And we are very sorry to reiterate a minor editorial point, but the typo we commented on in the 1st round is still there. in the sub-bullet under Opt1 should be .  [Mod: Sorry I missed this in round-1, thanks]  **Proposal 3.D.1:**  Support. |
| Xiaomi | **Proposal 3.C.2**  Slightly prefer scheme 1  **Proposal 3.C.3**  Slightly prefer PSRS =1  **Proposal 3.D.1:**  Fine**.**  **Proposal 3.H.1:**  Yes for the same bandwidth**.**  **Proposal 3.H.2:**  Yes for the same resource set (2nd sub-bullet) and the same bandwidth (5th sub-bullet). And prefer 1 resource set for the 3rd sub-bullet. |
| Mod V11 | **Revision per inputs** |
| Nokia | **Question 3.A.3**  We propose the two additional values that are linked to the reference signal resource resolution in frequency, i.e. 1/PRB and 1/(PRB/3) (maximum delay range measurable with TRS density 3)  For we propose to add the two values as they are fractions of maximum the measurable frequency offset linked to the time separation between reference signal resources  **Proposal 3.B.2**  In our understanding, the motivation for Opt 2 is to increase robustness against measurement errors. However, for nonprecoded CSI-RS approach, there is a simpler way to increase robustness without increasing feedback overhead, i.e. by averaging measurements over multiple receive antennas. For nonprecoded CSI-RS approach, Opt 2 is not needed.  **Question 3.C.1**  In our understanding, for the precoded-CSI-RS approach, the gNB should be able to configure any of the y receive antennas for a UE supporting xTyR. Hence the number of trigger states needs to be y. So configuring Q=1 or makes no difference for the precoded-CSI-RS approach.  However, for the nonprecoded-CSI-RS scheme, where a UE can average measurements over multiple receive antennas, Q=1 restricts measurements within the ports of a single resource, without any apparent logic. So for the nonprecoded-CSI-RS scheme to support measurement averaged over multiple receive antennas Q=y/x is needed  **Proposal 3.C.2**  @OPPO, @Apple, @Intel. As you know, there are two different NW implementation for PO calibration.  One implementation requires MRT-precoded CSI-RS, and the UE can only be configured with one receive antenna for measurement, the antenna corresponding to the SRS port used to obtain the CSI-RS precoder.  Another implementation can use TRS or CSI-RS without need to be precoded, and the UE can measure from multiple receive antennas for better robustness against measurement error.  The second implementation in our view is clearly more robust against UL/DL channel reciprocity errors (because it does not rely on a precoder matched to the exact channel), against measurement error (because a UE can average measurements across receive antennas), and can reuse the same TRS used for the other calibration measurements, without need of a dedicated precoded CSI-RS.  This is an example of the measurement procedure with nonprecoded CSI-RS:   * A UE supporting xTyR transmits SRS with antenna switching, sounding y antennas, as per usual TDD operation * gNB measures phase difference from all SRS ports and triggers a UE to report a PO measurement averaged from ≤y receive antennas, where the value of is network configured. Which antennas to measure may be network configured, e.g. , or UE selected * UE reports the PO measurement from the configured/selected receive antennas and reports the selection if applicable.   If we don’t have UE dynamic indication, as per scheme 2, we would need a very large number of trigger states, under scheme 1, to trigger all different combinations of just 1 and 2 ports, for xT2R, xT4R, xT6R, xT8R.  **Question 3.C.3**  for a UE supporting xTyR.  **Question 3.H.1**   * Whether all the resources across the NTRP TRS resource sets are configured with the same bandwidth   + Yes * Whether aperiodic TRS resource set can also be used   + Yes * Whether CSI-RS for CSI can also be used   + No * Whether different RE locations (FDM) are supported for the RSs   + Yes, up to network configuration   **Question 3.H.2**   * Whether multi-port CSI-RS for CSI can also be used   + No * Whether all the ‘CSI-RS for CSI’ resources within each resource set follow the legacy pre-Rel-19 rules of CSI-RS resources associated with a same resource set   + Yes, this question is applicable to TRS only in our understanding * Whether only 1 or NTRP >1 resource sets are used   + NTRP sets, to support the use of the same TRS sets used for the other calibration measurements * Whether different RE locations (FDM) are supported for the RSs   + Yes, up to network configuration * Whether all the resources across the NTRP CSI-RS resources/resource sets are configured with the same bandwidth   Yes |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | RP-240087 | Revised WID: NR MIMO Phase 5 | Samsung (Moderator) |
| 2 | R1-2404107 | Moderator Summary for OFFLINE discussion on Rel-19 CSI enhancements | Moderator (Samsung) |
| 3 | [R1-2403847](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403847.zip) | Discussion on Rel-19 Enhancements of CSI | InterDigital, Inc. |
| 4 | [R1-2403876](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403876.zip) | Discussion on Rel-19 CSI enhancements | New H3C Technologies Co., Ltd. |
| 5 | [R1-2403884](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403884.zip) | CSI enhancement for NR MIMO Phase 5 | Tejas Networks Limited |
| 6 | R1-2405340 | CSI enhancements to support up to 128 CSI-RS ports | MediaTek Inc. |
| 7 | R1-240[5445](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403945.zip) | On 128 CSI-RS ports and UE reporting enhancement | Huawei, HiSilicon |
| 8 | [R1-2403981](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403981.zip) | CSI enhancements for MIMO | Intel Corporation |
| 9 | [R1-2404004](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404004.zip) | Discussion on Rel-19 CSI enhancements | TCL |
| 10 | [R1-2404020](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404020.zip) | Discussion on CSI enhancements | Spreadtrum Communications |
| 11 | R1-2405365 | Views on Rel-19 CSI enhancements | Samsung |
| 12 | [R1-2404171](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404171.zip) | Discussion on Rel-19 CSI enhancements | vivo |
| 13 | [R1-2404240](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404240.zip) | Discussion on CSI enhancements | ZTE |
| 14 | [R1-2404278](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404278.zip) | Views on R19 MIMO CSI enhancement | Apple |
| 15 | [R1-2404337](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404337.zip) | Discussion on CSI enhancements | Lenovo |
| 16 | [R1-2404395](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404395.zip) | Views on MIMO CSI enhancements in Rel-19 | CATT |
| 17 | [R1-2404450](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404450.zip) | Discussion on CSI enhancements | CMCC |
| 18 | [R1-2404495](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404495.zip) | Additional views on CSI enhancements | Sony |
| 19 | [R1-2404551](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404551.zip) | Discussions on CSI enhancements | LG Electronics |
| 20 | [R1-2404575](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404575.zip) | Discussion on CSI enhancements | HONOR |
| 21 | [R1-2404588](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404588.zip) | Discussion on Rel-19 CSI enhancements | Fujitsu |
| 22 | [R1-2404612](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404612.zip) | Discussion on CSI enhancement | Xiaomi |
| 23 | [R1-2404668](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404668.zip) | Discussion on CSI enhancements | NEC |
| 24 | [R1-2404687](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404687.zip) | CSI Enhancement for NR MIMO | Google |
| 25 | [R1-2404883](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404883.zip) | CSI enhancements for Rel-19 MIMO | OPPO |
| 26 | [R1-2404919](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404919.zip) | CSI enhancement for NR MIMO Phase 5 | Nokia |
| 27 | [R1-2404923](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404923.zip) | CSI enhancements for Rel.19 MIMO | Fraunhofer IIS, Fraunhofer HHI |
| 28 | [R1-2404971](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404971.zip) | CSI enhancements | Sharp |
| 29 | [R1-2405005](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405005.zip) | CSI enhancements for large antenna arrays and CJT | Ericsson |
| 30 | [R1-2405036](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405036.zip) | Discussion on CSI enhancements | NTT DOCOMO, INC. |
| 31 | [R1-2405149](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405149.zip) | CSI enhancements for >32 ports and UE-assisted CJT | Qualcomm Incorporated |
| 32 | [R1-2405206](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405206.zip) | CSI enhancements | NICT |
| 33 | [R1-2405239](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405239.zip) | CSI Enhancements | CEWiT |
| 34 | [R1-2405255](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405255.zip) | Discussion on CSI enhancements for NR MIMO Phase 5 | KDDI Corporation |
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