**3GPP TSG RAN WG1 #118bis R1-2409059**

**Hefei, China, October 14th – 18th, 2024**

**Agenda item:** 9.2.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#3 on Rel-19 CSI enhancements: Round 3

**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 (2d added in [1]):

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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    4. SRS port grouping and its association to the two codewords for the 6/8Rx low complexity receiver supporting more than 4 layers, with legacy codebook       * No enhancement on codeword-to-layer mapping, DL resource allocation, CSI feedback, and DCI format       * Note: Whether to support 6Rx with more than 4 layers is to be decided in RAN4 Rel-19 RF enhancements WI 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** |
| **New issues/proposals** | | |
| 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, when SRS port grouping is configured, regarding the mapping between CSI-RS ports and SRS port groups, no additional specification support is introduced   * Note: When SRS port grouping is configured, the UE doesn’t expect reportQuantity set to ‘cri-RI-CQI’ without ‘*non-PMI-PortIndication*’   **FL assessment**: Please check the wording of the Note | |
| **Issues/proposals from previous round(s)** | | |
| 1.2.2 | **Proposal 1.B.2**: For the Rel-19 Type-I SP and Type-II codebook refinements (except based on Rel-18 Type-II Doppler) for 48, 64, and 128 CSI-RS ports, change the *maxNumberTxPortsPerResource* to *maxNumberTxPortsPerReport* for Rel-19 codebook triplet capability   * Note: Since ARC=1 was agreed, the K aggregated resources are perceived as 1 resource for ARC, and *maxNumberTxPortsPerResource* cannot be larger than 32.     **FL assessment**: This proposal is technically sound. | **Support/fine:** vivo, Spreadtrum (name change), Samsung, Qualcomm, HONOR, Xiaomi, MediaTek, CATT, Nokia/NSB, Fraunhofer IIS/HHI (open), Ericsson, TCL (open), NEC, Tejas,  **Not support:** ZTE, OPPO (UE feature), Google (fine for UE feature) |
| 1.2.3 | **[117] Agreement**  For the Rel-19 Type-I SP and Type-II codebook refinements (except based on Rel-18 Type-II Doppler) for 48, 64, and 128 CSI-RS ports, regarding CPU occupation   * For Capability 1 timeline: OCPU = ceil(P/32) * For Capability 2 timeline: OCPU = 1   **Proposal 1.B.3**: For the Rel-19 Type-I SP and Type-II codebook refinements (except based on Rel-18 Type-II Doppler) for 48, 64, and 128 CSI-RS ports, to match Capability 2 timeline, scale the associated CSI reference resource slot location nCSI\_ref by ceil(P/32)  **FL assessment**: The above issue needs some discussion. | **Support/fine:** vivo, Spreadtrum, Samsung (open), HONOR (open), Fraunhofer IIS/HHI (open), Qualcomm, TCL (open), Tejas (open),  **Not support:** ZTE, CMCC, Nokia/NSB (not sure but ok to discuss), Ericsson (ok to dis-cuss), OPPO, Google |
| 1.5 | **Proposal 1.E**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, extend the agreed Scheme-A and Scheme-B to the legacy number of CSI-RS ports (i.e. 4, 8, 12, 16, 24, and 32 ports) for all applicable RI values (1, …, min(PCSI-RS,8)) with K=1 only, and without any further modification/enhancement of the sub-features pertinent to the Rel-19 Type-I SP design (including, e.g. the Rel-19 Type-I SP CBSR, soft scaling).   * [The following of Rel-19 Type-I SP are four separate UE features: (1) Scheme-A >32port; (2) Scheme-B >32port; (3) Scheme-A ≤32port; (4) Scheme-B ≤32 port.]   **FL assessment**: This was discussed during Monday Offline session.  This proposal is sound for the completeness of Rel-19 Type-I SP codebook. Note that this doesn’t impact the legacy Rel-15 Type-I SP design.  Re whether this is OOS or not, the WID says “… 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)**, …” which, strictly speaking, doesn’t preclude <=32 ports. So this extension proposal is not OOS. | **Support/fine:** ZTE, Lenovo/MotM, IDC, Samsung (ok), Xiaomi, Nokia/NSB, NEC, Fujitsu, Intel (FFS capability), NTT DOCOMO, CATT (only Scheme-B, no scheme-A), Spreadtrum, CMCC, MediaTek (ok with bullet),  **Not support:** Google,OPPO,HONOR, TCL, Fraunhofer IIS/HHI, Tejas,  **Concern**: Apple, vivo (ok RI=3-4 & 16, 24, 32 ports), Huawei/HiSi (same as vivo), Ericsson, Lenovo/MotM |

Table 1B SLS results: issue 1

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| **Company** | **SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| ZTE | 1.5 | UPT gain | SLS results of UPT gain for R19 Type-I(Scheme-A) codebook for RI=3-4 compared with R15 legacy: indicating that R19 Type-I(Scheme-A) codebook for rank-3/4 still offers a UPT gain (i.e., ~21.2% for cell-edge UE, ~3.8% for near-field UE, ~8.1% in average) over legacy mechanisms for ≥16 ports when PCSI-RS = 32 |

Table 1C Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 1A**   * **Please focus on the new issues/proposals** * **Please also check if you change your mind on the old proposals (from previous round(s)) or have additional inputs** |
| Lenovo/ MotM | **Proposal 1.A.2:**  OK. The current note is then used as guidance for implementation but is not captured in the spec as implied in the main paragraph. Is that correct?  **Proposal 1.E:**  We do not support this proposal but do not have strong concern. As mentioned, there is backdoor to support this for NW implementation via Type-I Rel-19 + NES SD Type-I |
| Samsung | **Proposal 1.A.2**  OK |
| Fujitsu | **Proposal 1.A.2:** Support |
| Huawei, HiSilicon | **Proposal 1.A.2:** we have concern on the note. Note that the support of non-PMI is an optional UE feature, SRS port grouping with cri-RI-CQI should not rely on it.  **Proposal 1.B.2:** support it.  **Proposal 1.B.3:** we don’t see the need to extend the CSI reference resource. |
| Xiaomi | **Proposal 1.A.2:**  We think the Note is needed when rank>4. When rank<=4, the reportQuantity ‘CRI-RI-CQI’ could be configured even without ‘non-PMI-PortIndication’.  **Proposal 1.B.3**:  For Capability 2, it has agreed that the legacy timeline Z/Z’ is scaled with ceil(P/32). We think such scaling timeline is sufficient for CSI processing. It is not clear why scaling the CSI reference resource slot location. |

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

Table 2A Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| **New issues/proposals** | | |
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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 1A**   * **Please focus on the new issues/proposals** * **Please also check if you change your mind on the old proposals (from previous round(s)) or have additional inputs** |
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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** |
| **New issues/proposals** | | | |
| 3.3.12 | **Proposal 3.C.12**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, when linking CJTC Dd and Rel-18 eType-II CJT CSI reports is configured with two separate triggers, to indicate *whether or not* the UE should perform delay offset (DO) compensation based on the latest linked CJTC Dd report when calculating the Rel-18 Type-II CJT CSI, introduce a 1-bit indicator per CSI trigger state:   * The 1-bit indicator is an RRC parameter * This is done without increasing the bit-width of the CSI request field of the DCI triggering a Rel-18 CJT eType-II CJT CSI report * FFS (RAN1#119): Whether the 1-bit indicator applies to all the NTRP CSI-RS resources, or to each of the NTRP CSI-RS resources * FFS (RAN1#119): How this applies to a single CSI trigger state associated with >1 CSI reports   **FL assessment**: Tuesday **OFFLINE** agreement (R1-2409062):  Without increasing the bit-width of the CSI request field of the DCI triggering a Rel-18 CJT eType-II CJT CSI report, 1 bit [FFS: per resource vs. for all NTRP resources] RRC parameter (functioning as a flag) per CSI trigger state   * FFS when >1 reports are associated with a single state | | **Support/fine:** Nokia, Ericsson, vivo, Samsung (ok), ZTE, Apple (all NTRP resources), Huawei, CATT, …  **Not support:** |
| 3.4 | **[118] Agreement**  For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, to facilitate UE-specific frequency offset pre-compensation on PDSCH by the NW, *decide*, by RAN1#118, whether to support configuring a UE (via RRC signaling) to perform PMI calculation for the Rel-18 eType-II CJT CSI report assuming pre-compensation using the UE-reported frequency offset (when ReportQuantity is ‘cjtc-F’). And if supported, whether any of the following is additionally supported or not:   * NW indicates the frequency offset value to be compensated for the Rel-18 eType-II CJT CSI report, and/or * The two separately configured reports (i.e. Rel-18 eType-II CJT CSI report and the CJTC frequency offset report) are always jointly triggered and carried on a same PUSCH (hence on a same slot) * The frequency offset value to be compensated is the latest reported fO before the DCI triggering the CJT CSI reporting   FFS: AP-CSI-RS can be configured for the Rel-18 eType-II CJT report  The above only applies when the CMRs do not share common QCL source for Doppler shift indication  **Question 3.D.1**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, to facilitate UE-specific frequency offset pre-compensation on PDSCH by the NW, please share your view whether to support configuring a UE (via RRC signaling) to perform PMI calculation for the Rel-18 eType-II CJT CSI report assuming pre-compensation using the UE-reported frequency offset (when ReportQuantity is ‘cjtc-F’), using the same mechanism as that for UE-reported delay offset (when ReportQuantity is ‘cjtc-Dd’).   * Yes: vivo, Xiaomi, Fujitsu, Sharp, Sony, Samsung, * No (NW implementation): Huawei/HiSi, MediaTek, CMCC, CATT, Nokia/NSB,   **FL assessment**: The above issue needs some discussion. For a given issue, if there is no consensus on ‘Yes’, we will assume that the answer is ‘No’ | | |
| **Issues/proposals from previous round(s)** | | | |
| 3.3.5 | **Proposal 3.C.5**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, when linking CJTC Dd and Rel-18 eType-II CJT CSI reports is configured with two separate triggers, introduce a UE capability for the following:   * The UE capability is used to inform the NW on the maximum duration for the latest CJTC Dd report, measured from the reception of the trigger for a Rel-18 eType-II CJT CSI * One supported value of the UE capability is ‘Infinity’   + FFS: The other supported value(s) * Introduce an RRC parameter to enable/disable this feature * When the UE does not report this UE capability, a default value of ‘Infinity’ applies.   **FL assessment**: Wording is based on the outcome of Monday offline session.  Its resolution may help confirming the WA for separate triggering (issue 3.3.1 proposal 3.C.1). This is intended to avoid stale Dd report from being utilized. However, it can be argued that this can be handled via NW implementation. | **Support/fine**: Lenovo/MotM, ZTE, Samsung, Qualcom, vivo, Ericsson, OPPO, Xiaomi, Nokia/NSB, Huawei/HiSi, NEC, HONOR, Sharp, KDDI, MediaTek, NTT DOCOMO, Apple,  **Not support**: Google, Spreadtrum, Intel, CATT, TCL, | |
| 3.3.14 | **Proposal 3.C.14**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, when linking CJTC Dd and Rel-18 eType-II CJT CSI reports is configured, support linking the CMRs in the two CSI Report Settings so that UE knows which CMRs in the two report settings correspond to the same TRP.   * Based on a fixed correspondence between the set of TRS resource set IDs in ascending order and the set of CSI-RS resource IDs in ascending order   **FL assessment**: This proposal needs some discussion. | **Support/fine:** HONOR,Samsung, Qualcomm, Xiaomi, MediaTek, CATT, Nokia/NSB (or in DCI), Lenovo/MotM, Sony, OPPO, Google, NEC, NTT DOCOMO,  **Not support:** Ericsson, | |
| 3.3.9 | **Proposal 3.C.9**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, when linking CJTC Dd and Rel-18 eType-II CJT CSI reports is configured with two separate triggers, when at least one of the NTRP reported delay offset (DO) values in a linked CJTC Dd report is ‘out of range’, the UE does not perform DO compensation on the triggered Rel-18 eType-II CJT CSI associated with TRP(s) that are ‘out of range’  **FL assessment**: Tuesday **OFFLINE** outcome. The above two issues need some discussion. For a given issue, if there is no consensus on ‘Yes’, we will assume that the answer is ‘No’ | **Support/fine**: Huawei/HiSi, Qualcomm, Samsung, Ericsson, Sony, Lenovo/MotM, Xiaomi, NEC, HONOR, OPPO,  **Not support**: Nokia/NSB, vivo, ZTE, Apple, IDC, NTT DOCOMO, | |
| 3.3.10 | **Proposal 3.C.10**: For the Rel-19 aperiodic standalone CJT calibration (CJTC) reporting, when linking CJTC Dd and Rel-18 eType-II CJT CSI reports is configured with a joint trigger:   * Reuse the CPU occupation and active resource counting for the Rel-18 eType-II CJT * FFS (RAN1#119): Re timeline, decide whether to reuse or further relax the timeline for the Rel-18 eType-II CJT   **FL assessment**: Tuesday **OFFLINE** agreement  Alt1 for OCPU, ARC  Timeline: Alt1 vs Alt2 119  Alt1: Reuse the timeline, CPU occupation, and active resource counting for the Rel-18 eType-II CJT   * Support/fine: Samsung, HONOR, Xiaomi, vivo, Ericsson, OPPO, NTT DOCOMO, * Not support:   Alt2: Add the timeline, CPU occupation, and active resource counting for the Rel-19 CJTC to the timeline, CPU occupation, and active resource counting for the Rel-18 eType-II CJT, respectively   * Support/fine: ZTE, MediaTek, Google, NEC, * Not support: | **Support/fine**: Huawei/HiSi, Qualcomm, Samsung, Ericsson, Sony, Lenovo, Xiaomi, NEC, HONOR, OPPO, Nokia/NSB, vivo, ZTE, Apple, IDC, NTT DOCOMO,  **Not support**: | |
| 3.7.1 | **Proposal 3.G.1:** For the Rel-19 aperiodic standalone CJT calibration reporting, support joint Dd + phase offset (PO) reporting as follows:   * Only wideband (=1) PO is supported * No further optimization of CSI reporting format, e.g. configurability of not reporting {dn} * The UCI parameters are captured in the table below   *When ReportQuantity is ‘cjtc-Dd-P’ (joint Doffset+d and PO)*   |  |  | | --- | --- | | Parameter | Details/description | | nref1 | Reference TRS resource set index for Doffset+d, based on the ordering from RRC configuration:  bits | | nref2 | Reference TRS resource set index for PO, based on the ordering from RRC configuration: bits | | {Dn,offset,  n=0, 1, …, NTRP – 1 n≠nref1} | Delay offset for CSI-RS resource set n:  bits | | {dn,  n=0, 1, …, NTRP – 1, n≠nref1 } | 1-bit inside/outside indicator for CSI-RS resource set n: bits | | {POn ,  n=0, 1, …, NTRP –1, n≠nref2} | Wideband phase offset for CSI-RS resource n:  bits |  * The UCI mapping order is as follows:   + nref1,   + nref2,   + {Dn,offset, n=0, 1, …, NTRP – 1, n≠nref} ordered from the lowest to highest CSI-RS resource set ID,   + {dn, n=0, 1, …, N TRP – 1, n≠nref} ordered from the lowest to highest CSI-RS resource set ID   + {POn, n=0, 1, …, NTRP – 1, n≠nref} ordered from the lowest to highest CSI-RS resource ID,   **FL assessment**: This proposal (from RAN1#118) is an optimization since each can be reported separately. | | **Support/fine:** Qualcomm, Sony, Samsung (ok), Google, ZTE, Fujitsu, Sony, Lenovo/MotM, Ericsson (open),  **Not support**: Huawei/HiSi, MediaTek, NTT DOCOMO, NEC, Intel, Apple, TCL, Huawei/HiSi, Xiaomi, IDC, Sharp, KDDI, CMCC, ETRI, OPPO, Apple, vivo, New H3C, Nokia/NSB, Spreadtrum, TCL, |
| 3.7.2 | **Proposal 3.G.2:** For the Rel-19 aperiodic standalone CJT calibration reporting, support reporting, in one CSI reporting instance, L1-RSRPs associated with the configured NTRP CSI-RS resources and the following CJT calibration report type:   * ReportQuantity is ‘cjtc-Dd’ (delay offset), or * ReportQuantity is ‘cjtc-F’ (frequency offset), or * ReportQuantity is ‘cjtc-Dd-F’ (delay+frequency offset), or * ReportQuantity is ‘cjtc-P’ (DL/UL phase offset)   Regarding the L1-RSRP:   * The legacy L1-RSRP is fully reused, where the L1-RSRP associated with nref is the reference for the other (NTRP-1) differential L1-RSRP(s)   + The NTRP CRI(s) are not reported * FFS: Whether this is supported via a new ReportQuantity or a joint CSI request/triggering   **FL assessment**: This proposal (from RAN1#118) is an optimization primarily for TRP selection (which utilizes both RSRP and CJTC report) | | **Support/fine:** NEC, NTT DOCOMO, Lenovo/MotM, Samsung (ok), Sony (open),  **Not support**: ZTE, Xiaomi, Fujitsu, Ericsson, Apple, Huawei/HiSi, OPPO, TCL, ETRI, New H3C, Google, Nokia/NSB, vivo, Sharp, Intel, KDDI, Spreadtrum, TCL, |

Table 3B LLS/SLS results: issue 3

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| **Company** | **LLS/SLS results** | | |
| **Issue #** | **Metric** | **Observation** |
| Qualcomm | 3.7.1 | Relative UPT gain vs DL SNR | A graph of different types of data  Description automatically generated with medium confidence  Performance comparison between PO+delay/TAE and subband phase with MRT-precoded CSI-RSs (left figure) and non-MRT-precoded CSI-RSs (right figure)  From the SLS results, the following observations can be made:   * For MRT-precoded CSI-RSs, Opt1 (wideband/initial PO + delay/TAE) outperforms Opt2 (subband PO) for the case of all 16 subbands (which is with massive UCI overhead). * For non-MRT-precoded CSI-RS), the benefit of Opt1 (wideband/initial PO + delay/TAE) over Opt2 (subband PO) is reduced. |

Table 3C Additional inputs: issue 3

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 3A**   * **Please focus on the new issues/proposals** * **Please also check if you change your mind on the old proposals (from previous round(s)) or have additional inputs** |
| Mod V3 | **Added the outcome of Tuesday Offline session cf. R1-249062**   * **Proposals 3.C.10 and 3.C.12** * **Proposal 3.C.9: companies positions indicating no consensus** |
| ZTE | **Proposal 3.C.12:**  Fine with the proposal.  Regarding the following issues mentioned in FL assessment:   1. We prefer to include this 1-bit indicator as a part of trigger state to reduce the total number of required CSI reporting settings. 2. We do NOT support per-resource or per-TRP 1-bit indicator. Based on the discussion, this 1-bit indicator is to reflect whether the gNB successfully receives or decodes the CJTC Dd report. So, we did NOT see the necessity of per-resource or per-TRP indicator. Besides, it also causes unclear UE behaviour when the indicator is set to 1 for some resources but set to 0 for other resource.   **Question 3.D.1**:  Support configuring the frequency pre-compensation assumption for PMI calculation. Basically, this issue is same as the DO pre-compensation assumption. |
| Lenovo/ MotM | **Proposal 3.C.12:**  Support  **Proposal 3.D.1:**  DO pre-compensation in CB is important due to delay-domain transformation/compression in Type-II CJT CB, not sure if this issue holds for FO though, could be handled via implementation. We are OK to discuss if proponents can elaborate on scenarios where FO cannot be pre-compensated at NW side via implementation |
| KDDI | **Proposal 3.C.14:** Support. |
| Samsung | **Proposal 3.C.12**  Fine with the proposal. Although we think 1-bit indicator per TRP is not needed, we can keep it as FFS to discuss further. |
| Fujitsu | **Proposal 3.C.12&14:** Support. |
| Huawei, HiSilicon | **Proposal 3.C.5:** too many options of the capability will make gNB scheduling more complicated, propose to limit to one additional value for UE capability.   * One supported value of the UE capability is ‘Infinity’, and one other value X.   + FFS: X ~~The other supported value(s)~~   **Proposal 3.C.14:** fine with the proposal. |
| Xiaomi | **Proposal 3.C.12**  Support. And for the first FFS, we don’t think the 1-bit for each of the NTRP CSI-RS resources is needed. |

# References