**3GPP TSG RAN WG1 #117 R1-2405485**

**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, CEWiT, Nokia/NSB, CATT, Fraunhofer IIS/HHI, Ericsson, Tejas,  **Not support:** ZTE, Huawei/HiSi, Lenovo/MotM (UE feature), |
| 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  Note: The above grouping assumption is to align NW and UE on the association between SRS ports and reported CQIs for the two CWs when reportQuantity = ‘cri-RI-CQI’.  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 |
| 1.1.6 | **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)   FFS0: Combinatorial indication (agreed) of SD bases per codeword vs Combinatorial indication of SD bases across 2 CWs   * **Per CW**: Nokia/NSB * **Across 2 CWs**:   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, Fraunhofer IIS/HHI, Huawei/HiSi, Ericsson, Lenovo/MotM * **UE indication**: Intel, ZTE, Qualcomm,   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, Tejas, * **Not support**: ZTE, Intel, Samsung, OPPO, NTT DOCOMO, MediaTek, Fraunhofer IIS/HHI, Ericsson, Lenovo/MotM   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, Tejas, * **Not support**: OPPO, NTT DOCOMO, ZTE, MediaTek, Ericsson, Lenovo/MotM   **FL assessment**: This FFS needs resolution to finalize codebook and UCI design | |
| 1.4 | **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) | **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: Independent 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**: Based on Tuesday morning offline, changing “common” to “independent”  Note that **all the available SLS results show that Scheme2 outperforms Scheme1 (cf. Table 1B).** | **Support/fine**: MediaTek, Qualcomm, Ericsson, Nokia/NSB, vivo (ok), Samsung, Tejas (ok), NTT DOCOMO, CMCC, ZTE, Huawei/HiSi, OPPO, CATT, Intel (ok), HONOR, Fujitsu, LG (ok), CEWiT, Fraunhofer IIS/HHI, New H3C, NEC, KDDI, IDC,  **Not support (No T1 MP)**: Apple, TCL, Xiaomi, Spreadtrum, Google, Lenovo/MotM |
| 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   **Proposal 1.F.4**: For the Rel-19 Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, on CBSR, the following (X1, X2) values are supported: (1,1), (2,1), (2,2), (4,1), (4,2), (4,4),   * FFS: (1,2), (1,4), (2,4)   **FL assessment**: After further consideration, the same (X1,X2) should be applicable to Type-II | **Support/fine:**  **Not support:** |
| 1.8.3 | **Conclusion 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, there is no consensus on specifying further restriction on *m* values based on the slot location(s) of the CSI-RS resources in a resource group  **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}   **Support/fine**: CEWiT, CATT,  **Not support:** Samsung, Fujitsu, ZTE, Xiaomi, Fraunhofer IIS/HHI, Ericsson,  **FL assessment**: This FFS needs to be resolved | |
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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** |
| ZTE | 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. |
| CEWiT | **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. |
| Nokia | **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 |
| Huawei, HiSilicon | **Question 1.A.6:** For FFS1, fixed mapping is preferred.  For FFS2, whether to support up to 3 or up to 4 should depend on simulation results, while scheme-B is targeted better performance. The simulation results can also show that by supporting 3-4 SD basis vectors, UEs with RI=5-6 can have a performance gain of 5~11%. There’s no reason to fallback to 3 SD basis vectors, while scheme-B Rank 1-4 has supported up to 4 basis vectors. |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 1A**  **Re 1.A.6: please check ZTE, CEWiT, Nokia, and Huawei explanation** |
| Qualcomm | **Proposal 1.A.6** (FFS0)  I feel I understand Nokia’s argument is, a same beam should not be distributed across two CWs  But,  1. I seem not understand why combinatorial selection across two CWs can’t achieve that (maybe except for some special cases as belew)  2. A minor special case: Rank=6 with =3, seems anyway we can’t avoid a beam to distribute across two CWs, regardless whether it is combinatorial selection across two CWs, or per CW |
| NTT DOCOMO | **Question 1.A.6:**  For FFS1, we’d like to change our view because we just realized that following has been supported for SD beam indication. In this case, we think the mapping between a SD vector and a layer-pair or orphan layer is beneficial. Thus, the additional indication of ordering of the selected SD basis vectors is needed, not only for orphan layer but also for each layer-pair.   * The SD basis vectors are freely selected from a group of N1N2 orthogonal SD DFT basis vectors via combinatorial indication, as well as a layer-common (q1,q2) |

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

Table 2A Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1.2 | **[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) |
| 2.1.6 | **Proposal 2.A.6:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding UCI parameters when two-part UCI/CSI is used, reuse the Rel-17 NCJT UCI rules where:   * Part 1: M CRI(s), M RI(s), M sets of CQI values for 1st CW   + Ordered based on a CSI-RS resource priority rule  * Part 2: M sets of {PMI, LI (if applicable), CQI values for 2nd CW (if applicable)}   + Ordered following the same CSI-RS resource priority rule    FFS: How to define CSI-RS resource priority rule  (in relation to UCI omission rule)  **FL assessment**: There is no reason to do otherwise since multi-CRI has been supported since Rel-17. A resource priority rule will be discussed together with UCI omission rule | **Support/fine:** Intel,  **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), Nokia/NSB (common CBSR) |
| 2.4.2 | **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:   * Alt1: OCPU = M + KS * Alt2: OCPU = M + KS – 1   **Alt1**: vivo  **Alt2**: OPPO, Intel  **FL assessment**: Two alternatives were proposed for OCPU | |
| 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)*   **Conclusion 2.E**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, there is no consensus on supporting the following report quantities when Rel-15 Type-I SP codebook: *‘cri-RI-i1-CQI’, ‘cri-RI-i1’,* ‘*cri-RI-CQI*’  **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*’   **Support/fine:** IDC, MediaTek, Spreadtrum, CMCC, Xiaomi (M=1), Huawei/HiSi, HONOR, Sharp, NTT DOCOMO,  **Not support:** Google, Samsung, Ericsson, Apple, Fujitsu  **FL assessment**: The restriction M=1 only was proposed by Xiaomi (need to check with companies) | |
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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** |
| NTT DOCOMO | **Proposal 2.A.6:**  OK.  **Proposal 2.B**:  The per-resource RI restriction is supported only when Resource-specific RI is configured. Note that we have an FFS on Resource-common RI indication. In case resource-common RI indication is supported/configured, we think resource-common RI restriction is sufficient.  **Question 2.D.2**:  We prefer Alt2 to align with the legacy case for M=1. |
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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, 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, Intel, Qualcomm (optional)  Not support: ZTE, Nokia/NSB, Xiaomi, Google, Sharp, IDC, OPPO, | |  | Support/fine: 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, 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: 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, CMCC, NICT, Sharp, MediaTek, Huawei/HiSi, NTT DOCOMO,  **Support only Opt1**: NEC, NICT, Sony, OPPO (2nd), Nokia/NSB,  **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 * …   **Proposal 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, support Q=1 where:   * the configured associated SRS resource is selected from all the y/x SRS resources and all the configured resource set(s) * the number of ports = x (as supported in legacy SRS for antenna switching, which is ≥1)   **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**:**   * For Q=1, the number of ports can be >1  |  |  | | --- | --- | | **Value of Q** | **Company views** | | 2 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, Ericsson, Intel, | | 3 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, Ericsson, Intel, | | 4 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, Ericsson, Intel, | | 6 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, Ericsson, Intel, | | 8 | Support/fine:  Not support: Samsung, Fujitsu, ZTE, Ericsson, Intel, | | y/x | Support/fine: NTT DOCOMO, Nokia/NSB (non-precoded CSI-RS),  Not support: Samsung, Fujitsu, ZTE, Ericsson, Intel, | | 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. | **Support/fine:** Samsung, Fujitsu, ZTE, Ericsson, Intel, Qualcomm  **Not support:** |
| 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 (only Scheme1):** OPPO, Apple, Intel, Panasonic, Xiaomi, Lenovo/MotM, |
| 3.3.3 | **Proposal 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’, support PSRS =1 SRS port selected from all the ports from the configured Q associated SRS resource(s)   * FFS (by RAN1#118): Whether PSRS >1 is also supported   **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, Ericsson, Intel, * PSRS ≥1 SRS ports: OPPO (all), Nokia/NSB (1, …, y)   **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 | **Support/fine:** Samsung, Fujitsu, ZTE, Xiaomi, Ericsson, Intel, Qualcomm, Nokia/NSB, [OPPO]  **Not support:** |
| 3.5.1 | **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 |
| 3.8.1 | **[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   **Proposal 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), all the resources across the NTRP TRS resource sets are configured with the same bandwidth  **Support/fine:** Huawei, Intel, Spreadtrum, CATT, Fujitsu, NTT DOCOMO, Samsung, OPPO, Xiaomi, Nokia/NSB, Qualcomm, Lenovo/MotM  **Not support:**  **Conclusion 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), there is no consensus on:   * Supporting aperiodic TRS resource set * Supporting CSI-RS for CSI * Supporting different RE locations (FDM) for the RSs   **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, Nokia/NSB, Qualcomm, Lenovo/MotM,   + No: CMCC * Whether aperiodic TRS resource set can also be used   + Yes: Intel, Fujitsu, Samsung, Sharp, Ericsson, NTT DOCOMO, Nokia/NSB, Lenovo/MotM,   + No: Spreadtrum, CATT, OPPO, Qualcomm, * Whether CSI-RS for CSI can also be used   + Yes: ZTE, Qualcomm,   + No: Samsung, NTT DOCOMO, OPPO, Fujitsu, Nokia/NSB, Lenovo/MotM, * Whether different RE locations (FDM) are supported for the RSs   + Yes: Huawei, ZTE, CATT, Nokia/NSB, Qualcomm,   + No: Intel, Spreadtrum, NTT DOCOMO, Samsung, OPPO, Fujitsu, Lenovo/MotM,   **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   **Proposal 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),   * 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 * all the resources across the NTRP CSI-RS resources/resource sets are configured with the same bandwidth * UE is configured with 1 CSI-RS resource set comprising NTRP CSI-RS resources   **Support/fine**: Samsung, OPPO, Fujitsu, Xiaomi, Nokia/NSB, CATT, Qualcomm, Lenovo/MotM, CMCC, [Nokia/NSB],  **Not support**:  **Conclusion 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), there is no consensus on:   * Supporting multi-port CSI-RS for CSI * Supporting different RE locations (FDM) for the RSs   **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, Qualcomm,   + No: Spreadtrum, Samsung, OPPO, Fujitsu, Nokia/NSB, Lenovo/MotM, * 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, Nokia/NSB, CATT, Qualcomm, Lenovo/MotM,   + No: * Whether only 1 or NTRP >1 resource sets are used   + 1 set, NTRP resources: CATT, CMCC, Samsung, OPPO, Fujitsu, Xiaomi, CATT, Lenovo/MotM,   + NTRP sets: Nokia/NSB, Qualcomm, * Whether different RE locations (FDM) are supported for the RSs   + Yes: ZTE, Nokia/NSB, CATT,   + No: Samsung, OPPO, Fujitsu, Lenovo/MotM, * Whether all the resources across the NTRP CSI-RS resources/resource sets are configured with the same bandwidth   + Yes:CMCC, Samsung, OPPO, Fujitsu, Xiaomi, Nokia/NSB, CATT, Lenovo/MotM,   + 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. |
| 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/NSB | 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** |
| Nokia/NSB | **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. |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 3A**  **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’)?**  **Please check Nokia’s explanation for 3.C.2** |
| Qualcomm | **Proposal 3.H.2**: We are not OK with the last bullet, and want to add some FFS to August (similar as that for **3.C.3**)   |  | | --- | | …   * UE is configured with 1 CSI-RS resource set comprising NTRP groups of single-port CSI-RS resources   + Each group comprises y CSI-RS resources, y=1 is supported   + FFS (by RAN1#118): Whether y>1 is also supported | |
| NTT DOCOMO | Proposal 3.C.1:  OK.  Question 3.C.1:  Given that Q>1 is not popular at least for gNB vendors, we are ok to support Q=1 only.  Proposal 3.C.3:  OK.  Question: 3.C.3:  Fine with PSRS=1 only.  Proposal 3.H.2:  Support. |
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# References

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| --- | --- | --- | --- |
| 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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