**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   + FFS: The candidate values for *L*n, e.g. 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   + FFS: The candidate values for *L*n * 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. L1=L and other Ln = L/2   + FFS: The candidate values for *L* * 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 relative value(s) of {Ln, n=1, ..., N} are reported by the UE, 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   + FFS: The candidate values for *L*n   MOVED TO EMAIL ENDORSEMENT 4, PLEASE COMMENT THERE  **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, LG, MediaTek, Xiaomi, ZTE, Qualcomm, OPPO, Huawei/HiSi, vivo, DOCOMO, Lenovo * **Not support:**   **Alt1:** LG, MediaTek, Xiaomi, ZTE  **Alt2:** Qualcomm, OPPO, Huawei/HiSi, vivo  **Alt3:** Samsung  **Alt4**: AT&T, DOCOMO, Qualcomm, |
| 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   **Proposal 1.G.3**: For the Rel-18 Type-II codebook refinement for CJT mTRP, also support a constraint on the total number of non-zero coefficients (NZCs) summed across all layers:   * Following the legacy specification, the maximum total number is 2K0   **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?  MOVED TO EMAIL ENDORSEMENT 4, PLEASE COMMENT THERE  **FL Notes**: Please share your views on the answers to Q1 and Q2 | **Proposal 1.G.3:**   * **Support/fine:** Samsung, LG, DOCOMO, MediaTek, OPPO, Huawei/HiSi, vivo, * **Not support:** ZTE (sub-bullet FFS)   **Question 1:**   * **Yes:** AT&T, Samsung, LG, DOCOMO, MediaTek, Xiaomi, OPPO, Huawei/HiSi, ZTE, vivo * **No:**   **Question 2:**   * **Yes:** Samsung, LG, DOCOMO, MediaTek, OPPO, Huawei/HiSi, vivo * **No:** ZTE |
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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) |
| MediaTek | Regarding **Proposal 1.E.3** we would prefer Alt 1. We would rather prefer the gNB to configure Ln for each TRP n. Such a gNB configuration extends from the Rel-16 configuration of L and is friendlier to UE implementation.  **On Issue 1.7:**   * Q1: yes * Q2: yes. Similar view as Samsung. |
| Xiaomi | **Proposal 1.E.3**  Support and prefer Alt 1 for UE complexity reduction. We are not clear about the difference between Alt 3 and Alt 2, and we think these two can be combined.  **Issue 1.7**  Yes to Q1 and Q2 |
| OPPO | For **proposal 1.E.3，**we support it and prefer Alt.2. As mentioned by QC, gNB is not able to acquire the channel of each TRP and UE, and UE reporting can achieve higher THP with the same reporting overhead.  For issue 1.7, yes to both |
| Huawei, HiSilicon | **Issue1.5**  We support **Proposal 1.E.3** and our preference is Alt2. We share similar view with Qualcomm. Since UE has certain knowledge regarding both large-scale and small-scale channel properties, it’s more reasonable for UE to determine Ln based on the difference of spatial sparsity and channel quality across TRPs, so as to achieve better performance. And gNB can configured the total number of SD basis to control the overhead.  Regarding **AT&T’s proposed Alt4**, the main difference between it and Alt2 is whether the gNB-configured parameter is Ltot or Lmax. We think these two can be merged, and whether the gNB-configured parameter is Ltot or Lmax can be discussed later.  **Issue 1.7**  Yes to Q1 and Q2. |
| ZTE | Proposal 1.E.3: In our views, some further studies seem to be needed. We think that Alt-1 can be assumed as a baseline? But, we think that the candidate value should be FFS, due to that eitherway, we need to discuss the candidate value.   * + FFS: The candidate values of Ln   Then, regarding Alt2, compressing the reporting overhead may be needed  Q1: We are fine. Q2: Some further evaluation may be needed. |
| vivo | **Proposal 1.E.3**  We support Proposal 1.E.3 and prefer Alt 2.  Question for Alt 3: How can Ln be determined by a single L? It’s better to give some specific solutions for companies to have focused study or evaluation. Otherwise potential solutions for Alt 3 will be too divergent in next meeting. The example from SS can be used, i.e., a reference TRP and L/2 for the remaining N-1 TRPs.  **Issue 1.7**  Q1: Yes, across all the layers.  Q2: We fine to reuse legacy definition. |
| Lenovo | **Issue 1.3:**  We are fine with Proposal 1.E.3  **Issue 1.7:**  Since we have agreed to support a bitmap for indicating the activated N out of NTRP TRPs, we believe there should also be a constraint on the minimum number of coefficients per TRP, e.g., no selected TRP can have less than 2 NZ coefficients per layer (at least one per polarization). We therefore propose to add the following FFS  **FFS: whether a constraint on the minimum/maximum number of NZ coefficients per CSI-RS resource is needed**  [Mod: This is a different issue since the prposal deals with maximum #. Please propose this in the next meeting and I’ll include it in the FL summary for 111] |
| MediaTek | **Proposal 1.E.3**  Even though our first preference is Alt 1, we would to like discuss other options listed. Firstly, we think that having is too restrictive. It gives a feeling of forcing the UE to report beams when in fact the channel may not allow it. Qualcomm’s explanation is a good example for such a situation. Allowing is more reasonable.  Having said this, taking the example of a more mTRP friendly channel, it is possible that all TRPs provide SD beam rich channels. In such a case, having only a single constraint SD beams becomes complex for the UE to find the optimal number and candidate SD beams for each TRP *n*. (Imagine a 32-port x 4 TRP scenario, which is not disallowed as per the discussion so far). It is therefore better for UE implementation to have a restriction on the values can take. For example, . The value of is needed to support low Tx port TRPs and lower the CJT CSI feedback overhead, and follows the UE optional feature of Rel-16. However, this may be discussed later as part of parameter combinations.  From the above explanation, it is not necessary to restrict the combinations of {*Ln*, *n*=1, ..., *N*} as in the current wording of Alt 2, but only a restriction on the individual .  Therefore, we propose to add an extra subbullet in Alt 4 proposed by AT&T as follows:   * 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   + FFS: Each UE reported value of is taken from a single candidate value set.   + 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 |
| Mod V21 | **Revision on 1.E.3**  **Added proposal 1.G.3** |

### 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 * **Concern (Rel-16 only):** vivo, Lenovo, LG, Apple, DOCOMO, Spreadtrum, Qualcomm, Lenovo |
| 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, support 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):   MOVED TO EMAIL ENDORSEMENT 4, PLEASE COMMENT THERE  **FL Note**: Please share your preference Alt1 vs Alt2 | **Proposal 2.G.2:**   * **Support/fine:** ZTE, LG, Xiaomi, CMCC, Qualcomm, Huawei/HiSi, Samsung, LG, OPPO, vivo, * **Not support:** MediaTek, DOCOMO   **Alt1:** ZTE, LG, Xiaomi, CMCC, Qualcomm, Huawei/HiSi, Samsung, LG, OPPO, vivo,  **Alt2:** MediaTek, Samsung (2nd preference), OPPO, DOCOMO |
| 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  Defer to the next meeting since companies request for SLS evaluation which I tend to agree, STOP DISCUSSION  **FL Notes:** Please share your preference for Alt1 vs Alt2 | **Alt1:** Intel, ZTE**,** Xiaomi, Ericsson, CMCC, LG, Qualcomm, Xiaomi, OPPO, DOCOMO, ZTE, Lenovo,  **Alt2:** Samsung, IDC  **Defer to next meeting**: Samsung, MediaTek, Huawei/HiSi, Lenovo |
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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. |
| MediaTek | Regarding **Issue 2.7**, We like to highlight that if we go for Alt1 then we also need to redefine how the active CSI-RS resource/ports in UE capability for CSI processing is counted. if we go with Alt 1 then we have different resource ID for each instance of repetition and hence they will take up one active resource/ports or mandate higher mandatory values for UEs which support feature  While for Alt 2, since the resource ID is the same, we don’t need to revisit the UE capability for CSI-RS resource  More importantly if we want a reliable channel predication we may need 8-10 instance of CSI-RS this would mean high RRC overhead just to configure these CSI-RSs since each CSI-RS resource needs to be configured individually, while this can be done in compact format of sending RRC configuration for just one single CSI-RS in Alt2.  Regarding **Issue 2.9,** we agree with Samsung. We would like to have more time to evaluate the alternatives before deciding. |
| Xiaomi | **Issue 2.9**  Alt1 is preferred. In our view, Alt2 is too restrictive, which may make performance degraded compared with Alt1.  Regarding indication overhead of NZC reduction, we agree with QC and Fraunhofer.  @Fraunhofer, if reporting M FD and DD pair, are 2LM bits is used to indicate the location of NZC? While MQ bits is used to indication the selected FD and DD pair? Then, those selected FD and DD basis are indicated respectively through additional basis indication. |
| Fraunhofer IIS/Fraunhofer HHI | @Xiaomi, we assume separate indication of selected FD components per layer (like in Rel.16 eType II CB) and DD components per layer. The MQ-sized bitmap is based on the local indices of the selected FD and DD components. |
| OPPO | Issue 2.7: Fine with either Alt1 or Alt2.  Issue 2.9: Our preference is Alt1, and slightly prefer the way such as Fraunhofer proposed for a better tradeoff. The performance of Alt 2 would be degraded with low overhead. |
| DOCOMO | Issue 2.1: We share the same understanding as Qualcomm. Use of delay compensation for the scenario with large Doppler does make less sense. Support to focus on Rel-16 eType-II more.  Issue 2.7: We tend to agree with MTK. Alt2 could give more flexible resource configuration with limited configuration overhead.  Issue 2.9: Alt1 is preferred. |
| Huawei, HiSilicon | **Proposal 2.A**  We support the proposal. As most of the refinement for Rel-16/17 codebooks are the same, including codebook structure, Doppler basis design and indication, and W2 reporting. Therefore, support Rel-17 FeType-II CB require doesn’t need too much workload. The Rel-17 FeType-II CB exploiting SD/FD reciprocity makes the SD/FD domain sparser. Therefore, the Rel-17 FeType-II CB could feedback less NZC coefficient(s) than Rel-16 Type II CB, and reduces the CSI overhead compared with the Rel-16 codebook.  Thanks for QC’s comments. Regarding QC’s comment on slower progress, we have the opposite feeling that CSI enhancement has a rather good progress with all colleagues working together. ^\_^ In addition, refinement over Rel-16 and Rel-17 codebooks can share the same design, so no further spec work is needed.  On the change of delay property, assuming a UE with 60km/h and CSI-RS periodicity of 5ms, then the delay change of adjacent CSI-RS is less than 0.3ns, which can still be compensated by gNB. For Rel-16 based refinement for mobility, if the delay properties do change too fast, the channel prediction will also be a problem as currently only Doppler domain compression is assumed. From evaluation results from companies, it seems the change of delay property is small enough that the channel compression only need to consider Doppler domain.  **Proposal 2.G.2**: We prefer Alt 1, which seems less spec impact based on current RRC structure.  **Proposal 2.I.2:** In our understanding, this proposal needs more evaluate and analysis, we prefer not to decide in this meeting. In addition, we would like to understand and clarify that the proposal introduces no extra restriction for the reporting order/priority of NZC(s). We believe some evaluation is needed for the decision. |
| ZTE | Proposal 2.G.2: We prefer Alt1. If going with Alt2, we may need further review the definition of CSI-RS and corresponding procedure (e.g., CPU calculation).  Proposal 2.I.2: Alt1 is preferred. But, we are open to consider Alt2, if there are some clear benefits for saving overhead. |
| vivo | **Proposal 2.I.2**  We support Alt 1. Alt 2 may suffer performance loss due to limiting same coefficient locations are selected for different DD basis vectors.  For Alt 1, the current formulation is okay, but we share similar concern as SS that to let the bitmap size simply scale with the increase of Q will cause too much overhead. We suggest to further study potential reduction of NZC location bitmap overhead. |
| Lenovo | **Issue 2.1 (Proposal 2.A):**  Do not support the proposal. Only Rel-16 eType-II CB should be considered as a baseline. As of now, we have added a case that was not explicitly identified in the WID as a standalone problem (TDCP reporting), as well as two codebook sub-types for CJT (based on Rel-16 and 17 eType-II CB), and each with two reporting modes. We cannot keep adding sub-types/branches/mode to the codebook sub-types.  More importantly, Port-selection codebook for high speed would make sense if DD based CSI-RS beamforming is considered, which in our opinion is a much larger project that cannot fit into this agenda. Needless to say, FeType-II CB is constrained with small duplexing distance and lower Fc, we don’t see strong motivation to keep piling the workload like that  **Issue 2.7 (Proposal 2.G.2):**  Prefer Alt-1 which is more straightforward to support, compared with Alt-2 which would make AP CSI-RS resemble SP/P CSI-RS and hence leading to confusion  **Issue 2.9 (Proposal 2.I.2):**  We are fine with the proposal, prefer to down select in the next meeting as suggested by Samsung |
| MediaTek | **@ZTE,** Actually in our opinion Alt 1 needs redefinition of CPU and active CSI-RS not Alt2. If we keep the same CPU rules each time CSI-RS in Alt 1 takes place, it will consume one CPU. Let’s assume we have 5 CSI-RS in the set then we consume in Alt 1, it will consume 5 CPUs and 5 active CSI-RS until PUSCH carrying the report, even though, practically, it’s the same CSI-RS and the same CPU. In Alt 2, this would not happen, because it’s the same CSI-RS ID. To support Alt 1 we either have to redefine the CPU/CSI-RS counting rules or have UE support high numbers of CPUs/active CSI-RSs. |
| Mod V21 | **Added proposal 2.G.2 – moved to email endorsement 4, please comment there**  **STOP DISCUSSION FOR 2.9 (too many companies requesting further evaluation)** |

### 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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