**3GPP TSG RAN WG1 #110 R1-2207978**

**Toulouse, France, August 22nd – 26th, 2022**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

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

**Document for:** Discussion and Decision

## Introduction

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

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

## Summary of companies’ views

Proposals planned for presentation and potential endorsement on 1st online session for AI 9.1.2:

* Issue 1:

|  |
| --- |
| **Proposal 1.I**: On the Type-II codebook refinement for CJT mTRP, regarding W2 quantization group and Strongest Coefficient Indicator (SCI) design, for each layer, down-select one from the following alternatives by RAN1#110bis-e:* ...
* Alt4. For 1 TRP/TRP-group, one group comprises one polarization, and for remaining N-1 TRPs, one group comprises one polarization across remaining N-1 TRPs/TRP-groups (*C*group,amp=2+2=4), with a common phase reference across TRPs/TRP-groups (*C*group,phase=1)
	+ FFS: Quantization of N strongest coefficients
 |
| **Proposal 1.F**: For the Rel-18 Type-II codebook for CJT mTRP based on the Rel-16 Type-II codebook, SD basis and FD basis are separate, each fully reusing the legacy Rel-16 DFT-based design.* **Support/fine:** Apple, AT&T, DOCOMO, ZTE, NEC, CATT, Samsung, IDC, Spreadtrum, vivo, Lenovo, OPPO, Xiaomi, CMCC, MediaTek, Ericsson, Nokia/NSB, Intel, Google, Qualcomm, LG, Fraunhofer IIS/HHI, Sharp, Sony, CEWiT
* **Not support:** Huawei/HiSi (Alt4)
* Alt4 (separate, eigenvector): SD basis and FD basis are separate, using eigenvector-based basis
	+ FFS: eigenvector codebook design, parameterization
 |
| **Proposal 1.C**: The Rel-18 Type-II codebook for CJT mTRP comprises refinement of the following codebooks:* Refinement of the Rel-16 eType-II regular codebook
* Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the same design details as the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations
* **Support/fine:** Huawei/HiSi, Sharp, Xiaomi, AT&T (1st pref Rel-16), ZTE
* **Not support (Rel-16 only):** CEWiT, Intel, Spreadtrum, DOCOMO, NEC
 |
|  |

* Issue 2:

|  |
| --- |
| **Proposal 2.H**: For the Rel-18 Type-II codebook refinement for high/medium velocities, support DD/TD (compression) unit (analogous to PMI sub-band for Rel-16 codebook) as a codebook parameter.* FFS: whether this parameter is defined as a function of another parameter
* FFS: whether this is used for PMI only, or PMI/CQI

**Yes:** OPPO, Samsung, LG, MediaTek, Qualcomm (same as time-interval b/w two consecutive CSI-RS occasions, e.g. periodicity for P-CSI-RS), Ericsson, Spreadtrum, ZTE (configurable, and subjective to UE capability), Xiaomi, Nokia/NSB, CMCC, Sharp, Sony, CEWiT, CATT**No:** |
| **Proposal 2.D**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities assuming the UE-side prediction, on the definition of UE-side prediction, down-select one from the following alternatives by RAN1#110bis-e:* Alt1. UE “predicting” channel/CSI after the slot with a reference resource
* Alt2. UE “predicting” channel/CSI after slot n (where the CSI is reported)
* ~~Alt3. UE “predicting” channel/CSI after the slot where CSI-RS resides~~

**Proposal 2.D:*** **Support/fine:** Sharp, Qualcomm, Samsung, LG, ZTE, Fraunhofer IIS/HHI, DOCOMO, Huawei/HiSi, vivo, Nokia/NSB (2nd pref), Lenovo, Google, Intel**,** MediaTek, Ericsson, Spreadtrum, CATT, CMCC, Apple, NEC
* **Not support:**

**Alt1:** Qualcomm, Samsung, LG, ZTE, Fraunhofer IIS/HHI, DOCOMO**Alt2:** Huawei/HiSi, vivo, Nokia/NSB (2nd pref), Lenovo, Google, Intel**,** MediaTek, Ericsson, Spreadtrum, CATT, CMCC, Apple, DOCOMO (2nd pref)**Alt3:** Samsung, DOCOMO, NEC, Nokia/NSB (1st pref) |
| **Proposal 2.F**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, when UE-side prediction is assumed, down-select ~~at least~~ one from the following alternatives by RAN1#110bis-e:* ~~Alt1.A:~~ *~~l~~* ~~+~~ *~~W~~*~~CSI~~ ~~–1 ≤~~ *~~n~~*~~ref~~
	+ *~~n~~*~~ref~~ ~~(CSI reference resource slot) as boundary~~
* Alt1.B:  *l* ≥ *n*ref
	+ *n*ref (CSI reference resource slot) as boundary
* Alt2.B: *l* ≥ *n*
	+ *n* (report slot) as boundary
* ~~Alt3.B:~~ *~~l~~* ~~≥~~ *~~k~~* ~~+~~ *~~W~~*~~meas~~ ~~–1~~
	+ ~~End slot of~~ *~~W~~*~~meas~~ ~~(~~*~~k~~* ~~+~~ *~~W~~*~~meas~~ ~~–1) as boundary, assuming CSI-RS measurement window of [~~*~~k~~*~~,~~*~~k~~*~~+~~*~~W~~*~~meas~~ ~~–1]~~

**Proposal 2.D:*** **Support/fine:** Sharp, MediaTek, ZTE, vivo, OPPO, NEC, CMCC, CATT, Huawei, HiSi, Ericsson, Intel, Google, Nokia/NSB (2nd pref), Qualcomm, LG, IDC
* **Not support:**
 |
| **Proposal 2.G**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, support the following CSI-RS resource types/structures for CMR:* Time-domain behaviour for each NZP CSI-RS resource: periodic, semi-persistent, aperiodic
* The use of K≥1 NZP CSI-RS resources:
	+ FFS: whether the resources are in the same CSI-RS resource set, other details
	+ FFS: whether different resources are associated with different time-domain behaviors

**Proposal 2.G:*** **Support:** Google, Samsung, Nokia/NSB, Lenovo, DOCOMO, MediaTek, Qualcomm, LG, Spreadtrum, ZTE, Xiaomi, NEC, OPPO, CATT, CMCC, Sharp, Apple
* **Not support:** vivo (concern on AP)
 |
| **Proposal 2.A**: The Rel-18 Type-II codebook refinement for high/medium velocities comprises refinement of the following codebooks:* Refinement of the Rel-16 eType-II regular codebook
* Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the same design details as the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations

**Proposal 2.A:*** **Support/fine:** Huawei/HiSi, Xiaomi, AT&T (1st pref Rel-16), ZTE, Qualcomm, Sony
* **Not support (Rel-16 only):** CEWiT, Intel, Spreadtrum, DOCOMO, NEC, vivo, Fraunhofer IIS/HHI
 |

* Issue 3: Proposal 3.C

|  |
| --- |
| **Proposal 3.B**: For the Rel-18 TRS-based TDCP reporting, down select one of the following alternatives by RAN1#110bis-e:* AltA. Based on Doppler profile
	+ E.g., Doppler spread derived from the 2nd moment of Doppler power spectrum, average Doppler shifts, Doppler shift per resource, maximum Doppler shift, relative Doppler shift, etc
* AltB. Based on time-domain correlation profile
	+ E.g. Correlation within one TRS resource, correlation across multiple TRS resources
	+ Note: The correlation over one or more lags of TRS resource may be considered. The lags may be within one TRS burst or different TRS bursts
* AltC: CSI-RS resource and/or CSI reporting setting configuration parameter(s) to assist network
 |

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

Table 1A Summary: issue 1

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 1.3 | [109-e] **Agreement**The work scope of Type-II codebook refinement for CJT mTRP includes refinement of the following codebooks:* Rel-16 eType-II regular codebook
* Rel-17 FeType-II port selection (PS) codebook

FFS: Whether to prioritize/down-select from the two**Proposal 1.C**: The Rel-18 Type-II codebook for CJT mTRP comprises refinement of the following codebooks:* Refinement of the Rel-16 eType-II regular codebook
* Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the same design details as the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations
 | **Support (equal priority for) both Rel-16 eType-II and Rel-17 FeType-II:** Huawei/HiSi, Sharp**Down-select to only (prioritize) Rel-16 eType-II:** Apple, AT&T, Google, DOCOMO, MediaTek, NEC, CATT, Samsung, IDC, Spreadtrum, vivo, Lenovo, Intel, Xiaomi, Fraunhofer IIS/HHI, Qualcomm, Ericsson, Sony, LG, ZTE (involving R16 port-selection CSI), Sony (at least Rel-16), CEWiT**Down-select to only (prioritize)Rel-17 FeType-II:** **Proposal 1.C:*** **Support/fine:** Huawei/HiSi, Sharp, Xiaomi, AT&T (1st pref Rel-16), ZTE
* **Not support (Rel-16 only):** CEWiT, Intel, Spreadtrum, DOCOMO, NEC
 |
| 1.6 | [109-e] **Agreement** On the spatial-domain (SD) and frequency-domain (FD) basis design for the Rel-16 Type-II codebook refinement for CJT mTRP, down-select from the following alternatives:* Alt1 (separate, legacy DFT): SD basis and FD basis are separate, each fully reusing the legacy Rel-16 DFT-based design
* Alt2 (joint, DFT): joint SD-FD DFT-based basis
	+ FFS: Details on DFT parameters, e.g. length, oversampling (if any), rotation (if any)
* Alt3 (joint, eigenvector): joint SD-FD eigenvector-based basis
	+ FFS: eigenvector codebook design, parametrization
* Alt4 (separate, eigenvector): SD basis and FD basis are separate, using eigenvector-based basis
	+ FFS: eigenvector codebook design, parameterization

**Proposal 1.F**: For the Rel-18 Type-II codebook for CJT mTRP based on the Rel-16 Type-II codebook, SD basis and FD basis are separate, each fully reusing the legacy Rel-16 DFT-based design**FL note**: This proposal was already discussed at length in round 0 | **Proposal 1.F:*** **Support/fine:** Apple, AT&T, DOCOMO, ZTE, NEC, CATT, Samsung, IDC, Spreadtrum, vivo, Lenovo, OPPO, Xiaomi, CMCC, MediaTek, Ericsson, Nokia/NSB, Intel, Google, Qualcomm, LG, Fraunhofer IIS/HHI, Sharp, Sony, CEWiT
* **Not support:** Huawei/HiSi (Alt4)
 |
| 1.9 | **Agreement**: On the Type-II codebook refinement for CJT mTRP, regarding W2 quantization group and Strongest Coefficient Indicator (SCI) design, for each layer, down-select one from the following alternatives by RAN1#110bis-e:* ...
* Alt4. For 1 TRP/TRP-group, one group comprises one polarization, and for remaining N-1 TRPs, one group comprises one polarization across remaining N-1 TRPs/TRP-groups (*C*group,amp=2+2=4), with a common phase reference across TRPs/TRP-groups (*C*group,phase=1)
	+ FFS: Quantization of N strongest coefficients

**FL Note:** Companies to check and give inputs on wording |
|  |  |  |

Table 2 Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Huawei, HiSilicon | For proposals 1.E and 1.F, we think the decision should be made based on comparison of feedback overhead and performance. To align the understanding of companies and to have a fair comparison between alternatives, it will be much appreciated if the information of following aspects can be provided, so that we can based on the same understanding to compare the feedback and performance gain. Our understanding of the alternatives is provided as below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Per TRP or TRP common basis for W1 and Wf | PMI obtained by SVD over separate TRP channel or over concatenated channel | W2 coefficients separately selected per-TRP or jointly selected across TRPs | Feedback overhead | Performance |
| Alt 1A/1B: per-TRP basis for W1, Wf, or Ws-fAlt 2: per-TRP basis for W1, and TRP common Wf | Alt 1A/1B/2: SVD over concatenated channel | Alt 1A/1B/2: can be jointly selected across TRPs | Alt 1A: per-TRP W1, W2, Wf feedback;Alt 1B: per-TRP W1, Ws-f feedback; long-term eigenvector basis feedback;Alt 2: per-TRP W1, W2, and TRP-common Wf feedback.The same feedback overhead for W1, W2 between alternatives. | Eigenvector basis > DFT basis;Alt 1B>Alt 1A>W2. |

 |
| Samsung | Re HW’s questions, in our view, the two modes are different (especially the FD bases part). So, the UE implementation for PMI calculation can also be different. In particular, in mode 1, the FD basis can be selected based on per TRP channel, whereas in mode 2, it can be selected based on aggregated (across TRPs) channel.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Per TRP or TRP common basis for W1 and Wf | PMI obtained by SVD over separate TRP channel or over concatenated channel | W2 coefficients separately selected per-TRP or jointly selected across TRPs | Feedback overhead | Performance |
| Same as HW | Alt 1A/1B: SVD over per TRP channelAlt2: SVD over concatenated channel | W2 design can be the same or different for all alts | The same feedback overhead for W1. If W2 design is the same for mode 1 and mode2, then the feedback overhead for W2 will also be the same. | (Assuming DFT based Alt2B) Alt2 >Alt1A~Alt2B The perf. Of Alt2B can be improved (E.g. per element quantization of eigenvector), but @ cost of increased overhead |

 |
| Nokia/NSB | Regarding Huawei’s comments on P1.E/1.F: eigenvector-based $W\_{1}$-$W\_{f}$ assumes UE-specific basis vectors, which requires a redesign of $W\_{1}$ and $W\_{2}$ codebooks, for which companies may have very different proposals. We observe significant performance gains of CJT with the legacy DFT codebooks, so we don’t see the need for this laboursome redesign. Regarding feedback overhead, the difference between Mode 1 and Mode 2 depends on the design of W2 and how Wf is reported in Mode 1. But, in general, we think Mode 2 needs less overhead than Mode 1. Regarding performance, we have same assessment as Samsung in that Alt 2 shows better performance than Alt 1.  |
| vivo | **On Proposal 1.E and 1.F**We think from standard perspective, the difference between Mode 1 and Mode 2 is a same set of FD basis is selected for multiple TRPs in Mode2, while Mode 1 can allow same or different sets of FD basis for multiple TRPs. Considering this, we don’t agree with the statement that a common size of W2 is always used for both Mode 1 and Mode 2. To maintain a same number of NZ coefficients, the size of W2 can be different for the two modes considering different location distribution of the coordinated TRPs, i.e., the delay range and relative delay difference of different TRPs. Also, different total numbers of FD basis may be observed for the two TRPs. Therefore these two are actually different modes. However, we should strive to have a common design on the mechanism for the UCI reporting details.Regarding Alt 1B and joint FD/SD basis, we feel like the difference between Alt 1B and Alt 1A includes only UCI design details, which Alt 1B just uses a joint coding for FD basis and SD basis. We don’t see the need of discussing such micro-optimization of UCI signaling at this stage. |
| Intel (2) | We share similar understanding with Samsung on the different modes (proposal 1E). In our understanding different UE implementation may be assumed for different alternatives. Also, W2 design might be different for different alternatives. So, we support this proposals, other details can be considered further. |
| MediaTek | Re Proposal 1.F1. Per WID, Rel-16/17 codebook would be enhanced for CJT. Although it is up to interpretation, we believe that redesigning SD and FD bases would be much more than enhancement/refinement of these codebooks.
2. Although we agree with HW that long term feedback of eigen bases may reduce overhead, such form of long term feedback is not specified for current Rel-16/17 codebooks. For the ongoing work item on CSI enhancement for high velocities, it is mandated that SD and FD bases would not be modified, even if long term feedback is eventually agreed.

Considering these aspects, the case for joint SD-FD bases (DFT/eigen) and joint or separate eigen bases stands weak. |
| Mod (round 0) | **Thanks for the comments from companies that respond to Huawei’s inquiries re proposals 1.E and 1.F. Overall the concern on joint eigenvector basis for Rel-16-based (hence Alt1B codebook) includes unclear throughput-overhead trade-off benefit (optimization), spec impact, the amount of works involved (vs. scope/TU, time/efforts).*** **Other companies are encouraged to comment as well**

**Minor revision on proposals 1.B (including the bullet from 1.A) and 1.E (different 🡪 independent)** |
| Huawei, HiSilicon | Not support Proposal 1.F. Since SD-FD joint codebook structure is not agreed, we support Alt4 (separate eigenvector basis). Evaluation results show that Alt4 still has up to 8% performance gain over Alt1.C:\Users\w00383792\AppData\Roaming\eSpace_Desktop\UserData\w00383792\imagefiles\ADDD351A-7A81-4F91-AAAB-FBF5A3A2B35C.png C:\Users\w00383792\AppData\Roaming\eSpace_Desktop\UserData\w00383792\imagefiles\CC3C5641-4FBF-4C55-BF5D-9E59905CF9F8.png |
| ZTE | **Proposal 1.C:** We can be flexible for progress. One question for double check: If proposal 1.C is approved, does it means that Rel-17 Fe-TypeII PS codebook and Rel-16 eTypeII codebook are treated equally?[Mod: In some way. The proposal suggests that the work will be done around Rel-16 Type-II and then directly applied to Rel-17 Type-II except for parameter combination. Meaning that the proposal doesn’t increase workload (at least significantly) compared to that for only Rel-16 Type-II] |
| Mod V0 | 1. **Check and, if needed, update your view in Table 1A, especially on the moderator proposals**
	1. **Please check the wording of Alt4**
2. **Share additional inputs here, if needed**
3. **Technical discussion re proposal 1.F from ROUND 0 and 1 is copied above.**
 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

### Issue 2: Type-II codebook refinement for high/medium UE velocities (with time/Doppler-domain compression)

Table 3A Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | [109-e] **Agreement**The work scope of Type-II codebook refinement for high/medium velocities includes refinement of the following codebooks, based on a common design framework:* Rel-16 eType-II regular codebook
* Rel-17 FeType-II port selection (PS) codebook

FFS: Whether to prioritize/down-select from the two**Proposal 2.A**: The Rel-18 Type-II codebook refinement for high/medium velocities comprises refinement of the following codebooks:* Refinement of the Rel-16 eType-II regular codebook
* Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the same design details as the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations
 | **Support (equal priority for) both Rel-16 eType-II and Rel-17 FeType-II:** Huawei/HiSi**Down-select to only (prioritize) Rel-16 eType-II:** Apple, DOCOMO, MediaTek, NEC, Xiaomi, Samsung, Lenovo, Intel, Xiaomi. Qualcomm, Apple, DOCOMO, Ericsson, ZTE, Nokia/NSB, LG, Spreadtrum, CMCC**Down-select to only (prioritize) Rel-17 FeType-II:** Huawei/HiSi**Proposal 2.A:*** **Support/fine:** Huawei/HiSi, Xiaomi, AT&T (1st pref Rel-16), ZTE, Qualcomm, Sony
* **Not support (Rel-16 only):** CEWiT, Intel, Spreadtrum, DOCOMO, NEC, vivo, Fraunhofer IIS/HHI
 |
| 2.6 | [109-e] **Agreement**On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, *at least for discussion purposes*, define the following:* Assume a CSI report in slot *n*, and let the length of the DD/TD basis vector be *N*4
	+ Note that basis vector has no span/window in time-domain, only length
* CSI-RS measurement window of [*k*,*k*+*W*meas –1], representing the window in which CSI-RS occasion(s) are measured for calculating a CSI report
	+ *k* is a slot index and *W*meas is the measurement window length (in slots)
	+ Note: In the legacy Rel-16/17 CSI, the CSI-RS occasion(s) are configured in *CSI-ReportConfig*
* CSI reporting window of [*l*,*l*+*W*CSI –1], associated to the CSI report in slot *n*
	+ *l* is a slot index and *W*CSI is the reporting window length (in slots)
* CSI reference resource(s) in time-domain
	+ The location of a CSI reference resource is denoted as *n*ref (slot index)

[109-e] **Agreement**On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, consider *at least* the following alternatives for potential down-selection:* Alt1: *n*ref (CSI reference resource slot) as boundary
	+ Alt1.A:  *l* + *W*CSI –1 ≤ *n*ref
	+ Alt1.B:  *l* ≥ *n*ref
	+ Alt1.C: *l* < *n*ref and *l* + *W*CSI –1 > *n*ref
* Alt2: *n* (report slot) as boundary
	+ Alt2.A: *l* + *W*CSI –1 ≤ *n*
	+ Alt2.B: *l* ≥ *n*
	+ Alt2.C: *l* < *n* and *l* + *W*CSI –1 > *n*
* Alt3: End slot of *W*meas (*k* + *W*meas –1) as boundary
	+ Alt3.A: *l* + *W*CSI –1 ≤ *k* + *W*meas –1 with the following as a special case: *l=k,* *W*CSI = *W*meas
	+ Alt3.B: *l* ≥ *k* + *W*meas –1
	+ Alt3.C: *l* < *k* + *W*meas –1 and *l* + *W*CSI –1 > *k* + *W*meas –1 with the following as special cases:
		- *l=k,* *l* + *W*CSI = *n*
		- *l=k,* *l* + *W*CSI > *n*

FFS: whether *n*ref represents the slot index of Rel-15 CSI reference resource or a newly defined CSI reference resourceFFS: whether/how the CSI measurement window and reporting window are configured**Proposal 2.F**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, when UE-side prediction is assumed, down-select ~~at least~~ one from the following alternatives by RAN1#110bis-e:* ~~Alt1.A:~~ *~~l~~* ~~+~~ *~~W~~*~~CSI~~ ~~–1 ≤~~ *~~n~~*~~ref~~
	+ *~~n~~*~~ref~~ ~~(CSI reference resource slot) as boundary~~
* Alt1.B:  *l* ≥ *n*ref
	+ *n*ref (CSI reference resource slot) as boundary
* Alt2.B: *l* ≥ *n*
	+ *n* (report slot) as boundary
* ~~Alt3.B:~~ *~~l~~* ~~≥~~ *~~k~~* ~~+~~ *~~W~~*~~meas~~ ~~–1~~
	+ ~~End slot of~~ *~~W~~*~~meas~~ ~~(~~*~~k~~* ~~+~~ *~~W~~*~~meas~~ ~~–1) as boundary, assuming CSI-RS measurement window of [~~*~~k~~*~~,~~*~~k~~*~~+~~*~~W~~*~~meas~~ ~~–1]~~

**FL Note**: Since we have agreed on UE-side prediction, Alt1.A should be excluded. | **Alt1.A:** Spreadtrum, Xiaomi, LG, Fraunhofer IIS/HHI, Qualcomm, DOCOMO**Alt1.B:** IDC, ZTE, LG, CMCC, DOCOMO**Alt2.B:** Huawei/HiSi, Spreadtrum, vivo, Google, OPPO, CATT, Intel, CMCC, MediaTek, Ericsson, Nokia/NSB, DOCOMO (optional)**Alt3.B:** CMCC, Fraunhofer IIS/HHI, Nokia/NSB, Samsung, NEC, [Apple]**FL Note**: This topic and proposal have been discussed OFFLINE [1]. * Alt1.A: Qualcomm, DOCOMO, LG, Intel, Xiaomi
* Alt1.B: Qualcomm, ZTE, LG, OPPO, CMCC, Intel, IDC
* Alt1.C: Qualcomm, ZTE, LG, NEC
* Alt2.A:
* Alt2.B: MediaTek, vivo, OPPO (1st pref), NEC, CMCC, CATT, Huawei, HiSi, Ericsson, Intel, Google, Nokia/NSB (2nd pref)
* Alt2.C:
* Alt3.A: Samsung, DOCOMO, MediaTek (no need to define Wmeas), Apple (gNB-side prediction $l=k, W\_{CSI}=W\_{meas}$), Fraunhofer IIS/HHI (gNB-side prediction $l=k, W\_{CSI}=W\_{meas}$), Google,
* Alt3.B: Samsung, OPPO, NEC, CMCC, Nokia/NSB (1st pref)
* Alt3.C: Samsung, NEC

Some discussion points:* Concern on x.C (UE complexity): MediaTek, Spreadtrum, Xiaomi, vivo
* Concern on gNB-side prediction (e.g. Alt3.A): vivo, Ericsson, ZTE, Nokia/NSB
* UE-side (only) prediction (x.B) is supported by a number of companies, at least as an optional feature

Based on the offline discussion, I have narrowed down the alternatives by removing the ones with concern and lack of support. *Please fit your preferences on the four remaining alternatives. Else it would be hard for us to focus our discussion.***Proposal 2.D:*** **Support/fine:** Sharp, MediaTek, ZTE, vivo, OPPO, NEC, CMCC, CATT, Huawei, HiSi, Ericsson, Intel, Google, Nokia/NSB (2nd pref), Qualcomm, LG, IDC
* **Not support:**
 |
| 2.7 | CSI-RS resource types/structures **supported** for measurement (discussion on whether/how the legacy Resource setting needs enhancement will take place in later rounds)[109-e] **Agreement**On potential refinement of Resource setting configuration associated with Type-II codebook refinement for high/medium velocities, study the following options to assess whether/how the legacy Resource setting configuration needs to be enhanced for “burst” measurement:* Periodic (P) CSI-RS: periodicity and offset
* Semi-persistent (SP) CSI-RS: activation/deactivation, periodicity, and offset
* Aperiodic (AP) CSI-RS: triggering, offset of a group of AP CSI-RS resources

FFS: Support for K>1 NZP CSI-RS resources association with Type-II codebook refinement for high/medium velocitiesFFS: Whether specification support for jointly utilizing two types of CSI-RS time-domain behaviors is needed**Proposal 2.G**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, support the following CSI-RS resource types/structures for CMR:* Time-domain behaviour for each NZP CSI-RS resource: periodic, semi-persistent, aperiodic
* The use of K≥1 NZP CSI-RS resources:
	+ FFS: whether the resources are in the same CSI-RS resource set, other details
	+ FFS: whether different resources are associated with different time-domain behaviors
 | **Proposal 2.G:*** **Support:** Google, Samsung, Nokia/NSB, Lenovo, DOCOMO, MediaTek, Qualcomm, LG, Spreadtrum, ZTE, Xiaomi, NEC, OPPO, CATT, CMCC, Sharp, Apple
* **Not support:** vivo (concern on AP)
 |
|  |  |  |

Table 4 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Vivo (from ROUND 0) | **Proposal 2.G**We have concern on supporting aperiodic CSI-RS for this high/medium CSI enhancement. Based on our study, to have a satisfied prediction performance, it is needed to use sufficient number of CSI-RS occasion (e.g., 16 for 2-ms CSI-RS periodicity) to perform measurement. 16 CSI-RS occasions mean at least 32 ms to measure CSI-RS. In 30kHz SCS, it is 64 slots. Such huge delay makes to trigger aperiodic CSI-RS nearly impossible as it introduces large CSI latency. It does not make sense that gNB triggers CSI-RS and wait more than 64 slots to get the CSI. Further, if the CSI-RS periodicity is larger, saying 4-ms, more CSI-RS occasions will be needed to ensure the performance, e.g., 32 occasions in our evaluation. Such latency will increase to 256 slots, which is not practical at all for aperiodic CSI-RS.Further, the need to have multiple CSI-RS resources for measurement is not justified. In our understanding, at least periodic or semi-persistent CSI-RS does not require multiple resources to measure. UE can just uses the multiple periodic CSI-RS occasions. |
| Samsung | @**vivo: re Proposal 2.G** in our view, Ap-CSI-RS should be supported, since some scenarios P or SP CSI-RS resources can’t be used, e.g., due to limitations such as a min periodicity of 4 slots. If the NW wants to configure measurement faster than 4 slots (i.e. periodicity < 4 slots), then the current P/SP CSI-RS resource can’t be used. We need some enhancements in measurement to support this important use case. |
| Huawei, HiSilicon | **Support proposal 2.A**, Rel-17 Type II codebooks can reuse the Rel-16 Type II codebooks enhancement for mobility including codebook structure, doppler basis waveform, CSI measurement and reporting configuration etc, which needs little spec effort to support. Moreover, Rel-17 Type II has better performance than Rel-16 Type II. |
| Mod V0 | 1. **Check and, if needed, update your view in Table 3A, especially on the moderator proposals**
2. **Share additional inputs here, if needed**
 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

### Issue 3: TRS-based reporting of time-domain channel properties (TDCP)

Table 5A Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | [109-e] **Agreement**The work scope of TRS-based TDCP reporting focuses on the following use cases for evaluation purposes:* Targeting medium and high UE speed, e.g. 10-120km/h as well as HST speed
* Aiding gNB to determine
	+ CSI reporting configuration and CSI-RS resource configuration parameters,
	+ Precoding scheme, using one of the CSI feedback based precoding schemes or an UL-SRS reciprocity based precoding scheme
* Aiding gNB-side CSI prediction

[109-e] **Agreement**For Rel-18 CSI enhancements, proceed to support and specify the following features (the previously agreed work scopes apply):* Type-II codebook refinement for CJT mTRP
* Type-II codebook refinement for high/medium UE velocities exploiting time-domain correlation/Doppler-domain information
* UE reporting of time-domain channel properties (TDCP) measured via CSI-RS for tracking
	+ The use case of aiding gNB-side CSI prediction is to be confirmed in RAN1#110

**Conclusion 1.A**: For the Rel-18 TRS-based TDCP reporting, there is no consensus in confirming the use case of aiding gNB-side CSI prediction.**FL Note**: Need to decide whether this use case is kept or not. This topic has been discussed OFFLINE [1] | **TDCP use case of “aiding gNB-side CSI prediction”*** **Confirm**: CATT, DOCOMO, Lenovo
* **Remove**: Huawei/HiSi, Ericsson, vivo

[Mavenir] Propose to add additional use cases:* Aiding gNB to determine
	+ whether to enable joint channel estimation for PUSCH/PUCCH or not and the time domain window size if applicable.

[Mod: Similar proposal was brought up in the last meeting but it was opposed by many. It is not within the scope of CSI agenda item 9.1.2]* + TDCP-aware (Doppler shift aware) LA

[Mod: It is not within the scope of CSI agenda item 9.1.2][Mod: Re use cases, we appreciate the proposals for new use cases. But the use cases have been finalized in the last meeting. Unless the group can agree on adding new use cases, we cannot go back and add new ones.] |
| 3.2 | [109-e] **Agreement**The work scope of TRS-based TDCP reporting includes down selection from the following TDCP parameters:* Alt1. Doppler shift
* Alt2. Doppler spread **(=max Doppler shift)**
* Alt3. Cross-correlation in time
* Alt4A. Relative Doppler shift of a number of peaks in CIR
* Alt4B. Relative Doppler shifts of different TRSs
* Alt5: CSI-RS resource and/or CSI reporting setting configuration assistance

**Proposal 3.B**: For the Rel-18 TRS-based TDCP reporting, down select one of the following alternatives by RAN1#110bis-e:* AltA. Based on Doppler profile
	+ E.g., Doppler spread derived from the 2nd moment of Doppler power spectrum, average Doppler shifts, Doppler shift per resource, maximum Doppler shift, relative Doppler shift, etc
* AltB. Based on time-domain correlation profile
	+ E.g. Correlation within one TRS resource, correlation across multiple TRS resources
	+ Note: The correlation over one or more lags of TRS resource may be considered. The lags may be within one TRS burst or different TRS bursts
* AltC: CSI-RS resource and/or CSI reporting setting configuration parameter(s) to assist network
	+ [Need some more descriptive wording]
 | **AltA:** IDC, Samsung, Spreadtrum, Mavenir, Google, OPPO, CATT, Xiaomi, LG, CEWiT, Apple, Sharp, DOCOMO, ZTE, Huawei/HiSi, vivo, CEWiT, Nokia/NSB**AltB:** vivo, OPPO, CEWiT, Ericsson**AltC:** MediaTek, Qualcomm |
|  |  |  |

Table 6 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Ericsson | Regarding AltC, we share similar understanding as vivo that gNB and UE may have implementation details. So what is recommended by UE may not be suitable for gNB. For example, consider the case the UE recommends a CSI report setting with type II CSI to the gNB. But if the gNB does not see an opportunity to do MU-MIMO scheduling, it may simply schedule with type I CSI. Also, one question for the proponents of AltC. Could you provide some high level description of this alternative? We assume this is still based on TRS measurements of some sort that trying to quantify how much the channel is changing? |
| MediaTek | **@Ericsson,** Thank you for the comments on poroposal 3.B, regarding AltC, as you pointed out there are implementation specific factors for each Ue which can impact the optimal choice of CSI/CSI-RS parameters for a given scenario, for example some UEs may be handle to higher doppler more gracefully than others or UEs can report CSI/CSI-Rs periodicity which can deliver the best power vs performance tradeoff, these UE implementation specific details are missing at the gNB side and hence can lead to same issue we are trying to fix by introducing the TDCP feature. As you pointed out, the CSI/CSI-RS parameters which UE reports back part of this TDCP has to carefully chosen to deliver meanginful configurations details. We don’t believe in this report UE needs to report back its perfernce for Type I/Type II codebook but rather information such as: CSI-RS/CSI periodicity preferences, reporting granularity, i.e., whether WB or SB PMI/CQI is needed, SB size when in SB reporting mode, rank restriction (based on the antenna correlation computed through TRS). |
| Mod V0 | 1. **Check and update your view in Table 5, especially on the moderator proposals**
	1. **Conclusion 3.A: @Huawei, Ericsson, vivo, OK confirming this use case or still proposing to remove?**
	2. **Proposal 3.B: @Proponents of AltC, please provide wording proposal for more description**
2. **Share additional inputs here if needed**
 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | R1-2206813 | Summary of OFFLINE discussion on Rel-18 MIMO CSI | Moderator (Samsung) |
| 2 | [R1-2205818](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205818.zip) | CSI Enhancements for CJT and High Doppler Operations | InterDigital, Inc. |
| 3 | [R1-2205881](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205881.zip) | CSI enhancement for coherent JT and mobility | Huawei, HiSilicon |
| 4 | [R1-2205920](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205920.zip) | CSI enhancement for high/medium UE velocities and CJT | ZTE |
| 5 | [R1-2205983](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205983.zip) | Discussion on CSI enhancement for high/medium UE velocities and coherent JT | Spreadtrum Communications |
| 6 | [R1-2206026](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206026.zip) | Discussion on CSI enhancement for high-medium UE velocities and coherent JT | vivo |
| 7 | [R1-2206101](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206101.zip) | Discussion on CSI enhancement | Mavenir |
| 8 | [R1-2206189](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206189.zip) | On CSI Enhancement | Google |
| 9 | [R1-2206211](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206211.zip) | Discussion of CSI enhancement for high speed UE and coherent JT | Lenovo |
| 10 | [R1-2206265](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206265.zip) | CSI enhancement for high/medium UE velocities and coherent JT | OPPO |
| 11 | [R1-2206377](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206377.zip) | On Rel-18 CSI enhancements for high/medium UE velocities and coherent JT | CATT |
| 12 | [R1-2206459](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206459.zip) | Discussion on CSI enhancement | NEC |
| 13 | [R1-2206572](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206572.zip) | On CSI enhancements | Intel Corporation |
| 14 | [R1-2206622](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206622.zip) | Discussion on CSI enhancements | Xiaomi |
| 15 | R1-2206812 | Moderator summary on Rel-18 CSI enhancements | Moderator (Samsung) |
| 16 | [R1-2206813](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206813.zip) | Summary of OFFLINE discussion on Rel-18 MIMO CSI | Moderator (Samsung) |
| 17 | [R1-2206814](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206814.zip) | Views on CSI enhancements | Samsung |
| 18 | [R1-2206868](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206868.zip) | Potential CSI enhancement for high/medium UE velocities and coherent JT | LG Electronics |
| 19 | [R1-2206896](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206896.zip) | Discussion on CSI enhancement for high/medium UE velocities and CJT | CMCC |
| 20 | [R1-2206974](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206974.zip) | CSI enhancements for medium UE velocities and coherent JT | Fraunhofer IIS, Fraunhofer HHI |
| 21 | [R1-2206992](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206992.zip) | CSI enhancement | MediaTek Inc. |
| 22 | [R1-2207066](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207066.zip) | Discussion on CSI Enhancements for high/medium UE velocities and coherent JT | CEWiT |
| 23 | [R1-2207217](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207217.zip) | CSI enhancements for high/medium UE velocities and Coherent-JT | Qualcomm Incorporated |
| 24 | [R1-2207322](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207322.zip) | Views on Rel-18 MIMO CSI enhancement | Apple |
| 25 | [R1-2207369](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207369.zip) | CSI Enhancements for CJT | AT&T |
| 26 | [R1-2207395](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207395.zip) | Discussion on CSI enhancement | NTT DOCOMO, INC. |
| 27 | [R1-2207452](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207452.zip) | CSI enhancement | Sharp |
| 28 | [R1-2207505](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207505.zip) | On CSI enhancements for Rel-18 NR MIMO evolution | Ericsson |
| 29 | [R1-2207546](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207546.zip) | CSI enhancement for high/medium UE velocities and CJT | Nokia, Nokia Shanghai Bell |
| 30 | [R1-2207603](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207603.zip) | Additional considerations on CSI enhancement for high/medium UE velocities and coherent JT (CJT) | Sony |
|  |  |  |  |
|  |  |  |  |