**3GPP TSG RAN WG1 #117 R1-2404108**

**Fukuoka, Japan, May 20th – 24th, 2024**

**Agenda item:** 9.2.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary on Rel-19 CSI enhancements

**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:

|  |
| --- |
| 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

***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

|  |  |  |
| --- | --- | --- |
| **#** | **Issue/proposal** | **Companies’ views** |
| 1.1.1 | **[116bis] Agreement**For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports with RI=5-8, decide, by RAN1#117, from the following schemes:* Scheme1: adding new (N1, N2) values for the Rel-15 Type-I RI=5-8
* Scheme2:
	+ W1 structure: Independent selection of different ceil(v/2) SD basis vectors for RI = v, where each SD basis vector is applied to two respective layers except that, if v is odd, the last SD basis vector is applied to the orphan layer. Each of the SD basis vectors is freely selected from a group of N1N2 orthogonal SD DFT basis vectors via combinatorial indication
		- FFS: mapping between v layers and ceil(v/2) SD basis vectors
		- FFS: support of 4 selected SD basis vectors for RI=5-6
	+ W2 structure:
		- For inter-polarization co-phasing, M (e.g., M = 4) codepoints for the orphan layer and M/2 codepoints for two layers sharing a same SD basis vector;
		- A fixed  rotation of inter-polarization co-phasing between two layers sharing a same SD basis vector to achieve layer orthogonality.
* Scheme3: the 1st beam is freely selected and subsequent 2 beams (RI=5-6) or 3 beams (RI=7-8) are freely selected such that they are orthogonal in at least one dimension (horizontal or vertical). Layers are mapped to the selected SD basis vectors following legacy Rel-15 for RI=5-8. One co-phasing across all layers ∈{1,j} following legacy Rel-15 Type-I RI=5-8
* Scheme4: concatenate two independently calculated RI=1-4 PMIs for RI=5-8 to reduce UE complexity where each PMI is calculated from the agreed RI=1-4 codebook (Scheme-A or Scheme-B) and the CQI for each of the two CWs is derived assuming it is received by one antenna group of 4 antenna ports (FFS: Whether additional mapping between the two PMIs and the two UE antenna groups is needed)
* Other schemes are not precluded

**Proposal 1.A.1**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports with RI=5-8, support the following schemes:* The same O1=O2 value(s) as RI=1-4 are supported
* Scheme-A (based on Scheme3 described in RAN1#116bis):
	+ W1 structure:
		- The 1st SD basis vector is freely selected and subsequent 2 (RI=5-6) or 3 SD basis vectors (RI=7-8) are freely selected such that they are orthogonal in at least one dimension (horizontal or vertical).
		- The v layers are mapped to the selected SD basis vectors following legacy Rel-15 Type-I for RI=5-8.
	+ W2 structure:
		- Following legacy Rel-15 Type-I RI=5-8
* Scheme-B (based on Scheme2 described in RAN1#116bis):
	+ W1 structure:
		- Independent selection of different ceil(*v*/2) SD basis vectors for RI = *v*, where each SD basis vector is applied to two respective layers following legacy Rel-15 Type-I for RI=5-8, except that, if *v* is odd, the last SD basis vector is applied to the orphan layer.
			* FFS: mapping between the orphan layer and its selected SD basis vector and, if needed, UE reporting of the selection
			* FFS: support of 4 selected SD basis vectors for RI=5-6
		- The SD basis vectors are freely selected from a group of N1N2 orthogonal SD DFT basis vectors via combinatorial indication, as well as a layer-common (q1,q2)
	+ W2 structure:
		- For the orphan layer, the inter-polarization co-phasing is selected from {1, j, -1, -j}
		- For two layers sharing a same SD basis vector, the inter-polarization co-phasing between two layers is selected from the following pairs {(1, -1), (j, -j)} to achieve inter-layer orthogonality.
* A UE can be configured by the NW via higher-layer (RRC) signalling with either Scheme-A (RI=1-4+RI=5-8) or Scheme-B (RI=1-4+RI=5-8)

**FL assessment**: This was discussed OFFLINE [2]. Some wording revision (in change marks) to improve clarity without changing the content of the proposalAll companies are fine with Scheme-B, but a number of companies still prefer Scheme1 for Scheme-A (as opposed to the proposed Scheme3). **However, all available SLS results for Scheme-A show that the scheme in the above proposal (Scheme3) is superior to Scheme1 (cf. Table 1B).** A small number of companies prefer other schemes (Scheme 4, 5) but there is no empirical evidence to justify their preferences.  | **Support/fine**: ZTE, Nokia/NSB, Ericsson, NTT DOCOMO, Intel, Samsung, Huawei/HiSi (ok w/ 1.A.2), Qualcomm, MediaTek, vivo (ok), Xiaomi, NEC, HONOR, Kyocera, Sharp, CMCC, KDDI, Google (ok), Apple (ok), OPPO (ok), TCL (ok)**Not support (SchA=1, SchB ok)**: Fraunhofer IIS/HHI, CEWiT, Tejas, Spreadtrum, Lenovo/MotM**Not support (other schemes)**: CATT (new Scheme 5), New H3C (Sch4), IDC (Sch4), LG (Sch1 only), Fujitsu (Sch4), |
| 1.1.2 | **Proposal 1.A.2**: For a UE configured with a total of PSRS=6 or 8 ports across ≥1 SRS resources for antenna switching intended for xT6R or xT8R, respectively, support the following fixed SRS port grouping where (with the PSRS ports indexed in an ascending order according to SRS resource ID and port number within each SRS resource): * SRS port group 0, corresponding to CW0, comprises the first PSRS/2 out of PSRS ports; and
* SRS port group 1, corresponding to CW1, comprises the second PSRS/2 out of PSRS ports

For CQI calculation, UE follows the above grouping assumption Note: different SRS ports are associated with different UE antenna ports.Note: if one single CW is scheduled, both SRS port groups can correspond to the same CWNote: This feature is a separate UE capability and, for UEs supporting this capability, configured via RRC (FFS details on the extend of RRC configuration)**FL assessment**: This was discussed OFFLINE [2]. | **Support/fine**: Huawei/HiSi, Samsung, ZTE, Ericsson, Nokia/NSB, Fujitsu, Tejas, Xiaomi, vivo, NTT DOCOMO, NEC, OPPO, TCL, KDDI, Sharp, MediaTek**Not support**: HONOR |
| 1.1.3 | **Proposal 1.A.3**: On the NZP CSI-RS resource aggregation of *K*=2, 3 or 4 legacy NZP CSI-RS resources to attain a total of 48, 64, and 128 ports (for Rel-19 Type-I/II codebook refinement), support to configure a CSI-RS resource set with the *K* CSI-RS resources as the associated NZP CSI-RS for each of the SRS resource set(s) with higher layer parameter usage in *SRS-ResourceSet* set to 'nonCodebook',* The previously agreed restrictions on the *K* resources for Rel-19 Type-I/II codebook refinement apply
* Reuse the legacy approach for triggering of the NZP-CSI-RS resources and the legacy timeline for the NZP-CSI-RS resources and SRS

**FL assessment**: This was discussed OFFLINE [2]. | **Support/fine**: vivo, Samsung, Fujitsu, Xiaomi, Spreadtrum, Tejas, Huawei/HiSi, NTT DOCOMO, TCL Google, CMCC, Nokia/NSB, Ericsson, Sharp, **Not support**: HONOR, OPPO |
| 1.1.4 | **Proposal 1.A.4:** For the Rel-19 Type-I single-panel (SP) codebook refinement for 48, 64, and 128 CSI-RS ports, for Scheme-A RI=3-4, the legacy mapping of i1,3 to (k1,k2) for (N1=3,N2=2) from Table 5.2.2.2.1-4 of TS 38.214 is used for all of the newly supported (N1,N2) values. * FFS: whether the i1,3 table (Table 5.2.2.2.1-4 of TS 38.214) needs to be further extended.

**FL assessment**: This is the only solution that reuses legacy spec to allow 3 orthogonal SD basis vectors. There seems no need for additional extension beyond this but this can be kept FFScid:image001.jpg@01DAA0DC.7225A550 | **Support/fine**: Samsung, ZTE,**Not support**:  |
| 1.2.1 | **[116bis] Agreement**For the Rel-19 Type-I single-panel (SP) codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=1-4, support the following:* …
* Scheme-B (based on Scheme2 in RAN1#116 agreement): Adding new (N1, N2) values where 2N1N2 (>32) is the total number of CSI-RS ports across aggregated NZP CSI-RS resources, and
	+ W1 structure: …
	+ W2 structure: Layer-specific inter-polarization co-phasing with the alphabet {+1, +j, -1, -j}

**[116bis] Agreement**For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, the UCI parameters are captured in the tables below for Scheme-A and Scheme-B:* Note: The second column includes the location of the parameters when reported with two-part UCI
* FFS (RAN1#117): Select between Alt1 and Alt2 for Scheme-B

…**Scheme-B**

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | UCI | Details/description | Status |
| … |  |  |  |
| SD basis vector selection indicator for each layer | Alt1: Part 1Alt2: Part 2 Wideband | *v*=1-4: * Alt1: $\left⌈log\_{2}\left(N\_{1}N\_{2}\right)\right⌉$ bit indicator per layer *l=*1*, …, RIMAX*
* Alt2: $\left⌈log\_{2}\left(N\_{1}N\_{2}\right)\right⌉$ bit indicator per layer *l=*1*, …, v*

*v*=5-8: FFS | Pending |
| Inter-pol co-phase selection indicator for each layer | Part 2Wideband or Subband (\*\*) | *v*=1-4: * Alt1: QPSK with orthogonality constraints across *v* layers
* Alt2: QPSK: 2-bit indicator per layer *l=*1*,…,v*

*v*=5-8: FFS | Pending |
| … |  |  |  |

**Proposal 1.B.1**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding UCI parameters for Scheme-B RI=*v*=1-4:* SD basis vector selection indicator for each layer is in Part 2 (wideband) and $\left⌈log\_{2}\left(N\_{1}N\_{2}\right)\right⌉$ bits per layer *l=*1*, …, v*
* Inter-pol co-phase selection indicator for each layer is in Part 2 (wideband or subband) and 2 bits (representing {+1, +j, -1, -j}) per layer *l=*1*,…,v*

**FL assessment**: This was discussed OFFLINE [2]. It was observed that Alt1 for co-phase selection is not aligned with the previous agreement.It was also argued that the overhead reduction from Alt1 (for both) is marginal and highly dependent on UE implementation, while complicating the UE PMI selection algorithm. Therefore Alt2 (as proposed in 1.B.1) is the outcome. | **Support/fine**: Samsung, OPPO, ZTE, NTT DOCOMO, Qualcomm, Fraunhofer IIS/HHI, Apple, CATT, MediaTek, TCL, CEWiT, Intel, New H3C, Nokia/NSB, Huawei/HiSi, Fujitsu, Xiaomi, Spreadtrum, Tejas, Google, NEC, HONOR, Kyocera, Sharp, OPPO, CMCC, KDDI, Lenovo/MotM **Not support**: vivo (new SDBVI, joint co-phase when >1 layers same SDBV) |
| 1.3 | **Proposal 1.C**: For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding UCI omission, fully reuse the legacy rules for Rel-15 Type-I SP codebook **FL assessment**: There is no reason to design a different UCI omission rule | **Support/fine**: MediaTek, Intel, Samsung, ZTE, [Lenovo/MotM?]**Not support:** TCL (NES rule) |
| 1.4.1/2 | **[116bis] Agreement**For the Rel-19 Type-I SP and Type-II codebook refinements for 48, 64, and 128 CSI-RS ports via aggregating K>1 CSI-RS resources, regarding timeline, introduce two UE capabilities:* Capability 1: Reuse legacy Z/Z’ values
* Capability 2: Scale the legacy timeline Z/Z’ by ceil(P/32) where P is the total number of ports across all the K aggregated CSI-RS resources

FFS: CPU occupation and active resource counting…**Proposal 1.D.1**: For the Rel-19 Type-I SP and Type-II codebook refinements for 48, 64, and 128 CSI-RS ports, regarding CPU occupation* For Capability 1 timeline: OCPU = ceil(P/16)
* For Capability 2 timeline: OCPU = 1

**Proposal 1.D.2**: For the Rel-19 Type-I SP and Type-II codebook refinements for 48, 64, and 128 CSI-RS ports, active resource counting is:* For Capability 1 timeline: K (following legacy)
* For Capability 2 timeline: K (following legacy)

**FL assessment**: Since Capability 2 is quite (too) relaxed, there is no reason to further relax both OCPU and ACR for Capability 2 | **1.D.1:****Support/fine:** [Huawei/HiSi], Intel, TCL, Samsung, vivo, [Lenovo/MotM], CATT, Qualcomm, [Xiaomi], [NTT DOCOMO]**Not support:****1.D.2:****Support/fine:** [Huawei/HiSi], Intel, TCL, Samsung, vivo, [Lenovo/MotM], CATT, Qualcomm, [Xiaomi], [NTT DOCOMO] **Not support:** |
| 1.5.1 | **[116bis] Agreement**For the Rel-19 Type-I multi-panel (MP) codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=1-4, decide, by RAN1#117, whether to support Type-I multi-panel (MP) codebook refinement in Rel-19. If supported, decide from the following alternatives:* Scheme1. Based on Rel-15 Type-I MP design directly extended with Ng=K (2, 3, and 4), and new (N1, N2) values
* Scheme2. Based on Scheme4/6 as described in the RAN1#116 agreement
	+ W1 structure: Reuse legacy Rel-15 Type-I SP SD basis selection with L=1 independently for each of the K NZP CSI-RS resources
	+ W2 structure:
		- Legacy Rel-15 Type-I inter-polarization co-phasing rules independently in each resource,
		- Layer-common inter-resource M-PSK co-phasing, where M is further down-selected from {2,4}
			* FFS: Whether inter-resource co-phasing is wideband or per subband.

If so, decide, by RAN1#117, whether port mapping scheme similar to, e.g. Rel-18 Type-II CJT, needs to be specified. …**Proposal 1.E.1**: For the Rel-19 Type-I multi-panel (MP) codebook refinement for 48, 64, and 128 CSI-RS ports, for RI=1-4, support the following (compromise between Scheme1 and Scheme2 described in RAN1#116bis):* W1 structure: Common SD basis selection across all the Ng=K NZP CSI-RS resources, reusing legacy Rel-15 Type-I SP SD basis selection rules with L=1 for RI=1-4
	+ Ng = *K* = {2, [3], 4} denotes the number of NZP CSI-RS resources associated with the Ng panels
* W2 structure:
	+ Legacy Rel-15 Type-I inter-polarization co-phasing rules independently in each resource,
	+ Layer-common sub-band inter-resource QPSK co-phasing

**FL assessment**: This was discussed OFFLINE [2]. The proposal is a compromise between Scheme1 and Scheme2 (resource-common SD basis instead of resource-specific, just as Scheme1). The majority of companies supporting/ok with 1.E.1 are also supportive of/ok with Scheme2, e.g. MediaTek, Ericsson, Samsung, NTT DOCOMO, [Nokia/NSB], Huawei/HiSiNote that **all the available SLS results show that Scheme2 outperforms Scheme1 (cf. Table 1B).** | **Support/fine (panel-common SD basis, compromise between Scheme1 and 2)**: MediaTek, Qualcomm, Ericsson, Nokia/NSB, vivo (ok), Samsung, Tejas (ok), NTT DOCOMO, CMCC, ZTE, Huawei/HiSi **Prefer resource-specific SD basis, i.e. Scheme2**: OPPO, Fraunhofer IIS/HHI, CATT, CEWiT, New H3C, Fujitsu, NEC, HONOR, KDDI, IDC**Prefer Scheme1:** Intel, LG, **No T1 MP**: Apple, TCL, Xiaomi, Spreadtrum, Google, Lenovo/MotM |
| 1.6.1 | **[116bis] Agreement**For the Rel-19 Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, on CBSR, refine the legacy CBSR as follows:* …
* Group-based CBSR granularity where each bit in the CBSR is associated with a set of X1X2 SD basis vectors, where the set includes X1 adjacent SD basis vectors along the N1 direction and/or X2 adjacent SD bases along the N2 direction
	+ FFS: Value(s) of X1 and X2 and detailed design/spec impact

**[116bis] Agreement**For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding CBSR design:* …
* $ \frac{N\_{1}⋅O\_{1}⋅N\_{2}⋅O\_{2}}{X\_{1}⋅X\_{2}}$-bit CBSR where each bit in the CBSR is associated with a set of X1X2 SD basis vectors, where the set includes X1 adjacent SD basis vectors along the N1 direction and/or X2 adjacent SD bases along the N2 direction
	+ FFS: Value(s) of X1 and X2 and detailed design/spec impact

**Proposal 1.F.1**: For the Rel-19 Type-I SP and Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, on CBSR, the value of (X1, X2) is NW-configured via higher-layer (RRC) signalling from {(1,1), (1,2), (2,1), (1,4), (4,1), (2,2), (2,4), (4,2), (4,4)} * FFS: Dependence on each supported (X1, X2) value on (N1, N2)

**FL assessment**: The values of (X1,X2) need to be resolved to complete CBSR design | **Support/fine:** Huawei/HiSi, Spreadtrum, [TCL], ZTE, vivo, HONOR, NEC, Google, [Fraunhofer IIS/HHI], NTT DOCOMO, **Not support:**  |
| 1.6.2 | **[116bis] Agreement**For the Rel-19 Type-I SP codebook refinement for 48, 64, and 128 CSI-RS ports, regarding CBSR design:* 1-bit hard restriction is supported (analogous to Rel-15 Type-I)
* FFS: 3-bit scaling factor for soft restriction with the scaling factor taken into account in CQI/PMI calculation
* …

**Proposal 1.F.2**: For the Rel-19 Type-I and Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, in addition to the agreed (hard) CBSR, 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

**FL assessment**: The proposal is now formulated in terms of scaling factor (not CBSR), but with the same granularity as CBSR. **Ericsson has demonstrated the performance gain within the context of co-existence with NTN (cf. Table 1B).** | **Support/fine:** IDC, Ericsson, Huawei/HiSi, ZTE, Samsung, vivo, Qualcomm (only RI=1), MediaTek,**Not support:** Lenovo/MotM, OPPO, NTT DOCOMO,  |
| 1.7 | **[116bis] Agreement**For the Rel-19 Type-I and Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, regarding the mapping from CSI-RS resource index/port index per resource and port index to CSI/PMI calculation, support NW to configure UE with one of the following mapping methods via higher-layer (RRC) signaling, * *Mapping method 1*: Sequential ordering/indexing within (1st resource, 1st polarization), then (2nd resource, 1st polarization), …, then (Kth resource, 1st polarization), then (1st resource, 2nd polarization), then (2nd resource, 2nd polarization), …, then (Kth resource, 2nd polarization)
* *Mapping method 2*: Sequential ordering/indexing within (where K\*n2 = N2):
	+ for the 1st polarization, (1st n2 ports in 1st resource, 1st polarization), (1st n2 ports in 2nd resource, 1st polarization), …, (1st n2 ports in Kth resource, 1st polarization), then (2nd n2 ports in 1st resource, 1st polarization), (2nd n2 ports in 2nd resource, 1st polarization), …, (2nd n2 ports in Kth resource, 1st polarization), … then (N1th n2 ports in 1st resource, 1st polarization), (N1th n2 ports in 2nd resource, 1st polarization), …, (N1th n2 ports in Kth resource, 1st polarization) ,
	+ and then for the 2nd polarization, (1st n2 ports in 1st resource, 2nd polarization), (1st n2 ports in 2nd resource, 2nd polarization), …, (1st n2 ports in Kth resource, 2nd polarization), then (2nd n2 ports in 1st resource, 2nd polarization), (2nd n2 ports in 2nd resource, 2nd polarization), …, (2nd n2 ports in Kth resource, 2nd polarization), … then (N1th n2 ports in 1st resource, 2nd polarization), (N1th n2 ports in 2nd resource, 2nd polarization), …, (N1th n2 ports in Kth resource, 2nd polarization)

FFS: Exact port indexing within each CSI-RS resource or across K CSI-RS resources**Proposal 1.G**: For the Rel-19 Type-I and Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, regarding port mapping, * “sequential ordering/indexing within” a group of Q indices {i0, i1, …, iQ-1} is a linearly increasing sequence such that iq < iq+1 (where q=0, 1, …, Q-2).
* After resource aggregation, P (=48, 64, or 128) ports are numbered in accordance to Table 7.4.1.5.3-1 from TS 38.211

**FL assessment**: This was discussed in RAN1#116bis but the FL proposal wasn’t well formulated. We decided to postpone to RAN1#117. | **Support/fine:** NTT DOCOMO, Qualcomm, Nokia/NSB, Ericsson, Samsung, Tejas Network, CATT, Lenovo/MotM, OPPO, Fraunhofer IIS/HHI, [Huawei/HiSi], [LG] **Not support:**  |
| 1.8.1 | **[116] Agreement**For the Rel-19 Type-I and Type-II codebook refinement for up to 128 CSI-RS ports, regarding NZP CSI-RS resource aggregation to attain 32 < P (or PCSI-RS)≤ 128, support aggregating at least K=2, 3, or 4 legacy NZP CSI-RS resources with equal number of ports* …
* Note: If the supported number of ports does not require aggregation of 3 resources, K=3 can be removed

**Proposal 1.H.1:** For the Rel-19 Type-I and Type-II codebook refinement for 48, 64, and 128 CSI-RS ports, regarding aggregation of K NZP CSI-RS resources to attain 32 < P (or PCSI-RS)≤ 128, support *only* the following combinations of K and P (or PCSI-RS):* For P (or PCSI-RS) = 48, K = 2 (each resource 24 ports)
* For P (or PCSI-RS) = 64, K = 2 (each resource 32 ports) and 4 (each resource 16 ports)
* For P (or PCSI-RS) = 128, K = 4 (each resource 32 ports)

Note: This implies that K=3 is removed. **FL assessment**: By excluding K=3, the above proposal excludes the cyan aggregation. While there are other aggregations that may not be too useful, there is no need to exclude them (NW implementation and market will determine).

|  |  |  |
| --- | --- | --- |
| **New P** | **New (N1,N2)** | **Legacy resource aggregation** |
| **K** | **Old (N1’,N2’)** |
| 48 | (8,3) | 2; 3;  | (4,3); (8,1);  |
| (6,4) | 2/4; | (6,2)/(6,1);  |
| 64 | (16,2) | 2/4; 2; | (8,2)/(4,2); (16,1);  |
| (8,4) | 2; 2/4; | (4,4); (8,2)/(8,1);  |
| 128 | (16,4) | 4; 4; | (4,4); (16,1);  |
| (8,8) | 4; | (8,2);  |

Blue: mapping #1 (along horizontal dimension)Red: mapping #2 (along vertical dimension) | **Support/fine:** Qualcomm, Samsung, **Not support:**  |
|  |  |  |

Table 1B SLS results: issue 1

|  |  |
| --- | --- |
| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
| IDC | 1.5.1 | Normalized average throughput | From the result above, it is observed that 8-PSK and 4-PSK based co-phasing in Scheme-2 MP with 32 ports on each panel can achieve a reasonable performance. As shown in the result above, Scheme-2 MP achieves higher performance than the legacy Rel-15 Type-I MP with 32 ports albeit having smaller throughput performance than Rel-19 Type-I SP Scheme-A with 64 ports.  |
| MediaTek | 1.5.1 | Avg UPT gain vs feedback overhead | It is seen in the SLS results above that Scheme 2 with selection of SD beams and inter-polarization co-phasing per panel can offer about 10 % UPT gain compared to extension of Rel-15 Type I MP codebook.Additionally, it is shown that the performance gain of Scheme 2 is more when inter-panel distance is increased, because as antenna array size and/or inter-panel distance increases, angles across antenna elements start to decorrelate and different SD beams across panels are needed to match the channel.  |
| Huawei/HiSi | 1.1.1 | UPT gain | The simulation results in the figures above show that UEs with rank 6 can have 11% performance gain if 3 or 4 SD bases can be used compared to 3 SD bases only, and UEs with rank 5 with about 6% performance gain. |
| Samsung | 1.1.1 |  |  |
| on O1,O2 | Avg UPT Gain vs overhead | For Rel-19 Type-I for RI=1-4, it is shown in SLS results that the case of O1=O2=2 incurs 2% UPT loss compared to the case O1=O2=4 for both Scheme A and Scheme B. |
| ZTE | 1.1.1 | Average throughput gain | It is observed in the result above that, both scheme 2(A) and scheme 2(b) can provide over 10% average throughput gain over scheme 1. Besides, by indicating the SD basis applied to the orphan layer, scheme 2(B) further shows approximately 1% throughput gain over scheme 2(A). Note that, the RI is dynamically selected from 1-8 in SLS. For RI = 5 or 7 when the orphan layer occurs, the performance advantage of scheme 2(B) over scheme 2(A) would be more significant. |
| Nokia/NSB | 1.1.1 | Mean UPT gain vs overhead, cell-edge UPT gain vs overhead | **Throughput vs overhead comparison between Scheme 1,2 and 3 for ranks 5-8, with 64 ports and layout (16x2).**It is observed from SLS results (the above figures are the case of port layout (16x2)) that * Scheme 3 outperforms Scheme 1 in throughput, by about 167% to 423% depending on number of antenna ports (64 or 128), port layout (8x4), (16x2) or (8x8), RU (30%,50%,70%), reported rank (5 to 8) and cell-average or cell-edge UEs.
* Scheme 3 outperforms Scheme 2 in throughput, by up to 243%, for ranks 5,6 and 8, depending on number of antenna ports (64 or 128), port layout (8x4), (16x2) or (8x8), RU (30%,50%,70%), and cell-average or cell-edge UEs.
* Lower throughput of Scheme 3 than Scheme 2 is observed for rank 7, because in the legacy Rel15 layer-to-beam mapping, the orphan beam is mapped to beam 2, instead of, which is typically the second strongest beam, instead of weaker beam 4.
 |
| Ericsson | 1.1.1 | Average user relative throughput vs average overhead | **Average overhead vs throughput gain for (M, N, P) = (8, 8, 2) at 10% resource utilization for the different Type-I codebook schemes in dense urban scenario at 3.5GHz****Average overhead vs throughput gain for (M, N, P) = (4, 16, 2) at 10% resource utilization for the different Type-I codebook schemes in dense urban scenario at 3.5GHz**From the evaluation results above, it is observed that when Scheme 1 is used as the baseline in the simulations (the observations are valid for both 3.5 and 6.5GHz):* Scheme 2 has the best overall performance albeit at a slightly larger overhead
* Scheme 3 is able to achieve slight gains when compared to the baseline (Scheme 1), especially at low resource utilization, and at a slightly higher overhead than the baseline.
 |
| 1.4 | Mean user relative throughput,5th percentile user relative throughput | **Average and 5th percentile throughput gain for (M, N, P) = (8, 16, 2) at 20%, 50% and 70% resource utilization for eType-II in dense urban scenario at 3.5GHz with UE speed of 3km/h**From the evaluation results above, it is observed that when considering 4 slots of CSI feedback delay as the baseline in the simulations, the following performance losses:* With an increased feedback delay of 8 slots, up to 25% average throughput loss is observed for 64 CSI-RS ports for UEs at 8km/h.
* With an increased feedback delay of 12 slots, up to 31% average throughput loss is observed for 128 CSI-RS ports for UEs at 3km/h.
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Table 1C Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 1A** |
| Google | Proposal 1.A.1/2/3/4: SupportProposal 1.B.1: SupportProposal 1.C: SupportProposal 1.D.1/2: SupportProposal 1.E.1: We failed to see the necessity to enhance MP. It seems similar functionality can be achieved by CJT CSI.Proposal 1.F.1: OK. Probably we can consider to remove (1, 2), (1,4) and (2, 4). Usually, horizontal beams are narrower than vertical beams. The granularity for CBSR for horizontal beams could be larger than vertical beams.Proposal 1.F.2: We do not think this is needed for high rank case. For high rank, there is already power scaling for each layer. In addition, the actual power scaling factor for each layer should be defined as max(CBSR, sqrt(v)), where CBSR indicates the value configured by the codepoint and v indicates the number of layers. Further, if additional power scaling is applied for some layers, we should allow UE to perform power boosting for some other layers.Proposal 1.G: We do not know why this proposal is needed. Port indexing within each CSI-RS resource should remain the same as legacy.Proposal 1.H.1: Support |
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|  |  |

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

Table 2A Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1.1 | **RAN1#116bis discussion + OFFLINE****Question 2.F.2:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M>1, please share your view on whether the following overhead reduction schemes should be supported:* CRI/resource-common RI value (indication):
	+ *Support/fine*: NTT DOCOMO (1st), Xiaomi, TCL, Huawei/HiSi, CATT
	+ *Not support (CRI/resource-specific RI)*: vivo, Samsung, NEC, Qualcomm, NTT DOCOMO (2nd), Lenovo/MotM, Ericsson, Nokia/NSB, Google, Intel, CMCC, MediaTek, Fujitsu, Sharp, OPPO
* Differential WB CQI (the wideband CQI(s) associated with the 2nd, …, M-th CRI(s) is calculated differentially with respect to the 4-bit largest wideband CQI(s) associated with the 1st CRI into Bd<4 bits):
	+ *Support/fine*: NTT DOCOMO (1st), ZTE, Huawei/HiSi
	+ *Not support (No differential, Bd=4)*: vivo, Samsung, Qualcomm, Lenovo/MotM, Ericsson, Nokia/NSB, Google, Intel, TCL, CMCC, MediaTek, Fujitsu, Sharp, OPPO, NTT DOCOMO (2nd),
* 1-bit differential SB CQIs associated with the 2nd, …, M-th CRI(s), calculated differentially with respect to the 2nd, …, M-th WB CQI(s)
	+ *Support/fine*: Huawei/HiSi
	+ *Not support (No differential, legacy 2-bit)*: vivo, Samsung, Lenovo/MotM, Ericsson, Fujitsu Nokia/NSB, Google, Intel, TCL, CMCC, MediaTek, Sharp, OPPO

**Proposal 2.A.1:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M>1, support the following:* Resource-specific RI, i.e. RI is independently calculated and indicated for each of the selected M NZP CSI-RS resources
	+ FFS: If resource-common RI indication is also supported
* 4-bit wideband CQIs are independently calculated and reported across the M selected NZP CSI-RS resources
* 2-bit differential SB CQIs are independently calculated across the M selected NZP CSI-RS resource

**FL assessment**: This was already discussed in RAN1#116bis and also OFFLINE [2]. * Whether RI is CRI-common or CRI-specific should be decided first. In this case, the proponents of CRI-common should demonstrate that CRI-common is better than CRI-specific in UPT vs PMI overhead trade-off
	+ Given the marginal saving in overhead from CRI-common RI, CRI-common RI is justified only if there is practically no loss of UPT relative to CRI-specific RI
* If CRI-common is justified, whether differential CQI is supported or not can be decided with the same methodology (UPT vs PMI overhead). Else, the baseline (non-differential) is the natural outcome
 | **Support/fine**: OPPO, vivo, Samsung, Apple, MediaTek, Intel, CEWiT, Ericsson, NEC, Qualcomm, NTT DOCOMO, Lenovo/MotM, Nokia/NSB, Google, CMCC, Fujitsu, Sharp, Spreadtrum, HONOR, Kyocera, CMCC, KDDI, Lenovo/MotM, IDC**Not support**: Huawei/HiSi, ZTE, CATT, Xiaomi (CRI-common RI), TCL (CRI-common RI),  |
| 2.1.2 | **[116bis] Agreement**For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M>1, the M CRIs (each with $\left⌈log\_{2}K\_{S}\right⌉$ bits) are separated indicated * FFS: whether to support NW configuring/requesting the UE to report CRI/RI/PMI/CQI associated with *MR* (<*M*) of *KS* CSI-RS resources, including whether further reduction in the number of hypotheses is supported, i.e. reporting (*M* – *MR*) CRIs (each with $\left⌈log\_{2}\left(K\_{S}-M\_{R}\right)\right⌉$ bits)

**Proposal 2.A.2**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, the NW can configure *MR* (<*M*) of *KS* CSI-RS resources to be selected as part of reporting the *M* “quadruplets”: * (*M–MR*) CRIs, each with $\left⌈log\_{2}\left(K\_{S}-M\_{R}\right)\right⌉$ bits are reported, along with the *M* sets of CQI/PMI/RI/(if applicable) LI
* The value of *MR* is NW-configured via higher-layer (RRC) signaling
* The *MR* selected resources are NW-configured via higher-layer (RRC) signaling
	+ In addition, for A-CSI, the *MR* selected resources can be updated via DCI (as a part of CSI trigger state)

**FL assessment**: The additional trigger-state-based update offers flexibility. | **Support/fine:** MediaTek,Huawei/HiSi, Ericsson, Samsung (ok), CATT, HONOR, Fujitsu, NEC, Google, **Not support:** Spreadtrum, vivo, ZTE, NTT DOCOMO,  |
| 2.1.3 | **Question 2.A.3:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M=2, please share your view on the following proposal:* When Rel-16 eType-II codebook is configured, support resource-common FD basis selection and indication

**Support/fine:** Huawei/HiSi**Not support:** **FL assessment**: This is a proposal from Huawei to reduce overhead. Note that the **baseline is resource-specific**, and resource-specific SD basis has been agreed.  |
| 2.1.4 | **Question 2.A.3:** For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, for M=2, when Rel-16 eType-II codebook is configured, please share your preference on the following alternatives:* Alt1. Resource-specific RRC configuration of Parameter Combination
	+ Support/fine:
	+ Not support:
* Alt2. Resource-common RRC configuration of Parameter Combination
	+ Support/fine:
	+ Not support:

**FL assessment**: This needs to be resolved for Rel-16 eType-II based HBF. Analogous to Rel-18 Type-II CJT, **the baseline is Alt2.** |
| 2.2 | **Proposal 2.B**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, regarding CBSR, for each of the configured KS NZP CSI-RS resources, reuse per-resource CBSR from the legacy spec as follows: * Rel-17 Type-I NCJT CBSR when Rel-15 Type-I SP is configured
* Rel-18 Type-II CJT CBSR when Rel-16 eType-II is configured

**FL assessment**: No reason not to reuse legacy CBSR  | **Support/fine:** MediaTek, ZTE, Samsung, Lenovo/MotM, HONOR, Xiaomi, **Not support:** Huawei/HiSi (two-level) |
| 2.4 | **Proposal 2.D**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports:* OCPU = M + KS
* Timeline:
	+ Multiply legacy Z’ by a factor of M.
	+ Z is increased by (M–1)\*Z’ to match the increase in Z’
* Active resource counting = KS (following legacy)

**FL assessment**: This proposal is a synthesis between proposals from vivo and Qualcomm | **Support/fine:** vivo, [ZTE], [Xiaomi], [NTT DOCOMO], Qualcomm**Not support:**  |
| 2.5 | **[116bis] Agreement**For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, the following report quantities are supported:* *‘cri-RI-PMI-CQI ‘*
* *‘cri-RI-LI-PMI-CQI’ (only for Type-I)*
* *FFS: ‘cri-RI-i1-CQI’ (only for Type-I)*
* *FFS: ‘cri-RI-i1’ (only for Type-I)*

**Proposal 2.E**: For the Rel-19 CRI-based CSI refinement for up to 128 CSI-RS ports, the following report quantities are also supported only when Rel-15 Type-I SP codebook is configured [and only for M=1]:* *‘cri-RI-i1-CQI’*
* *‘cri-RI-i1’*

**FL assessment**: The restriction M=1 only was proposed by Xiaomi (need to check with companies) | **Support/fine:** IDC, MediaTek, Spreadtrum, CMCC, Xiaomi, **Not support:**  |
|  |  |  |

Table 2B SLS results: issue 2

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| --- | --- |
| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
| Huawei/HiSi | 2.1.2 | Relative Throughput | gNB-assisted reporting beam determination (*M=2, MR*=1*)* provides significant performance gain (~17.5%) over UE-autonomous reporting beam determination(*M=2, MR*=0) |
| 2.1 | Channel Correlation | The normalized power in spatial domain and delay domain of multiple beams are highly correlated  |
|  |  |  |  |

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** |
| Google | Proposal 2.A.1: SupportProposal 2.A.2: SupportProposal 2.A.3: We think all the CSI components should be resource-specific. Q 2.A.3: Support Alt1. Proposal 2.B: We think CBSR should be configured in resource-specific manner. The digital precoder status can be different on top of different beams.Proposal 2.D: SupportProposal 2.E: We failed to see the necessity to support these report quantities. |
|  |  |
|  |  |

### Issue 3 (WID objective 3): CJT calibration reporting for non-ideal synchronization and backhaul

Table 3A Summary: issue 3

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1.1/2 | **[116bis] Agreement**For the Rel-19 aperiodic standalone CJT calibration reporting, the dynamic range and resolution parameters for delay offset reporting Dn,offset, i.e. (AD, MD), are NW-configured via higher-layer (RRC) signalling from the following candidate values:* AD ={0.5CP, 0.75CP, CP, 1.5CP, 2CP, $\frac{1}{4∆f}$, $ \frac{1}{12∆f}$, $\frac{1}{24∆f}$} where CP and $∆f$ denote the length of the cyclic prefix according to the current specifications (for normal CP) within a slot and the SCS, respectively
	+ FFS: Further down-selection of the above candidate values for AD, including the use of a same unit for all supported values
* MD ={32, 64}
	+ FFS: If TDD TX/RX timing misalignment report is supported, whether different set of candidate MD values is needed

…**[116bis] Agreement**For the Rel-19 aperiodic standalone CJT calibration reporting, the dynamic range and resolution parameters for frequency offset reporting FOn, i.e. (AFO, MFO), are NW-configured via higher-layer (RRC) signalling from the following candidate values:* AFO = {0.01ppm, 0.1ppm, 0.2ppm, f, f/2, f/4,f/8, 1/(4t), 1/(8t), 1/(16t), 1/(32t), 1/(512t)} where f and t denote the SCS and duration of one OFDM symbol, respectively
	+ FFS: Further down-selection of the above candidate values for AFO, including the use of a same unit for all supported values
* MFO = {16,32}

…**Proposal 3.A.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the dynamic range for delay offset reporting Dn,offset, i.e. AD, at least support the following values: {0.5CP, CP}* Decide, by RAN1#117, whether any of the following candidate values are supported: {0.75CP, 1.5CP, $\frac{1}{24∆f}$}

**Proposal 3.A.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the dynamic range for frequency offset reporting FOn, i.e. AFO, at least support the following values: {0.1ppm, 0.2ppm}* Decide, by RAN1#117, whether any of the following candidate values are supported: {0.01ppm, 1/(8t), 1/(16t), 1/(32t)}

**FL assessment**: This was discussed OFFLINE [2] and this is the current situation justifying the above proposals

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Company view** |
| AD | 0.5CP | Support/fine: Samsung, OPPO, Qualcomm, Apple, Intel, Ericsson, NTT DOCOMO, Fujitsu, NEC, Google, Xiaomi, Sharp, KDDI, Lenovo/MotM, IDC, vivoNot support: ZTE, Nokia/NSB, |
| 0.75CP | Support/fine: Intel, Ericsson, NTT DOCOMO, Xiaomi, Google, NEC, Sharp, KDDI, IDCNot support: ZTE, Nokia/NSB, |
| CP | Support/fine: Samsung, OPPO, Qualcomm, Apple, Intel, Ericsson, NTT DOCOMO, Fujitsu, Google, Xiaomi, NEC, Kyocera, Sharp, KDDI, , Lenovo/MotM, IDCNot support: ZTE, Nokia/NSB, |
| 1.5CP | Support/fine: Samsung, Ericsson, NTT DOCOMO, Fujitsu, NEC, KDDINot support: ZTE, Nokia/NSB, Xiaomi, Google, Sharp, IDC,  |
| 2CP | Support/fine: NEC,Not support: ZTE, Nokia/NSB, Xiaomi, Google, Sharp, KDDI, IDC, vivo,  |
| $$\frac{1}{4∆f}$$ | Support/fine: ZTE, Huawei/HiSi, Nokia/NSB, CATTNot support: Samsung, OPPO, Apple, Intel, Xiaomi, Google, Fujitsu, NEC, Sharp, KDDI, IDC, |
| $$\frac{1}{12∆f}$$ | Support/fine: ZTE, Huawei/HiSi, Nokia/NSB, CATTNot support: Samsung, OPPO, Apple, Intel, Xiaomi, Google, Fujitsu, NEC, Sharp, KDDI, IDC, |
| $$\frac{1}{24∆f}$$ | Support/fine: ZTE, Huawei/HiSi, Qualcomm, Nokia/NSB, vivo, CATTNot support: Samsung, OPPO, Apple, Intel, Xiaomi, Google, Fujitsu, NEC, Sharp, KDDI, IDC, |
| AFO | 0.01ppm | Support/fine: Samsung, Qualcomm, Intel, Ericsson, NTT DOCOMO, Xiaomi, Sharp, IDC, vivo, Not support: ZTE, Huawei/HiSi, Apple, Nokia/NSB, NEC, Kyocera, |
| 0.1ppm (RAN4) | Support/fine: Samsung, OPPO, Qualcomm, Intel, Ericsson, NTT DOCOMO, Fujitsu, Xiaomi, NEC, Kyocera, Sharp, Lenovo/MotM, IDC, vivoNot support: ZTE, Huawei/HiSi, Apple, Nokia/NSB |
| 0.2ppm (RAN4) | Support/fine: Samsung, OPPO, Qualcomm, Intel, Ericsson, NTT DOCOMO, Fujitsu, Xiaomi, NEC, Kyocera, Sharp, Lenovo/MotM, IDC, vivoNot support: ZTE, Huawei/HiSi, Nokia/NSB |
| f | Support/fine:Not support: ZTE, Huawei/HiSi, Intel, Ericsson, Nokia/NSB, Samsung, Xiaomi, Fujitsu, NEC, IDC, vivo,  |
| f/2 | Support/fine: Google,Not support: ZTE. Huawei/HiSi, Intel, Ericsson, Nokia/NSB, Samsung, Xiaomi, Fujitsu, NEC, IDC, vivo,  |
| f/4 | Support/fine: Google,Not support: ZTE, Huawei/HiSi, Intel, Ericsson, Nokia/NSB, Samsung, Xiaomi, Fujitsu, NEC, IDC, vivo,  |
| f/8 | Support/fine: Apple, Google, Not support: ZTE, Huawei/HiSi, Intel, Ericsson, Nokia/NSB, Samsung, Xiaomi, Fujitsu, NEC, IDC, |
| 1/(4t) | Support/fine: Nokia/NSBNot support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, NEC, IDC, vivo,  |
| 1/(8t) | Support/fine: ZTE, Huawei/HiSi, CATTNot support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, NEC, IDC, |
| 1/(16t) | Support/fine: ZTE, Huawei/HiSi, Nokia/NSB, CATTNot support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, IDC, NEC |
| 1/(32t) | Support/fine: ZTE, Huawei/HiSi, Nokia/NSB, CATTNot support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, IDC,  |
| 1/(512t) | Support/fine: Qualcomm, Nokia/NSB, NECNot support: Samsung, Apple, Intel, Ericsson, Xiaomi, Fujitsu, IDC, |

 | **3.A.1:****Support/fine**: NTT DOCOMO, Sharp, OPPO, TCL, Sony, KDDI, Lenovo/MotM, IDC, Intel, Samsung, vivo, Xiaomi, NEC, Ericsson, Qualcomm**Not support**: **3.A.2:****Support/fine**: NTT DOCOMO, Sharp, OPPO, TCL, Sony, KDDI, Lenovo/MotM, IDC, Intel, Samsung, vivo, Xiaomi, NEC, Ericsson, Qualcomm**Not support**:  |
| 3.2.1 | **[116bis] Agreement**For the Rel-19 aperiodic standalone CJT calibration reporting, given the NTRP configured NZP CSI-RS resources/resource sets and the selected N resources/resource sets, support reporting, in one CSI reporting instance, {n, , n=0, 1, …, N – 1, n≠nref, =0,1,…,-1}, where n, denotes the measured phase offset between the n-th CSI-RS resource/resource set and the reference CSI-RS resource/resource set nref for the -th frequency unit *  =1 is supported
	+ FFS: whether >1 (sub-band reporting) is also supported. For this decision, companies are encouraged to evaluate performance loss without the support of >1 due to phase offset induced by TX-RX timing misalignment.

…**Proposal 3.B.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), =1 only (agreed in RAN1#116bis) implies that the measured/reported phase offsets {n,, n=0, 1, …, NTRP – 1, n≠nref} are associated with the entire configured CSI reporting band (i.e. ‘wideband’)**FL assessment**: Needed to clarify what =1 means, and set it apart from >1 (including the slope scheme) | **Support/fine:** Huawei/HiSi, Samsung, Ericsson, **Not support:**  |
| 3.2.2 | **[116bis] Agreement**For the Rel-19 aperiodic standalone CJT calibration reporting, given the NTRP configured NZP CSI-RS resources/resource sets and the selected N resources/resource sets, support reporting, in one CSI reporting instance, {n, , n=0, 1, …, N – 1, n≠nref, =0,1,…,-1}, where n, denotes the measured phase offset between the n-th CSI-RS resource/resource set and the reference CSI-RS resource/resource set nref for the -th frequency unit *  =1 is supported
	+ FFS: whether >1 (sub-band reporting) is also supported. For this decision, companies are encouraged to evaluate performance loss without the support of >1 due to phase offset induced by TX-RX timing misalignment.

…**Proposal 3.B.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), decide, by RAN1#117, whether to also support >1 (sub-band reporting) as follows:* A sub-band size is selected from {8,16} PRBs
	+ FFS: Whether the sub-band size is NW-configured via higher-layer (RRC) signalling or selected (hence reported) by the UE
* Denoting the number of sub-bands within the configured CSI reporting band as NSB-P, and the sub-bands are indexed as {0, 1, …, NSB-P –1}, decide, by RAN1#117, from the following reporting options:
	+ Opt1: {(n,, n), n=0, 1, …, NTRP – 1, n≠nref}, where n,is the phase offset corresponding to sub-band 0 and the phase offset for sub-band  can be calculated as n, + n
		- $Γ\_{n}\in \left\{0,\frac{2π}{M\_{Γ}}, ….,\frac{2π(M\_{Φ}-1)}{M\_{Γ}}\right\}$, where $M\_{Γ}\in $ {[32], [64], [128], [256]}
	+ Opt2: = NSB-P, i.e. {(n,, n,, NSB-P), n=0, 1, …, NTRP – 1, n≠nref}
		- FFS: Whether restriction on the maximum payload size is needed
	+ Note: For all the above reporting options, the UE performs measurement over the entire configured CSI reporting band

**FL assessment**: This was discussed OFFLINE [2]. This is the current situation:**Support/fine >1**: ZTE (both), Qualcomm (both), CATT, Ericsson, NTT DOCOMO (Opt1), Samsung (both), Fujitsu, NEC (Opt1), TCL, Sony (Opt1), KDDI, Lenovo/MotM (Opt2), CMCC (Opt2), NICT (Opt1), Sharp (Opt2)**Not support >1 (separate D/d+WB PO enough)**: OPPO, Apple, Intel, vivo, Google, Nokia/NSB, Huawei/HiSi  | **Support/fine:** ZTE, Qualcomm, CATT, Ericsson, NTT DOCOMO, Samsung, Fujitsu, NEC, TCL, Sony, KDDI, Lenovo/MotM, OPPO, Apple, Intel, vivo, Google, Nokia/NSB, Huawei/HiSi, CMCC, NICT, Sharp **Not support:**  |
| 3.3.1 | **Proposal 3.C.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset),* For a given phase offset reporting configuration, the UE can be configured (via higher-layer/RRC signaling) with Q associated SRS resource(s) for antenna switching
	+ FFS: The supported value(s) of Q
* The UE antenna port for transmitting the selected/configured port from the associated SRS resource(s) is same as the UE antenna port for receiving the CSI-RS configured for phase offset measurement
	+ For discussion purposes only (not necessarily for specification), the UE antenna port is referred to as the ‘reference UE antenna port’

**FL assessment**: To ensure no additional impairments and phase misalignment occur, the SRS and CSI-RS used for PO measurement should be linked via UE antenna port (since the SRS used here is SRS for AS) | **Support/fine:** Qualcomm, ZTE, CATT, Ericsson, Nokia/NSB, Huawei/HiSi, Samsung, vivo, MediaTek, CATT, **Not support:**  |
| 3.3.2 | **Proposal 3.C.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-P’ (DL/UL phase offset), regarding how to determine the SRS port corresponding to the ‘reference UE antenna port’, support the following* Scheme1. The UE is configured by NW (via higher-layer/RRC signaling) 1 or more SRS port(s) selected from all the port(s) from the configured Q associated SRS resource(s) for phase offset reporting
	+ FFS: Exact details of configuration mechanism
	+ FFS: Whether >1 SRS ports can also be selected
* Scheme2. The UE selects 1 or more SRS port(s) out of all the ports across Q resources and includes the selection in the phase offset report
	+ FFS: Whether >1 SRS ports can also be selected

FFS: Whether further restriction(s) to limit the time gap between the received CSI-RS and the transmitted associated SRS are needed**FL assessment**: This proposal is needed so that the UE and gNB know the exact SRS port(s) used for the linkage in 3.C.1. Scheme2 offers an additional freedom for the UE to select the port(s) according to its implementation, while Scheme1 relies on NW configuration. In some Tdocs it was argued that Scheme2 facilitates NW implementation using non-precoded CSI-RS linked with SRS.Supporting both schemes facilitates more use cases and deployment scenarios for PO report. | **Support/fine:** Qualcomm, Ericsson, Nokia/NSB, Samsung, vivo, MediaTek**Not support:**  |
| 3.5 | **Proposal 3.C.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding timeline, OCPU, and active resource counting, fully reuse those from Rel-18 TDCP reporting* For OCPU, Y denotes the number of reported offset values, i.e. NTRP for each CJT calibration report type

**FL assessment**: No strong reason to do otherwise | **Support/fine:** Samsung, vivo, ZTE, Xiaomi, NTT DOCOMO **Not support:**  |
| 3.6 | **[116bis] Agreement**For the Rel-19 aperiodic standalone CJT calibration reporting, an ‘invalid’ quantization state/hypothesis is supported for frequency offset and phase offset CJT calibration reporting* Note: already supported as ‘out-of-range’ for the (Dn,offset, dn) reporting
* FFS (RAN1#117): The need for a condition/event for ‘invalid’ to be specified as a UE procedure e.g. RSRP-based

**Question 3.F**: For the Rel-19 aperiodic standalone CJT calibration reporting, regarding the ‘out of range’ or ‘invalid’ quantization state/hypothesis, please share our view whether a condition/event for such state needs to be specified and, if so, please be specific**Yes (RSRP-based with RRC-configured threshold)**: IDC, CATT, NEC, Google, Nokia/NSB, **No (UE implementation)**: CMCC, KDDI**FL assessment**: Please share your views |
| 3.7 | **Proposal 3.G.1**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-Dd’ (Doffset+d), support the following* UE to compensate the delay offset for CSI-RS resources for CJT CSI reporting (e.g. with Rel-18 Type-II CJT codebook)
* Link the report to the CJT CSI reporting (e.g. with Rel-18 Type-II CJT codebook) so that the delay offset values for the transceiver compensation are aligned

**Proposal 3.G.2**: For the Rel-19 aperiodic standalone CJT calibration reporting, when ReportQuantity is ‘cjtc-F’ (frequency offset), support the following:* link the FO report to the CJT CSI reporting (e.g, with Rel-18 Type-II CJT codebook) so that the FO values for both UE and gNB compensation are aligned

**FL assessment**: Please share your views | **3.G.1****Support/fine:** vivo, ZTE, [Apple]**Not support:** **3.G.2****Support/fine:** vivo, [Apple]**Not support:**  |
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Table 3B LLS/SLS results: issue 3

|  |  |
| --- | --- |
| **Company** | **LLS/SLS results** |
| **Issue #** | **Metric** | **Observation** |
| Samsung | 3.2.2 | Avg UPT Gain | For CJTC phase-offset reporting, it is identified that Option 1 can perform sufficiently well and nearly achieve the performance of Option 2 and ideal calibration in the scenario with maxTAE=65ns, when only small measurement errors exist (without additional hardware impairments). However, when large measurement errors exist, Option 1 incurs some performance degradation (2% UPT loss) than Option 2, because the large measurement errors affect the underlying assumption of linear phase drift not working well. |
| vivo | 3.1 | SE gain vs maximum payload | It is observed in the result above that when the carrier is 2.2GHz, a frequency error of 0.01 ppm (~ 22Hz) results in a performance loss in the range of 3%, but a frequency error of 0.05 ppm results in a loss of 20% in DU scenarios, which is significant. |
| ZTE | 3.1 | Average throughput gain  | The figure above shows the SLS results of average throughput gain for MD = 32, AD = CP (baseline) or $\frac{1}{12∆f\_{SCS}}$. It is shown that, the performance of AD = CP and AD = $\frac{1}{12∆f\_{SCS}}$ is very close.The figure above shows the SLS results of average throughput gain for MFO = 16, AFO = 0.2ppm (baseline) or $\frac{1}{32∆t\_{symbol}}$. It is shown that the performances of AFO = 0.2ppm and AFO = $\frac{1}{32∆t\_{symbol}}$ are very close. |
| CATT | 3.2.2 | Mean UPT gain | The SLS results above show that the proposed low feedback overhead based calibration scheme with$ Σ=4$ (UE selects some SBs and reports POs corresponding to the selected SBs 🡺 NW inter/extrapolates missing SBs) can also achieve quite good performance while maintaining a moderate overhead cost.The SLS results above show that 1) aligned 4 subbands based calibration achieves similar performance to all subbands based calibration, and 2) calibration performance is degraded if misaligned frequency resources in DL and UL are used for phase offset calculation.  |
| Sony | 3.2.2 | Average throughput | The LLS simulations show that reporting information about the evolution of the phase offsets $Φ\_{n,σ}$ in the frequency domain improves the system’s throughput, at least for TAEs of 65 ns or larger. (2% gain over wideband PO reporting) |
| Nokia | 3.6 | Mean cell UPT vs total overhead | A graph with numbers and linesA graph with a line and a chart with numbers1. (b)

Normalized mean cell UPT (a) without RSRP condition on the invalid state and (b) when an RSRP threshold of 9dB is configured as a condition for invalid stateConfiguring an RSRP threshold of 8dB as condition for the invalid state for FO reporting shows average UPT gain of around 5% over not configuring an RSRP threshold. |
| 3.3.1 | Mean spectral efficiency gain  | A graph with different colored bars  Description automatically generatedA graph with different colored squares  Description automatically generatedIn the left figure, 2 out of 4 antennas at UE side are sounded and the same antennas are used to estimate the phase difference between the CSI-RS signals transmitted by TRP $n$ and the reference TRP, and received by antenna $i$, $Φ\_{i,n}^{UE}$. In the right figure, only 1 SRS antenna port is sounded in UL and all receive antennas are used to compute $Φ\_{i,n}^{UE}$. We can see how the mismatch between the SRS ports used to compute $Φ\_{n,i}^{TRP} $ and the receive antennas used to compute $Φ\_{i,n}^{UE}$, has impacted the performance greatly as shown in the right figure, where we can see about 60% loss. |
| Qualcomm | 3.2.2 |  | A couple of graphs with lines and numbers  Description automatically generated with medium confidenceAs seen in the results above, it is observed that tens of nano seconds can cause nearly 10% UPT loss. Furthermore, it is observed that the UPT loss is still significant, when a small bit, (e.g., 3-to-5 bits, i.e., 8 to 32 quantization levels) is used for TAE quantization. The UPT loss is around 2% to 10%, depending on the exact TAE value – this is due to some TAE value close to certain quantization point by chance. |
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Table 3C Additional inputs: issue 3

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 3A** |
| Google | Proposal 3.A.1: SupportProposal 3.A.2: OKProposal 3.B.1: OKProposal 3.B.2: What is the use case for the proposed subband PO report? For both proposals, is it possible for UE to report “invalid” for some subbands?Proposal 3.C.1: OK. One minor editorial comment, in the second bullet, “UE antenna port” should be “UE antenna port(s)”, since whether to use one or multiple ports are still open. Proposal 3.C.2 (Issue 3.3.2): One question, if only one or a subset of UE ports are selected/configured, how about the phase offset for other UE ports? Proposal 3.C.2 (Issue 3.5): Support for Ocpu and active resource counting, but the timeline may depend on how we define the condition to report “invalid”. If the “invalid” requires UE to measure SINR/RSRP or something else, more time needs to be considered. In addition, the timeline for PO report also depends on whether UE needs to calculate/compensate the TO/FO.Proposal 3.F: We think the condition could follow what has been defined in RAN4 for the condition to determine one resource is measurable, which are as follows:* RSRP > threshold1
* SINR > threshold2
* Delay offset is between the CSI-RS and the reference CSI-RS the UE has reported is smaller than CP

Proposal 3.G.1/2: Do not support. We think the NW should perform the pre-compensation to transmit the CSI-RS resources. Therefore, the NW can provide the corresponding QCL indication for the CSI-RS resources to tell UE whether pre-compensation has been done or not. Therefore, we propose the followings:**Support the network to indicate the QCL for the CSI-RS resources configured as CMR for CJT CSI based on one of the following schemes:*** **Scheme 1: Independent TCI configuration for each CSI-RS resources (Already supported)**
* **Scheme 2 (DO pre-compensation): Independent TCI configuration for each CSI-RS resources for QCL indication other than delay offset, and configure a common TCI for all the CSI-RS resources for QCL indication for delay offset**
* **Scheme 3 (FO pre-compensation): Independent TCI configuration for each CSI-RS resources for QCL indication other than Doppler shift, and configure a common TCI for all the CSI-RS resources for QCL indication for Doppler shift**
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# References

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| --- | --- | --- | --- |
| 1 | RP-240087 | Revised WID: NR MIMO Phase 5 | Samsung (Moderator) |
| 2 | R1-2404107 | Moderator Summary for OFFLINE discussion on Rel-19 CSI enhancements | Moderator (Samsung) |
| 3 | [R1-2403847](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403847.zip) | Discussion on Rel-19 Enhancements of CSI | InterDigital, Inc. |
| 4 | [R1-2403876](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403876.zip) | Discussion on Rel-19 CSI enhancements | New H3C Technologies Co., Ltd. |
| 5 | [R1-2403884](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403884.zip) | CSI enhancement for NR MIMO Phase 5 | Tejas Networks Limited |
| 6 | [R1-2403901](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403901.zip) | CSI enhancements to support up to 128 CSI-RS ports | MediaTek Inc. |
| 7 | [R1-2403945](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403945.zip) | On 128 CSI-RS ports and UE reporting enhancement | Huawei, HiSilicon |
| 8 | [R1-2403981](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403981.zip) | CSI enhancements for MIMO | Intel Corporation |
| 9 | [R1-2404004](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404004.zip) | Discussion on Rel-19 CSI enhancements | TCL |
| 10 | [R1-2404020](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404020.zip) | Discussion on CSI enhancements | Spreadtrum Communications |
| 11 | [R1-2404109](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404109.zip) | Views on Rel-19 CSI enhancements | Samsung |
| 12 | [R1-2404171](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404171.zip) | Discussion on Rel-19 CSI enhancements | vivo |
| 13 | [R1-2404240](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404240.zip) | Discussion on CSI enhancements | ZTE |
| 14 | [R1-2404278](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404278.zip) | Views on R19 MIMO CSI enhancement | Apple |
| 15 | [R1-2404337](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404337.zip) | Discussion on CSI enhancements | Lenovo |
| 16 | [R1-2404395](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404395.zip) | Views on MIMO CSI enhancements in Rel-19 | CATT |
| 17 | [R1-2404450](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404450.zip) | Discussion on CSI enhancements | CMCC |
| 18 | [R1-2404495](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404495.zip) | Additional views on CSI enhancements | Sony |
| 19 | [R1-2404551](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404551.zip) | Discussions on CSI enhancements | LG Electronics |
| 20 | [R1-2404575](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404575.zip) | Discussion on CSI enhancements | HONOR |
| 21 | [R1-2404588](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404588.zip) | Discussion on Rel-19 CSI enhancements | Fujitsu |
| 22 | [R1-2404612](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404612.zip) | Discussion on CSI enhancement | Xiaomi |
| 23 | [R1-2404668](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404668.zip) | Discussion on CSI enhancements | NEC |
| 24 | [R1-2404687](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404687.zip) | CSI Enhancement for NR MIMO | Google |
| 25 | [R1-2404883](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404883.zip) | CSI enhancements for Rel-19 MIMO | OPPO |
| 26 | [R1-2404919](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404919.zip) | CSI enhancement for NR MIMO Phase 5 | Nokia |
| 27 | [R1-2404923](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404923.zip) | CSI enhancements for Rel.19 MIMO | Fraunhofer IIS, Fraunhofer HHI |
| 28 | [R1-2404971](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404971.zip) | CSI enhancements | Sharp |
| 29 | [R1-2405005](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405005.zip) | CSI enhancements for large antenna arrays and CJT | Ericsson |
| 30 | [R1-2405036](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405036.zip) | Discussion on CSI enhancements | NTT DOCOMO, INC. |
| 31 | [R1-2405149](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405149.zip) | CSI enhancements for >32 ports and UE-assisted CJT | Qualcomm Incorporated |
| 32 | [R1-2405206](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405206.zip) | CSI enhancements | NICT |
| 33 | [R1-2405239](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405239.zip) | CSI Enhancements | CEWiT |
| 34 | [R1-2405255](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405255.zip) | Discussion on CSI enhancements for NR MIMO Phase 5 | KDDI Corporation |
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