**3GPP TSG RAN WG1 #110bis-e R1-2210507**

**e-Meeting, October 10th – 19th, 2022**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#3 on Rel-18 CSI enhancements: ROUND 2

**Document for:** Discussion and Decision

## Introduction

The scope given in the Rel-18 NR Evolved MIMO WID pertaining to CSI enhancement is as follows:

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| 1. Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:    * Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis    * UE reporting of time-domain channel properties measured via CSI-RS for tracking 2. Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4 TRPs, assuming ideal backhaul and synchronization as well as the same number of antenna ports across TRPs, as follows:    1. Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off |

## Summary of companies’ views

### Issue 1: Type-II codebook refinement for CJT

Table 1A Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.5 | [110bis-e] **Agreement**  On the SD basis selection for Type-II codebook refinement for CJT mTRP, support the following on the *L* parameter:   * Per-CSI-RS-resource *Ln* parameter   + TBD: Whether {*Ln*, *n*=1, ..., *N*} are higher-layer configured by gNB, or the total is higher-layer configured by gNB while {*Ln*, *n*=1, ..., *N*} are reported by the UE, one L configured and {*Ln*} determined from configured L   + FFS: The value of *Ln* is taken from a pre-defined set   **Proposal 1.E.3**: On the SD basis selection for Type-II codebook refinement for CJT mTRP, on the *L* parameter, down select from the following alternatives (by RAN1#111):   * Alt1. Each of the {*Ln*, *n*=1, ..., *N*} is gNB-configured via higher-layer (RRC) signaling   + The candidate values for follow the legacy specification * Alt2. where *Ltot* is gNB-configured via higher-layer (RRC) signaling and the relative value(s) of {*Ln*, *n*=1, ..., *N*} are reported by the UE   + TBD: Whether for a given configured value of *Ltot*, the possible combinations of {*Ln*, *n*=1, ..., *N*} are fixed/pre-determined or gNB-configured via higher-layer (RRC) signaling   + TBD: Whether the value(s) of {*Ln*, *n*=1, ..., *N*} are reported implicitly or explicitly, and whether some value(s) don’t need to be reported * Alt3. An *L* parameter is gNB-configured via higher-layer (RRC) signaling and {*Ln*, *n*=1, ..., *N*} are determined from the value of *L*   + TBD: How to determine {*Ln*, *n*=1, ..., *N*} from *L*, e.g. depending on RI value   **FL Notes**: We list alternatives for further down selection. For an early temp check, please feel free to share your initial preference ☺ | **Proposal 1.E.3:**   * **Support/fine:** Samsung, AT&T, * **Not support:**   **Alt1:**  **Alt2:**  **Alt3:** Samsung |
| 1.7 | [110bis-e] **Agreement**  For the Rel-18 Type-II codebook refinement for CJT mTRP, the constraint on the maximum number of non-zero coefficients (NZCs) per-layer (K0) is defined jointly across all N CSI-RS resources   * TBD: the constraint on the total number of NZCs across all layers   **Question 1**: Is a constraint on the total number of NZCs summed across all layers needed?  **Question 2**: If so, should we use the legacy constraint of 2K0?  **FL Notes**: Please share your views on the answers to Q1 and Q2 | **Question 1:**   * **Yes:** AT&T, Samsung * **No:**   **Question 2:**   * **Yes:** Samsung * **No:** |
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Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **PLEASE READ THE FL NOTES**   1. **Check and, if needed, update your view in Table 1A especially on the moderator proposals.** 2. **Share additional inputs here, if needed**   **More moderator proposals may be added in the next revision** |
|  | **Isuue1.5: Proposal 1.E.3**  we support Alt3 because the SD basis encountered by the UE is not uniformly distributed across the TRPs (see below). We think Alt3 gives the UE more flexibility to decide the SD to improve the performance and may be better fit for the agreement on Proposal 1.A since N is decided by the UE i.e. N{1,..., NTRP}    We would like change **Proposal 1.E.3** to the following:  **Proposal 1.E.3**: On the SD basis selection for Type-II codebook refinement for CJT mTRP, on the *L* parameter, down select from the following alternatives (by RAN1#111):   * Alt1. Each of the {*Ln*, *n*=1, ..., *N*} is gNB-configured via higher-layer (RRC) signaling   + The candidate values for follow the legacy specification * Alt2. where *Ltot* is gNB-configured via higher-layer (RRC) signaling and the relative value(s) of {*Ln*, *n*=1, ..., *N*} are reported by the UE   + TBD: Whether for a given configured value of *Ltot*, the possible combinations of {*Ln*, *n*=1, ..., *N*} are fixed/pre-determined or gNB-configured via higher-layer (RRC) signaling   + TBD: Whether the value(s) of {*Ln*, *n*=1, ..., *N*} are reported implicitly or explicitly, and whether some value(s) don’t need to be reported * Alt3. An *L* parameter is gNB-configured via higher-layer (RRC) signaling and {*Ln*, *n*=1, ..., *N*} are determined from the value of *L*   + The UE decides the associated SD for the CSI-RS resources {Ln, n=1, ..., N} such that   + TBD: How to determine {*Ln*, *n*=1, ..., *N*} from *L*, e.g. depending on RI value   Mod: This is actually Alt2]  **Isuue1.7**  **Question 1: Yes** |
| Samsung | **Proposal 1.E.3**  We support the proposal and our preference is Alt3. In our view, this can simplify the design of both parameter combination table and CSI part 1 and 2. One simple example on Alt3 we have considered in our SLS results is L for a reference TRP and L/2 for the remaining N-1 TRPs.  **On Issue 1.7,**   * Q1: yes * Q2: yes. We prefer to follow the legacy scheme, unless it is identified that another scheme outperforms the legacy. |
| Mod V5 | **No revision** |
| AT&T | **Correction:** we would like to correct our position on issue 1.5 Proposal 1.E.3, here is our updated one:  **Isuue1.5: Proposal 1.E.3**  Since the SD basis encountered by the UE is not uniformly distributed across the TRPs (see below), the gNB can be configured with the maximum number of SD basis rather than the total number of SD basis. This will give the UE more flexibility to decide the SD basis to improve the performance and may be better fit for the agreement on Proposal 1.A since N is decided by the UE i.e. N{1,..., NTRP}    We would like add Alt4 to **Proposal 1.E.3**:  **Proposal 1.E.3**: On the SD basis selection for Type-II codebook refinement for CJT mTRP, on the *L* parameter, down select from the following alternatives (by RAN1#111):   * Alt1. Each of the {*Ln*, *n*=1, ..., *N*} is gNB-configured via higher-layer (RRC) signaling   + The candidate values for follow the legacy specification * Alt2. where *Ltot* is gNB-configured via higher-layer (RRC) signaling and the relative value(s) of {*Ln*, *n*=1, ..., *N*} are reported by the UE   + TBD: Whether for a given configured value of *Ltot*, the possible combinations of {*Ln*, *n*=1, ..., *N*} are fixed/pre-determined or gNB-configured via higher-layer (RRC) signaling   + TBD: Whether the value(s) of {*Ln*, *n*=1, ..., *N*} are reported implicitly or explicitly, and whether some value(s) don’t need to be reported * Alt3. An *L* parameter is gNB-configured via higher-layer (RRC) signaling and {*Ln*, *n*=1, ..., *N*} are determined from the value of *L*   + TBD: How to determine {*Ln*, *n*=1, ..., *N*} from *L*, e.g. depending on RI value * Alt4. *Lmax* is gNB-configured via higher-layer (RRC) signaling and the relative value(s) of {*Ln*, *n*=1, ..., *N*} are reported by the UE   + The UE decides the associated SD for the CSI-RS resources {Ln, n=1, ..., N} such that   + TBD: Whether the value(s) of {*Ln*, *n*=1, ..., *N*} are reported implicitly or explicitly, and whether some value(s) don’t need to be reported |
| LG | **Proposal 1.E.3**  We support the proposal and our preference is Alt1, which is simple and align with legacy. We don’t see difference between Alt 2 and Alt 4. These two should be merged.  **On Issue 1.7,**   * Q1: yes * Q2: yes. Same view as Samsung. |
| AT&T | @LG: here is the difference between Alt2 & Alt4 from our perspective  In Alt4, the gNB is configured with max value rather than a total value.  Basically: in Alt2, the total value is a function of predefined combinations of {L1, L2, …, LN}, however, in our proposed version the Lmax does not need to be associated with predefined combinations but on max of the aggregate value of  .  This will give the network the tool to control overhead and gives the UE the flexibility to decide SD basis without defining the permitted combinations of Ln . |
| DOCOMO | **Proposal 1.E.3:**  After further thinking, we tend to agree with SS/AT&T’s intention on configuration of max value of L.  Then, our question is, what is the technical/performance difference among following 3 options.   * + OptA: NW configures a total max value of Ltot for all TRPs, and UE decides Ln for each TRP, where the sum value of Ln for all TRPs should be no larger than Ltot (Alt4)   + OptB: NW configures a common max value of L for each TRP, and UE decides Ln for each TRP, where Ln for each TRP should be no larger than L (Alt3)   + OptC: NW configures separate max values of Ln,max for each TRP, and UE decides Ln for each TRP, where Ln for each TRP should be no larger than Ln,max (a new Alt)   **Issue1.7:**  Yes to Q1 and Q2. |
| Qualcomm | Issue 1.5  Yes, finally we are on track of this essential issue.  In a high-level, we are OK with **Proposal 1.E.3** to simply list all alternatives for down-selection in the next meeting. Still, we want to input some of our analyses for discussion.  Firstly, we want to say Alt2 is more like legacy Rel-16 sTRP case, regarding only one L is configured. The value of L (larger or smaller) can be considered as a “report overhead resource” constraint, which could be the main consideration of network config – besides this, it does not assume network has certain knowledge regarding relative channel properties b/w ports (which are small-scale channel properties).  On the other side, in our view, both Alt1 and Alt3 assume gNB has certain knowledge regarding some small-scale channel properties of a specific UE. We believe this assumption is strong and is difficult to be obtained even with previously reported RSRP (which only represents large-scale channel properties – coarser spatial granularity, and may only works when RSRP is large enough e.g. >20 or 15dB).  Therefore, we **prefer Alt2**, which is also verified with some evaluations with considerable UPT gain under a same/similar overhead.  Besides, we also **support AT&T’s proposed Alt4** (also proposed by MediaTek in Round 1) – it does not matter whether this parameter is denoted as Lmax or Ltot). This case may be useful to “opportunistically” reduce UE complexity as well as report overhead, if RSRP gap b/w TRPs is large. For example, Ltot=6 is configured for a 8-port\*3-TRP cluster, and UE observed certain TRP#x has higher RSRP >20dB than the other two, then at most L=4 is possible – this is the total ports per-pol.  Issue 1.5  Support reuse legacy mechanism (possible optimization can be discussed later by adjusting ParamCombo values) |
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### Issue 2: Type-II codebook refinement for high/medium UE velocities (with time/Doppler-domain compression)

Table 3A Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | [109-e] **Agreement**  The work scope of Type-II codebook refinement for high/medium velocities includes refinement of the following codebooks, based on a common design framework:   * Rel-16 eType-II regular codebook * Rel-17 FeType-II port selection (PS) codebook   FFS: Whether to prioritize/down-select from the two  **Proposal 2.A**: The Rel-18 Type-II codebook refinement for high/medium velocities comprises refinement of the following codebooks:   * Refinement of the Rel-16 eType-II regular codebook * Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the same design details as the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations   + Time-/Doppler-domain reciprocity is not assumed   **FL Note**: This proposal has been discussed in RAN1#110 | **Support (equal priority for) both Rel-16 eType-II and Rel-17 FeType-II:** Huawei/HiSi, ZTE (Rel-16 first), Fraunhofer IIS/HHI   * **Concern:** vivo, Lenovo, LG, Apple, DOCOMO, Spreadtrum   **Down-select to only Rel-16 eType-II:** Apple, DOCOMO, MediaTek, NEC, Xiaomi, Samsung, Lenovo, Intel (if Rel-17, no DD reciprocity), Xiaomi. Qualcomm, Apple, DOCOMO, Ericsson, Nokia/NSB, LG, Spreadtrum, CMCC, vivo, OPPO, Google, Sharp  **Proposal 2.A:**   * **Support/fine:** IDC, ZTE, Huawei/HiSi, Fraunhofer IIS/HHI * **Not support (Rel-16 only):** vivo, Lenovo, LG, Apple, DOCOMO, Spreadtrum |
| 2.7 | [109-e] **Agreement**  On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, support the following CSI-RS resource types/structures for CMR:   * Time-domain behaviour for NZP CSI-RS resource: periodic (P), semi-persistent (SP), aperiodic (AP)   + FFS: Whether to introduce constraints on allowed configuration * Down select from the following:   + Alt1. Support K>1 NZP CSI-RS resources, received via a single triggering instance, for aperiodic (AP) -CSI-RS-based channel measurement in a same CSI-RS resource set where the separation between 2 consecutive AP-CSI-RS resources is m slot(s):   + Alt2. Support one NZP CSI-RS resource in a CSI-RS resource set, where K>1 occasions are received via a single triggering instance, for aperiodic (AP)-CSI-RS-based channel measurement where the separation between 2 consecutive AP-CSI-RS resources is m slot(s).   + For any of the alternatives:     - No CRI is reported     - FFS: Details, e.g., supported value(s) of K, m, other use cases for the AP-CSI-RS resources (e.g., for training filter coefficients, prediction or performance monitoring) * Support only one NZP CSI-RS resource for P or SP-CSI-RS-based channel measurement   **Proposal 2.G.2**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, support the following CSI-RS resource types/structures for CMR … {add later}  **FL Note**: Please share your preference Alt1 vs Alt2 | **Alt1:** ZTE, LG, Xiaomi, CMCC, Qualcomm, Huawei/HiSi, Samsung  **Alt2:** MediaTek, Samsung (2nd preference) |
| 2.9 | [110bis-e] **Agreement**  For the Type-II codebook refinement for high/medium velocities, down-select from the following alternatives:   * Alt1. *Q* different 2-dimensional bitmaps are introduced for indicating the location of the NZCs, where the qth (q=1,…., *Q*) 2-dimensional bitmap corresponds to qth selected DD basis vector   + The number of selected DD basis vectors is denoted as *Q*   + This implies that for each layer, the location of NZCs in SD-FD can be different for different selected DD basis vectors. * Alt2. A DD-basis-common per-layer 2-dimensional bitmap for indicating the location of NZCs used in Rel-16/17 Type-II is used   + This implies that for each layer, the location of NZCs in SD-FD is common across all the Q selected DD basis vectors   FFS: Further overhead reduction on bitmap(s)  FFS: Whether the number of NZCs is upper bounded across all DD basis vectors or per DD basis vector  **Proposal 2.I.2**: For the Type-II codebook refinement for high/medium velocities, ……. {add later}  **FL Notes:** Please share your preference for Alt1 vs Alt2 | **Alt1:** Intel, ZTE**,** Xiaomi, Ericsson, CMCC  **Alt2:** Samsung, IDC |
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Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | **PLEASE READ THE FL NOTES**   1. **Check and, if needed, update your view in Table 3A especially on the moderator proposals.** 2. **Share additional inputs here, if needed**   **More moderator proposals may be added in the next revision** |
| Fraunhofer IIS/Fraunhofer HHI | **Issue 2.9**:  We think that ALT1 is superior to Alt2, however with high feedback overhead. Therefore, we want to propose some optimization of the bitmaps of ALT1 that further reduces the feedback overhead. According to the agreement, the FD and DD components are commonly selected across all SD components. Therefore, for M FD components and Q DD components, there are MQ FD/DD component pairs which are common across all SD components (see the Figure below). Note that the figure is a representation of the 2D-bitmap of Alt1. Each column of the bitmap is associated with an FD/DD component pair. From our observations, the energy of each SD component/beamformed channel is only associated with either one or two FD-TD component pairs and not with all MQ FD-DD component pairs. Therefore, we think that the feedback overhead can be greatly reduced when reporting only M FD/DD pairs instead of reporting all MQ FD/DD component pairs. The TD component associated with each of the M FD/DD component pairs is reported by a Q-sized bitmap. By doing so, the size of the 2D-bitmap of ALT1 reduces from **2LMQ**to **2LM+MQ** bits.  A screenshot of a computer  Description automatically generated with low confidenceSupport of ALT1 with the following refinement (optimization of the bitmaps):  **Alt 1A: Single 2-dimensional bitmap of size 2LM (similar as in R16) for indicating the location of the NZCs, and a single bitmap of size MQ to report the association of each DD component to each FD component.**  [Mod: This is a part of the FFS: Further overhead reduction on bitmap(s). At this stage we don’t need to add a new alternative. If Alt1 is agreed, we will list sub-alternatives including the one you propose]  **Issue 2.7**: Will be commented later. |
| Samsung | Issue 2.7: we have slight preference for Alt1, but can also be OK with Alt2  Issue 2.9: in our view, the issue with Alt1 is the bitmap overhead scales linearly with Q. Alt2 on the other hand can keep overhead the same as legacy, and doesn’t impact the performance too much (when compared with Alt1), so we prefer Alt2 over Alt1. |
| Samsung2 | Re issue 2.9: since we just started discussing this issue in this meeting, and this issue requires some careful analysis via SLS, **we prefer not to decide on this issue in this meeting and defer it until next meeting,** so we have time to properly simulate and compare the two schemes  [Mod: I tend to agee. Let’s see what other companies say] |
| Mod V5 | **No revision** |
| LG | Issue 2.7: we prefer Alt1 because we already have similar concept in the spec for TRS, which have multiple CSIRS resources and same port assumption across the CSIRS resources.  Issue 2.9: we are not convinced that Alt 2 has minor/no performance degradation compared with Alt1. Al2 is too restrictive, reducing compression accuracy. |
| Qualcomm | Issue 2.1:  We are now even more preferred to **Rel-16-only** than before, seeing that the progress becomes slower down.  A comparison of this issue for CJT topic: Since delay-compensation is useful for larger delay spread of mTRP, it may still make sense; However, we don’t see a reason to have delay-compensated CSI-RS (which is UE-specific) for a fast moving UE (thus delay properties also changes fasters).  Issue 2.7:  Prefer Alt1 due to less change to existing RRC – can largely copy TRS config signaling  Issue 2.9:  We have similar observations as Fraunhofer regarding **channel sparsity** in SD&FD&TD, which could be exploited to reduce bitmap overhead of Alt1, and achieves an “intermediate mode” b/w Alt1 and Alt2.  We also agree with FL that this can already be included in current Alt1 description. |
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### Issue 3: TRS-based reporting of time-domain channel properties (TDCP)

Table 5A Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | [110bis-e] **Agreement**  For the Rel-18 TRS-based TDCP reporting, down select one of the following alternatives by RAN1#110bis-e:   * AltA. Based on Doppler profile   + E.g., Doppler spread derived from the 2nd moment of Doppler power spectrum, average Doppler shifts, Doppler shift per resource, maximum Doppler shift, relative Doppler shift, etc * AltB. Based on *quantized amplitude of* time-domain correlation profile   + E.g. Correlation within one TRS resource, correlation across multiple TRS resources   + Note: The correlation over one or more lags of TRS resource may be considered.  The lags may be within one TRS burst or different TRS bursts   Note: Different alternatives may or may not apply to different use cases  FFS: The need for a measure of confidence level in the TDCP report, and/or UE behaviour when the quality of TDCP measurement is not sufficiently high  FFS: TDCP parameter(s) signalled with respect to each alternative  **(I will add a proposal later based on the outcome of the ongoing email thread for Proposal 3.A)**  **FL Note**: Please check the revised proposal 3.A taking into account Ericsson’s input in breaking AltA into multiple proposals  This is the current situation.   * AltA: ZTE, vivo, Google, LG, OPPO, Huawei/HiSi, Xiaomi, Mavenir, Apple (1st pref), CATT, IDC, Spreadtrum, NEC (2nd pref), Nokia/NSB * AltB: Samsung, Ericsson, MediaTek, vivo, Qualcomm, DOCOMO, OPPO, Sharp, Lenovo, Apple (2nd pref), IDC, NEC (1st pref), CEWiT, Fraunhofer IIS/HHI, | |
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Table 6 Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | **PLEASE READ THE FL NOTES**   1. **Check and, if needed, update your view in Table 5A especially on the moderator proposals.** 2. **Share additional inputs here, if needed**   **More moderator proposals may be added in the next revision** |
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# References

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| --- | --- | --- | --- |
| 1 | R1-2209715 | Summary of OFFLINE discussion on Rel-18 MIMO CSI | Moderator (Samsung) |
| 2 | R1-2208441 | CSI enhancement for coherent JT and mobility | Huawei, HiSilicon |
| 3 | R1-2208495 | Enhanced CSI for CJT and High Doppler Operations | InterDigital, Inc. |
| 4 | R1-2208504 | CSI enhancement for high/medium UE velocities and CJT | ZTE |
| 5 | R1-2208541 | Discussion on CSI enhancement for high/medium UE velocities and coherent JT | Spreadtrum Communications |
| 6 | R1-2208628 | Discussion on CSI enhancement for high-medium UE velocities and coherent JT | vivo |
| 7 | R1-2208742 | Discussion of CSI enhancement for high speed UE and coherent JT | Lenovo |
| 8 | R1-2208794 | CSI enhancement for high/medium UE velocities and coherent JT | OPPO |
| 9 | R1-2208872 | On CSI Enhancement | Google |
| 10 | R1-2208893 | Potential CSI enhancement for high/medium UE velocities and coherent JT | LG Electronics |
| 11 | R1-2208947 | Discussion on CSI enhancements | CATT |
| 12 | R1-2209041 | On CSI enhancements | Intel Corporation |
| 13 | R1-2209090 | Further considerations on CSI enhancement for high/medium UE velocities and CJT | Sony |
| 14 | R1-2209140 | Discussion on CSI enhancement | NEC |
| 15 | R1-2209247 | Discussion on CSI enhancement | Mavenir |
| 16 | R1-2209258 | Discussion on CSI enhancement for high/medium UE velocities and CJT | xiaomi |
| 17 | R1-2209322 | Discussion on CSI enhancement for high/medium UE velocities and CJT | CMCC |
| 18 | R1-2209381 | CSI enhancement | Sharp |
| 19 | R1-2209494 | CSI enhancement | MediaTek Inc. |
| 20 | R1-2209545 | CSI enhancements for medium UE velocities and coherent JT | Fraunhofer IIS, Fraunhofer HHI |
| 21 | R1-2209570 | Views on Rel-18 MIMO CSI enhancement | Apple |
| 22 | R1-22010241 | Views on CSI enhancements | Samsung |
| 23 | R1-2209793 | Views on CSI Enhancements for CJT | AT&T |
| 24 | R1-2209852 | On CSI enhancements for Rel-18 NR MIMO evolution | Ericsson |
| 25 | R1-2209890 | Discussion on CSI enhancement | NTT DOCOMO, INC. |
| 26 | R1-2209969 | CSI enhancements for high/medium UE velocities and Coherent-JT | Qualcomm Incorporated |
| 27 | R1-2210063 | CSI enhancement for high/medium UE velocities and CJT | Nokia, Nokia Shanghai Bell |
| 28 | R1-2210105 | Discussion on CSI Enhancements for high/medium UE velocities and coherent JT | CEWiT |
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