**3GPP TSG RAN WG1 #118 R1-2407281**

**Maastricht, The Netherlands, August 19th – 23rd, 2024**

**Agenda item:** 9.2.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#4 on Rel-19 CSI enhancements: Round 4

**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
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## Summary of companies’ proposals and views

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***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** |
| 1.2.1 | **Proposal 1.B.1**: For the Rel-19 Type-I SP and Type-II codebook refinements (except based on Rel-18 Type-II Doppler) for 48, 64, and 128 CSI-RS ports, active resource counting is:* FFS: For Capability 1 timeline: 1 vs K
* For Capability 2 timeline: 1

**FL assessment**: This was discussed OFFLINE [2]. Since Capability 2 is quite (too) relaxed, there is no reason to further relax both OCPU and ARC for Capability 2. For ARC, since the increase in the total # antenna ports (to up to 128) will be addressed in the ‘triplet’, there doesn’t seem any need to double-book this (mostly relevant to measurement buffering) in ARC (hence 1 should be more fitting, and K is excessive). Hence legacy in FG 2-33 can be interpreted as “Ks=1” (post aggregation) rather than “Ks=K”(pre-aggregation) | **1:** **Support/fine:** Ericsson, Nokia/NSB, ZTE, Fraunhofer IIS/HHI, Intel, TCL, Samsung, vivo, Google, CATT, Qualcomm, NTT DOCOMO, Xiaomi, HONOR, Lenovo/MotM (Cap2), Spreadtrum, CMCC, Sharp, OPPO, MediaTek, NEC, New H3C, KDDI, Kyocera, **Concern:** Huawei/HiSi, Fujitsu (Cap1), Apple (Cap1)**K:** **Support/fine:** Huawei/HiSi, Fujitsu (Cap1), Apple (Cap1), Samsung (2nd), vivo, OPPO, Google (Cap 1), Lenovo/MotM (Cap1), TCL (Cap1)**Concern:** Qualcomm**1 and K (UE indicates):****Support/fine:** Apple, Fujitsu, Qualcomm, **Concern:** Huawei/HiSi, Samsung, Ericsson, CMCC, vivo,  |
| 1.3.1 | **[117] Agreement**For the Rel-19 Type-I codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=v=1, support the following:* for each group of $X\_{1}X\_{2}$ SD basis vectors, a 3-bit scaling factor can be NW-configured via higher-layer (RRC) signalling, where the scaling factors are defined as scalings on the power control offset configured for the associated CSI-RS resources
	+ The values of $X\_{1}$ and $X\_{2}$ for this feature are separately configured from those for CBSR
	+ Separate configuration (RRC signalling) from CBSR
	+ The candidate values of $X\_{1}$ and $X\_{2}$ are the same as those agreed for CBSR
* The codepoints of each of the group-specific 3-bit scaling factors are mapped to values of $\left\{\sqrt{1}, \sqrt{1/2}, \sqrt{1/3} ,\sqrt{1/4},\sqrt{1/6},\sqrt{1/8},\sqrt{1/12},\sqrt{1/16}\right\}$
* Note: This feature is a separate UE capability

FFS: Whether this can be extended to RI=v>1 … **Proposal 1.C.1**: For the Rel-19 Type-I codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=$ϑ$ >1, apply the 3-bit scaling factor(s) as agreed in RAN1#117, where the scaling factor applied to the $i^{th}$ selected SD basis vector is given by $min\left\{1,\frac{ϑs\_{i}^{2}}{r\_{i}}\right\}$, where unit scaling factor “1” is associated with the PDSCH-to-CSIRS EPRE offset “portion” contributed by the $i^{th}$ selected SD basis vector without the 3-bit scaling factor $s\_{i}$ configured, $s\_{i}\in \left\{\sqrt{1}, \sqrt{\frac{1}{2}}, \sqrt{\frac{1}{3}} ,\sqrt{\frac{1}{4}},\sqrt{\frac{1}{6}},\sqrt{\frac{1}{8}},\sqrt{\frac{1}{12}},\sqrt{\frac{1}{16}}\right\} $ is the scaling factor associated with the $i^{th}$ beam, and $r\_{i}\in \left\{1,2\right\}$ is the number of layers transmitted using the $i^{th}$ SD basis vector.* Note: This feature is a separate UE capability

**FL assessment**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding the 3-bit scaling factor, please share your view whether this can be extended to RI=v>1 (and provide justification)**Yes**: Ericsson, Nokia/NSB, **No**: IDC, TCL, OPPO, Xiaomi, Huawei/HiSi, ZTE, Fujitsu, **Need more discussion/study**: Qualcomm, CMCC, Samsung, Apple, NTT DOCOMO, Xiaomi (ok), HONOR, Google, Lenovo/MotM, Fraunhofer IIS/HHI,  | **Support/fine:** Ericsson, Nokia/NSB, MediaTek, Lenovo/MotM, NTT DOCOMO, [Qualcomm], Spreadtrum, KDDI, **Not support:** ZTE,Apple (more discussion) |
| 1.9 | **Proposal 1.I**: For the Rel-19 Type-I SP and MP codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=*v*>1, for each PMI sub-band, UE shall select a recommended *P*-by-*v* precoder matrix (associated with the reported PMI) with *v* orthogonal columns.**FL assessment**: This is to ensure orthogonality constraint for Type-I is maintained. It is argued that this is especially crucial for SU-MIMO where the gNB typically follows the recommended PMI. | **Support/fine:** Qualcomm,ZTE (open), MediaTek (SP), Nokia/NSB, Apple, Lenovo/MotM, Tejas, **Not support:** vivo, Samsung, Fujitsu, NTT DOCOMO, Huawei/HiSi, CMCC, OPPO, Xiaomi, TCL, Ericsson,  |
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Table 1B SLS results: issue 1

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| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
| Huawei/HiSi | Other (SRS port grouping) | Normalized throughput (LLS) | *It is observed in Figure 4 that 43% performance gain can be achieved by PDSCH reception with SRS port grouping compared to max Rank-4. The performance of 8R rank-8 is also shown in the figure as an upper bound, which is difficult to be implemented due to the high complexity currently.* *Moreover, it can be observed from figure 9 that the performance of low complexity receiver (two antenna groups) without SRS port grouping enhancement is very poor even at high SNR.*Figure 4 Performance of 8Rx UE with different receiver schemes under practical interference |
| Samsung | Other (SRS port grouping) | Avg UPT gain | *The case of low complexity 8 RX receiver w/o SRS port grouping incurs 65% UPT loss com-pared to 4RX scenario. This basically implies that it is not possible to work for RI>4 without SRS port grouping assumption for low-complexity 8RX receiver* |
| Ericsson | 1.3.3 | Mean user throughput gain, 5%-tile throughput gain | *In the table below, it is shown that the impact of using a group size larger than 1 along the* $N\_{2} $*dimension, i.e.,* $X\_{2}>1$*. As seen in the results, the mean and 5th-percentile throughput decrease with increasing group sizes along the* $N\_{2} $*dimension.* |

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

Table 2A Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.2 | **Proposal 2.B.3**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding resource-specific CBSR, support following two-level structure:* First level: resource-common group-based restriction via $\frac{N\_{1}⋅O\_{1}⋅N\_{2}⋅O\_{2}}{X\_{1}⋅X\_{2}}$-bit bitmap (reuse 128-port design)
* Second level: resource-specific restriction via X1·X2-bit bitmap for each unrestricted group

**FL assessment**: This proposal is to finalize CBSR design for HBF | **Support/fine**: Huawei/HiSi, **Not support**:  |
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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** |
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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** |
| 3.4.2 | **Proposal 3.D.2:** 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)*

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| Parameter | Details/description |
| nref1 | Reference TRS resource set index for Doffset+d, based on the ordering from RRC configuration: $\left⌈log\left(N\_{TRP}\right)\right⌉$ bits |
| nref2 | Reference TRS resource set index for PO, based on the ordering from RRC configuration: $\left⌈log\left(N\_{TRP}\right)\right⌉$ bits |
| {Dn,offset, n=0, 1, …, NTRP – 1 n≠nref1} | Delay offset for CSI-RS resource set n:$\left(N\_{TRP}-1\right)\left⌈log\left(M\_{D}\right)\right⌉$ bits |
| {dn, n=0, 1, …, NTRP – 1, n≠nref1 } | 1-bit inside/outside indicator for CSI-RS resource set n: $\left(N\_{TRP}-1\right)$ bits |
| {POn , n=0, 1, …, NTRP –1, n≠nref2} | Wideband phase offset for CSI-RS resource n: $\left(N\_{TRP}-1\right)\left⌈log\left(M\_{Φ}\right)\right⌉$ 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,
 | **Support/fine:** Qualcomm, vivo, Sony, Samsung (ok), Google, ZTE, Fujitsu, Sony, **Not support**: Huawei/HiSi, MediaTek, NTT DOCOMO, Ericsson, NEC, Intel, Apple, TCL, Huawei/HiSi, Xiaomi, IDC, Sharp, KDDI, CMCC, ETRI, OPPO, Lenovo/MotM (open, only if TRS can be used for PO), Apple (same as Lenovo) |
| 3.4.3 | **Proposal 3.D.3:** 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 is an optimization primarily for TRP selection (which utilizes both RSRP and CJTC report) | **Support/fine:** NEC, NTT DOCOMO, **Not support**: ZTE, Xiaomi, Fujitsu, Ericsson, Apple, Huawei/HiSi, OPPO, Lenovo/MotM, TCL, Sony,  |
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Table 3B LLS/SLS results: issue 3

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Table 3C Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 3A** |
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# References

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| 1 | RP-240087 | Revised WID: NR MIMO Phase 5 | Samsung (Moderator) |
| 2 | R1-2406643 | Moderator Summary for OFFLINE discussion on Rel-19 CSI enhancements | Moderator (Samsung) |
| 3 |  |  |  |
| 4 |  |  |  |