**3GPP TSG RAN WG1 #110bis-e R1-2209714**

**e-Meeting, October 10th – 19th, 2022**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary on Rel-18 CSI enhancements

**Document for:** Discussion and Decision

## Introduction

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

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

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

Table 1A Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.1 | [110] **Agreement**On the Type-II codebook refinement for CJT mTRP, down-select from the following TRP selection/determination schemes (where N is the number of cooperating TRPs assumed in PMI reporting) by RAN1#110bis-e:* Alt1. N is gNB-configured via higher-layer (RRC) signalling
	+ The N configured TRPs are gNB-configured via higher-layer (RRC) signalling
	+ Note: only one transmission hypothesis is reported
* Alt2. N is UE-selected and reported as a part of CSI report where N$\in ${1,..., NTRP}
	+ N is the number of cooperating TRPs, while NTRP is the maximum number of cooperating TRPs configured by gNB
	+ In this case, the selection of N out of NTRP TRPs is also reported (FFS: exact reporting scheme)
	+ FFS: Configuration of NTRP TRPs and the value of NTRP, whether explicit or implicit
	+ Note: only one transmission hypothesis is reported. UE is not mandated to calculate CSI for multiple transmission hypotheses.

FFS: Whether S-TRP transmission hypothesis is also reported**FL Note**: Companies have correctly pointed out that ***Alt2 (dynamic TRP selection by UE) can already be implemented in Alt1 using NZC selection (bitmap)* – hence there is no W2 overhead reduction from Alt2 compared to Alt1.**  | **Alt1**: Huawei/HiSi, Google, CMCC, MediaTek, Samsung, AT&T, DOCOMO, Nokia/NSB, **Alt2**: IDC, ZTE, Spreadtrum, vivo, Lenovo, OPPO, LG, CATT, Sony, NEC, Xiaomi, Apple, Ericsson, Qualcomm, CEWiT  |
| 1.2 | [110] **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:* Alt1. One group comprises one polarization across all TRPs/TRP-groups (*C*group,phase=1, *C*group,amp=2), one (common) SCI across all TRPs/TRP groups
* Alt2. One group comprises one polarization for one TRP/TRP-group (*C*group,phase=N, *C*group,amp=2N), per-TRP/TRP-group SCI
	+ FFS: Quantization of N strongest coefficients
* Alt3. One group comprises one polarization for one TRP/TRP-group with a common phase reference across TRPs/TRP-groups (*C*group,phase=1, *C*group,amp=2N)
	+ FFS: SCI, per-TRP/TRP-group vs. one (common) SCI across all TRPs/TRP groups
	+ FFS: Quantization of N strongest coefficients
* Alt4. For a selected TRP/TRP-group, one group comprises one polarization, and for remaining N-1 TRPs/TRP-groups, one group comprises one polarization across remaining N-1 TRPs/TRP-groups (*C*group,amp=2+2=4), with a common phase reference across all of N TRPs/TRP-groups (*C*group,phase=1)
	+ FFS: The selected TRP/TRP-group

FFS: The need for “strongest” TRP/TRP-group indicator in addition to SCI(s)**Proposal 1.B**: On the Type-II codebook refinement for CJT mTRP, regarding W2 quantization group and Strongest Coefficient Indicator (SCI) design, for each layer, further down-select one from the following alternatives by RAN1#110bis-e:* Alt1. One group comprises one polarization across all TRPs/TRP-groups (*C*group,phase=1, *C*group,amp=2), one (common) SCI across all N CSI-RS resources
* Alt3. One group comprises one polarization for one TRP/TRP-group with a common phase reference across TRPs/TRP-groups (*C*group,phase=1, *C*group,amp=2N), one (common) SCI across all N CSI-RS resources

FFS: The need for “strongest” TRP/TRP-group indicator in addition to the SCI**FL Note**: Out of the 4 candidates, 2 candidates are supported by most companies. It is proposed to better focus our difficult discussion by comparing the 2 most supported candidates. The need for strongest TRP indicator (issue 1.3) will be decided after this is finalized. | **Alt1:** IDC, vivo, MediaTek, Fraunhofer IIS/HHI, Apple, Samsung (2nd pref), DOCOMO (mode-2)**Alt2:** ZTE, LG, CATT, DOCOMO (mode-1)**Alt3:** * **1 SCI**: Huawei/HiSi, Ericsson, Lenovo, Intel, Xiaomi, NEC, CMCC, AT&T, Qualcomm, Nokia/NSB,
* **N SCIs**: ZTE, Spreadtrum, LG

**Alt4:** Samsung, AT&T |
| 1.3 | **Question**: Is “strongest CSI-RS resource indicator” needed given your preference on issue 1.2 (please also state your preference on issue 1.2)?   | **The need for “strongest CSI-RS resource indicator (along with preference on issue 1.2):*** **Yes:** ZTE, LG, CATT, Samsung, NEC, Xiaomi, CMCC
* **No:** Huawei/HiSi, Ericsson, Nokia/NSB,
 |
| 1.4 | **Proposal 1.D**: On the Type-II codebook refinement for CJT mTRP, following legacy (Rel-16 regular eType-II and Rel-17 PS FeType-II), for a given CSI-RS resource:* SD basis selection is layer-common and polarization-common, with *L*, *N*1, *N*2, *O*1, *O*2 defined per Rel-16 specification for refinement based on Rel-16 regular eType-II, and per Rel-17 specification for refinement based on Rel-17 PS FeType-II
* FD basis selection is
	+ For refinement based on Rel-16 regular eType-II: per-layer with *M*v, *p*v, *N*3, and *R* defined per Rel-16 specification
	+ For refinement based on Rel-17 PS FeType-II: layer-common with *M*, *N*3, and *R* defined per Rel-17 specification
	+ FFS: Details on FD basis selection window

Note: The supported value(s) for each of the defined parameters are to be discussed separately (e.g. possibilities of adding new or removing existing value(s) in addition to those supported by legacy specification).**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 1.1 | **Support/fine:** ZTE, Ericsson, MediaTek, vivo, Qualcomm, DOCOMO, Apple, Google, LG, OPPO, Xiaomi, Intel, Spreadtrum, NEC, Fraunhofer IIS/HHI, Lenovo, Sharp, Samsung, IDC, Sony, CMCC, AT&T, Nokia/NSB**Not support:** |
| 1.5 | **Proposal 1.E**: On the SD basis selection for Type-II codebook refinement for CJT mTRP, following legacy (Rel-16 regular eType-II and Rel-17 PS FeType-II), SD basis selection is per CSI-RS-resource. * Down select from the following alternatives (RAN1#110bis-e):
	+ Alt1. Per-CSI-RS-resource *Ln* parameter
		- TBD: Whether {*Ln*, *n*=1, ..., *N*} are higher-layer configured by gNB, or the total $\sum\_{n=1}^{N}L\_{n}$ is higher-layer configured by gNB while {*Ln*, *n*=1, ..., *N*} are reported by the UE
	+ Alt2. Common *L* parameter for all *N* CSI-RS resources

**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 1.2 | **Support/fine:** ZTE, Ericsson, Samsung, MediaTek, vivo, DOCOMO, LG, OPPO, Huawei/HiSi, Intel, Spreadtrum, Apple, NEC, Fraunhofer IIS/HHI, Lenovo, Sharp, Xiaomi, IDC, Sony, vivo, Google, Intel, NEC, Apple, CMCC, AT&T, Nokia/NSB **Not support:** |
| 1.6 | **Proposal 1.F**: On the Type-II codebook refinement for CJT mTRP, following legacy (Rel-16 regular eType-II and Rel-17 PS FeType-II), regarding the location of non-zero coefficients (NZCs) indicated by bitmap (following legacy mechanism), for each layer, support separate bitmaps for all *N* CSI-RS resources * Total size = $\sum\_{n=1}^{N}B\_{n}$ where $B\_{n}$ is the bitmap size for CSI-RS resource *n*
	+ TBD: Whether $B\_{n}=2L\_{n}M\_{v,n}$ ($M\_{v,n}=M\_{v}$ for mode 2) analogous to legacy, or further reduction of bitmap size is supported.
	+ FFS: Depending on the outcome of other issues, whether $M\_{v,n}=M\_{v}$ or $L\_{n}=L$
* FFS: Per-CSI-RS-resource NNZC (number of NZCs) constraint vs. joint NNZC constraint across *N* CSI-RS-resources

**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 1.3 | **Support/fine:** ZTE, Ericsson, MediaTek, Samsung, vivo, Qualcomm, DOCOMO, Apple, Google, LG, OPPO, Huawei/HiSi, Xiaomi, Intel, Spreadtrum, NEC, CATT, Fraunhofer IIS/HHI, IDC, Lenovo, Sharp, IDC, Sony, CMCC, AT&T, Nokia/NSB**Not support:** |
| 1.7 | Constraint on the (maximum) number of NZCs (K0) **for each layer**:* Alt1. K0 is defined per-CSI-RS-resource
* Alt2. K0 is defined jointly across all N CSI-RS resources
 | **Alt1 (per resource):** **Alt2 (joint):** vivo, Intel, Samsung, MediaTek, Fraunhofer IIS/HHI, Qualcomm  |
| 1.8 | **Proposal 1.H**: For the Rel-18 Type-II codebook refinement for CJT mTRP, * Only aperiodic CSI reporting is supported (following legacy Rel-16 and Rel-17 spec)
* An associated Resource Setting includes a CMR comprising *K*>1 NZP CSI-RS resources from one CSI-RS resource set
	+ Periodic, semi-persistent, and aperiodic NZP CSI-RS are supported
	+ The supported CSI-RS resource parameter settings follow the legacy specification (without additional enhancement)
	+ FFS: Whether or not the K NZP CSI-RS resources are constrained to be in the same slot

**FL Note**: This basically follows the legacy spec re Type-II codebook (only A-CSI is supported) and reuses the legacy CSI-RS.The use of K>1 NZP CSI-RS resources has been agreed in RAN1#110 | **Support/fine:** Google, LG, **Not support:**  |
| 1.9 | [110] **Agreement**For the Rel-18 Type-II codebook for CJT mTRP, support the following two modes:* Mode 1: Per-TRP/TRP-group SD/FD basis selection which allows independent FD basis selection across N TRPs / TRP groups. Example formulation (*N* = number of TRPs or TRP groups):

$$\left[\begin{matrix}W\_{1,1}\tilde{W}\_{2,1}W\_{f,1}^{H}\\\vdots \\W\_{1,N}\tilde{W}\_{2,N}W\_{f,N}^{H}\end{matrix}\right]$$* Mode 2: Per-TRP/TRP group (port-group or resource) SD basis selection and joint/common (across *N* TRPs) FD basis selection. Example formulation (*N* = number of TRPs or TRP groups):

$$\left[\begin{matrix}W\_{1,1}\tilde{W}\_{2,1}W\_{f}^{H}\\\vdots \\W\_{1,N}\tilde{W}\_{2,N}W\_{f}^{H}\end{matrix}\right]$$* Striving for the two modes to share commonality in detailed designs such as parameter combinations, basis selection, TRP (group) selection, reference amplitude, W2 quantization schemes.
* FFS: Depending on the decision on SCI design, whether additional per-TRP/TRP-group amplitude scaling and/or co-phase is needed or not, and whether they are a part of W2s

[109-e] **Agreement**For the Type-II codebook refinement for CJT mTRP, further study the following issues:* The need for the following additional parameters:
	+ …
	+ Indication of relative offset of reference FD basis per TRP with respect to a reference TRP
	+ …

Some companies suggest to use per-CSI-RS-resource FD basis offset (relative to a reference CSI-RS resource) for “per-TRP/TRP-group” FD basis selection in mode 1. | **Per-CSI-RS-resource FD basis offset (relative to a reference CSI-RS resource) for “per-TRP/TRP-group” FD basis selection in mode-1:*** **Support/fine**: Huawei/HiSi, ZTE, Xiaomi, Ericsson, Samsung, Fraunhofer IIS/HHI, [Qualcomm], Nokia/NSB
* **Not support**:

**For mode-1, the number of FD basis vectors (Mv relared to pv for Rel-16, M for Rel-17) is:*** **TRP-common**: Huawei/HiSi, Samsung
* **TRP-specific**:

**Switching between mode-1 and mode-2 is gNB-configured via higher-layer signalling:*** **Support/fine**: Xiaomi, Samsung
* **Not support**:
 |
| 1.10 | The need for new UCI/PMI-related parameters:[109-e] **Agreement**For the Type-II codebook refinement for CJT mTRP, further study the following issues:* The need for the following additional parameters:
	+ Receiver side information by per RX reporting or per layer, e.g. information related to the left singular matrix U of the channel
	+ …
	+ Information related to the windows for FD basis
	+ Delay/frequency difference(s) across TRPs

… | **RX side info:** Huawei/HiSi, ZTE, Sony**FD basis window info:** ZTE, Xiaomi, LG**Per-TRP delay/frequency offset:** Fraunhofer IIS/HHI (N-1 relative delay offsets), Ericsson (in a phase form) |
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Table 1B Type II CJT: summary of observation from SLS

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| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
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| **Summary**:  |

Table 2 Additional inputs: issue 1

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Check and, if needed, update your view in Table 1A especially on the moderator proposals**
2. **Share additional inputs here, if needed**
3. **More moderator proposals may be added in the next revision**
 |
| vivo | **Issue 1.1**Based on our evaluation in R1-2208628, the overhead saving from Alt 2 can be up to 40% due to the reduction of reporting SD basis, FD basis, coefficients and bitmap associated with the reduced CMR. Further, UE complexity can also be reduced due to UE does not have to further store the temporary CSI values in their buffer. Hence we support Alt 2.We think Alt 1 and Alt 2 can be configured by gNB, which is same as NCJT CSI in Rel-17. gNB can configure a minimum N value to be selected by UE to achieve this.**Proposal 1.B**We support Alt 1.* We do not observed clear gain from other Alts in our evaluation in R1-2208628.
* Alt 1 has the smallest overhead.

**Issue 1.3**No need for strongest CSI-RS resource indicator. |
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### Issue 2: Type-II codebook refinement for high/medium UE velocities (with time/Doppler-domain compression)

Table 3A Summary: issue 2

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

FFS: Whether to prioritize/down-select from the two**Proposal 2.A**: The Rel-18 Type-II codebook refinement for high/medium velocities comprises refinement of the following codebooks:* Refinement of the Rel-16 eType-II regular codebook
* Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the same design details as the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations
	+ Time-/Doppler-domain reciprocity is not assumed

**FL Note**: This proposal has been discussed in RAN1#110  | **Support (equal priority for) both Rel-16 eType-II and Rel-17 FeType-II:** Huawei/HiSi, ZTE (Rel-16 first), Fraunhofer IIS/HHI**Down-select to only Rel-16 eType-II:** Apple, DOCOMO, MediaTek, NEC, Xiaomi, Samsung, Lenovo, Intel (if Rel-17, no DD reciprocity), Xiaomi. Qualcomm, Apple, DOCOMO, Ericsson, Nokia/NSB, LG, Spreadtrum, CMCC**Proposal 2.A:*** **Support/fine:**
* **Not support (Rel-16 only):**
 |
| 2.2 | Supported RI values**Proposal 2.B**: For the Rel-18 Type-II codebook refinement for high/medium velocities, support RI={1,2,3,4}. | **Support/fine:** Xiaomi, Fraunhofer IIS/HHI, Apple, Samsung, **Not support (1,2 first – 3,4 FFS):** Lenovo, Intel  |
| 2.3 | **Proposal 2.C**: For the Rel-18 Type-II codebook refinement for high/medium velocities, down-select at least one from the following codebooks structures (by RAN1#110bis-e):* Alt1: Doppler-domain orthogonal DFT basis commonly selected for all SD/FD bases reusing the legacy$W\_{1}$and$W\_{f}$*,* e.g.$W\_{1}\tilde{W}\_{2}\left(W\_{f}⨂W\_{d}\right)^{H}$
	+ TBD (by RAN1#110bis): whether rotation is used or not
	+ FFS: identical or different rotation factors for different SD components
* Alt3. Doppler-domain basis is the identity (no Doppler-domain compression) reusing the legacy$W\_{1}$*,* $\tilde{W}\_{2}$*,* and$W\_{f}$*, e.g.* $W\_{1}\tilde{W}\_{2}(W\_{f}⨂I)^{H}$

In addition:* Note: Detailed designs for SD/FD bases including the associated UCI parameters follow the legacy specification
* FFS: Whether one CSI reporting instance includes multiple $W\_{2}$ and a single $W\_{1}$ and $W\_{f}$ report.
* FFS: Whether Doppler-/time-domain (DD/TD) basis vector length (N4) is RRC-configured or reported by the UE
* FFS: Whether the number of selected DD/TD basis vectors (for Alt1) is RRC-configured or reported by the UE

**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 2.1 | **Support/fine:** Samsung, ZTE, MediaTek, vivo, Qualcomm, Apple, LG, OPPO, Huawei/HiSi, Xiaomi, Intel, Spreadtrum, DOCOMO, NEC, Fraunhofer IIS/HHI, Lenovo, Sharp, Ericsson, Google, MediaTek, vivo, CATT, IDC, Sony, CMCC, Nokia/NSB, CEWiT **Not support:** |
| 2.4 | **Proposal 2.D**: For the Rel-18 Type-II codebook refinement for high/medium velocities, support the following codebook structure where N4 is gNB-configured via higher-layer signaling:* For N4=[1], Doppler-domain basis is the identity (no Doppler-domain compression) reusing the legacy$W\_{1}$*,* $\tilde{W}\_{2}$*,* and$W\_{f}$*, e.g.* $W\_{1}\tilde{W}\_{2}(W\_{f}⨂I)^{H}$
* For N4>[1], Doppler-domain orthogonal DFT basis commonly selected for all SD/FD bases reusing the legacy$W\_{1}$and$W\_{f}$*,* e.g.$W\_{1}\tilde{W}\_{2}\left(W\_{f}⨂W\_{d}\right)^{H}$
	+ TBD (by RAN1#110bis): whether rotation is used or not
	+ FFS: identical or different rotation factors for different SD components
	+ FFS: Whether the number of selected DD/TD basis vectors (denoted as *Q* at least for discussion purposes)) is RRC-configured or reported by the UE

Note: Detailed designs for SD/FD bases including the associated UCI parameters follow the legacy specificationFFS: Whether one CSI reporting instance includes multiple $W\_{2}$ and a single $W\_{1}$ and $W\_{f}$ report.**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 2.2 | **Proposal 1.D:*** **Support/fine:** Samsung, ZTE, Ericsson, Qualcomm, Apple, Google, OPPO, Huawei/HiSi, Intel, Spreadtrum, CATT, DOCOMO, NEC, [Fraunhofer IIS/HHI], Sharp, IDC, vivo, Sony, MediaTek, Nokia/NSB, CEWiT
* **Not support:**

**Rotation factor for DFT basis:*** **No:** Huawei/HiSi, Xiaomi, Ericsson, Qualcomm
* **Yes (details FFS):** Fraunhofer IIS/HHI, ZTE, Samsung
 |
| 2.5 | **Proposal 2.E**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, when UE-side prediction is assumed, support UE “predicting” channel/CSI after the slot with a reference resource (*l* ≥ *n*ref) where the location of CSI reference resource is configured (from multiple candidate values) by gNB via higher-layer signalling* Candidates of CSI reference resource location include the legacy slot location (*n* – *nCSI,ref* ) and slot *n*
* FFS: Possible value(s) of WCSI

**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 2.3 | **Support/fine:** Samsung, vivo, Qualcomm, DOCOMO, Lenovo, IDC, ZTE, Spreadtrum, vivo, [LG], CATT, Intel, NEC, Xiaomi, CMCC, MediaTek, [Ericsson], [Nokia/NSB] **Not support:** Fraunhofer IIS/HHI (only legacy slot) |
| 2.6 | **Question**: In addition to the already agreed assumption of UE-side prediction, can the Rel-18 Type-II codebook refinement for high/medium velocities be used with the following assumption?1. Legacy UE procedure for CSI measurement/calculation (the only spec impact would be to enable this as an option for CSI measurement/calculation. If proposal 2.E is agreed, the answer to this question is “yes” at least for W\_CSI=1)
2. gNB-side prediction (to be incorporated in the spec, assumed by the UE in CSI measurement/calculation)

**FL Note**: This proposal has been discussed in RAN1#110.  | **Legacy:*** **Yes:**
* **No:**

**gNB-side prediction (to be specified, assumed by the UE in CSI measurement/calculation):** * **Yes**: Google, CATT, Xiaomi,
* **No**: Samsung
 |
| 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)**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 NZP CSI-RS resource: periodic, semi-persistent, aperiodic
* The use of K≥1 NZP CSI-RS resources:
	+ FFS: details

[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**FL Note**: This proposal has been discussed in RAN1#110 | **Proposal 2.G:*** **Support:** Google, Samsung, Nokia/NSB, Lenovo, DOCOMO, MediaTek, Qualcomm, LG, Spreadtrum, ZTE, Xiaomi, NEC, OPPO, CATT, CMCC, Sharp, Apple, Huawei/HiSi, Fraunhofer IIS/HHI
* **Not support:** vivo (concern on AP)
 |
| 2.8 | **Proposal 2.H**: For the Type-II codebook refinement for high/medium velocities, only aperiodic CSI reporting is supported (following legacy Rel-16 and Rel-17 spec)**FL Note**: This basically follows the legacy Rel-16/17 spec re Type-II codebook and reuses the legacy CSI-RS | **Support/fine:****Not support:**  |
| 2.9 | **Proposal 2.I:** For the Type-II codebook refinement for high/medium velocities, the per-layer 2-dimensional bitmap for indicating the location of NZCs used in Rel-16/17 Type-II is extended to a per-layer 3-dimensional bitmap* The third dimension is associated with the number of selected DD basis vectors (denoted as *Q* at least for discussion purposes)
 | **Support/fine:****Not support:** |
| 2.10 | DD basis selection:* Alt1. Per layer,
	+ The number of selected DD basis vector (denoted as *Q*) is layer-common
* Alt2. Layer-common

**FL Note**: The above alternatives are analogous to legacy principle for SD/FD compression.  | **Alt1:** Intel**Alt2:** |
| 2.11 | For one CSI reporting instance associated with the Type-II codebook refinement for high/medium velocities, for a given CQI sub-band and a given layer, how many CQIs (sampled across time-/Doppler-domain) are included?  | **Only 1:** Google, Qualcomm**≥1 (configurable):** ZTE, NEC, Samsung, Ericsson, Nokia/NSB, Huawei/HiSi |
| 2.12 | [110] **Agreement**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
 | **PMI only:** Huawei/HiSi, ZTE, MediaTek, **PMI and CQI (common vs independent FFS):** Samsung |
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Table 3B Type II Doppler: summary of observation from SLS

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| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
|  |  |  |  |
|  |  |  |  |
| **Summary**:  |

Table 4 Additional inputs: issue 2

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| --- | --- |
| **Company** | **Input** |
| 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**
3. **More moderator proposals may be added in the next revision**
 |
| vivo | **Proposal 2.A**We don’t agree to further span the scope of 9.1.2 after we have already done so in last meeting. We support to only enhance Rel-16 eType II CSI. We have serious concern to include the work on Rel-17 FeType II CSI due to the workload.**Proposal 2.D**We think the intention of this proposal is to support Alt 3 and Alt 1 based on the configured N4 value. For N4 < the switching point, at least N4 =1 is supported. The detailed value of the switch point can be further studied, for which we propose N4=4. Hence we think a more accurate formulation of the current status is the following.**Proposal 2.D**: For the Rel-18 Type-II codebook refinement for high/medium velocities, support the following codebook structure where N4 is gNB-configured via higher-layer signaling:* For N4<= N0, Doppler-domain basis is the identity (no Doppler-domain compression) reusing the legacy$W\_{1}$*,* $\tilde{W}\_{2}$*,* and$W\_{f}$*, e.g.* $W\_{1}\tilde{W}\_{2}(W\_{f}⨂I)^{H}$
	+ At least N4=1 is supported
* For N4> N0, Doppler-domain orthogonal DFT basis commonly selected for all SD/FD bases reusing the legacy$W\_{1}$and$W\_{f}$*,* e.g.$W\_{1}\tilde{W}\_{2}\left(W\_{f}⨂W\_{d}\right)^{H}$
	+ TBD (by RAN1#110bis): whether rotation is used or not
	+ FFS: identical or different rotation factors for different SD components
	+ FFS: Whether the number of selected DD/TD basis vectors (denoted as *Q* at least for discussion purposes)) is RRC-configured or reported by the UE
* For the switch point N0, support one of the following
	+ Opt 1: N0 = 4
	+ …

Note: Detailed designs for SD/FD bases including the associated UCI parameters follow the legacy specificationFFS: Whether one CSI reporting instance includes multiple $W\_{2}$ and a single $W\_{1}$ and $W\_{f}$ report.**Proposal 2.E**Regarding the reference of CSI reporting window in case UE-side prediction is assumed, **it has been agreed in RAN1#109e that it is a length-WCSI window starting from slot l, i.e., it is a window of [*l*, *l*+*W*CSI –1]**. Two alternatives are suggested down selecting in RAN1#110, i.e.,* Alt 1B: **l ≥ n\_ref**, where n\_ref is a CSI reference resource slot as boundary
* Alt 2B: **l ≥ n**, where n is the CSI reporting slot as boundary

It is clear that from the previous agreements, the start of the CSI reporting window is l, and l >= n is defined for Alt 2B. Hence it is clear that Alt 2B includes the case that the start of the CSI reporting window is after slot n. Further, to support the case with N4=1, it only makes sense for UE prediction to have l>n, as gNB needs to know the CSI after the CSI report reception. Hence we suggest the following change.**Proposal 2.E**: On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, when UE-side prediction is assumed, support UE “predicting” channel/CSI after the slot with a reference resource (*l* ≥ *n*ref) where the location of CSI reference resource is configured (from multiple candidate values) by gNB via higher-layer signalling* Candidates of CSI reference resource location include the legacy slot location (*n* – *nCSI,ref* ) and slot *n+ndelta,* where *ndelta* is configured from thenumbers {0, 2, 4}
* FFS: Possible value(s) of WCSI

**Issue 2.6**We don’t support gNB side prediction. **Proposal 2.G**We still have concern on the supporting AP CSI-RS, due to the following reasons* It introduces large latency for CSI reporting due to triggering a number of CSI-RS occasions after sending the CSI triggering DCI.
* The large CSI latency requires gNB to schedule PUSCH with long duration between DCI and PUSCH. It will forbid gNB to schedule any other PUSCH for this UE due to out of order (OOO) issue during this long duration, which will reduce UL throughput.
* Last but not least, to support AP CSI-RS, RS enhancement is needed as the current specification does not support to use one DCI to trigger AP CSI-RS spanning more than 1 slot. However, RS enhancement is not included in the WID.

Hence we support to have only P/SP CSI-RS with one resource in this proposal.**Issue 2.11**We support only one CQI, which means W\_CSI is 1 or N4 TD units in this case. |
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### Issue 3: TRS-based reporting of time-domain channel properties (TDCP)

Table 5A Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | [110] **Agreement**For the Rel-18 TRS-based TDCP reporting, down select one of the following alternatives by RAN1#110bis-e:* AltA. Based on Doppler profile
	+ E.g., Doppler spread derived from the 2nd moment of Doppler power spectrum, average Doppler shifts, Doppler shift per resource, maximum Doppler shift, relative Doppler shift, etc
* AltB. Based on 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
	+ E.g. gNB configures UE with multiple choices on what to assist (e.g. two or more CSI-RS/report periodicities, or precoding schemes depending mainly on UE velocity), then UE report according to configuration; parameters correspond to CSI reporting periodicity, codebook type, etc.

Note: Different alternatives may or may not apply to different use cases**Proposal 3.A**: For the Rel-18 TRS-based TDCP reporting, down select one of the following alternatives by RAN1#110bis-e:* AltA. Based on Doppler profile
	+ E.g., Doppler spread derived from the 2nd moment of Doppler power spectrum, average Doppler shifts, Doppler shift per resource, maximum Doppler shift, relative Doppler shift, etc
* AltB. Based on *quantized amplitude of* time-domain correlation profile
	+ E.g. Correlation within one TRS resource, correlation across multiple TRS resources
	+ Note: The correlation over one or more lags of TRS resource may be considered. The lags may be within one TRS burst or different TRS bursts

Note: Different alternatives may or may not apply to different use cases**FL Note**: This issue/proposal has been discussed OFFLINE [1] as offline proposal 3.1This is the current situation. * AltA: Samsung (2nd pref), ZTE, vivo, Google, LG, OPPO, Huawei/HiSi, Xiaomi, Fraunhofer IIS/HHI, Mavenir, Apple (1st pref), CATT, IDC, Spreadtrum, NEC (2nd pref), Nokia/NSB
* AltB: Samsung (1st pref), Ericsson, MediaTek, vivo, Qualcomm, DOCOMO, LG, OPPO, Sharp, Lenovo, Apple (2nd pref), IDC, NEC (1st pref), CEWiT
 | **Proposal 3.A:*** **Support/fine**: Samsung, ZTE, vivo, Google, LG, OPPO, Huawei/HiSi, Xiaomi, Fraunhofer IIS/HHI, Mavenir, Apple, CATT, Ericsson, MediaTek, vivo, Qualcomm, DOCOMO, OPPO, Sharp, Lenovo, Sony, Nokia/NSB
* **Not support**:
 |
| 3.2 | Whether the following time-domain behaviour of TDCP reporting is supported:* Periodic
* Semi-persistent
* Event-triggered (UE-initiated)

Note: Aperiodic TDCP reporting has been agreed in RAN1#110**FL Note**: This can be decided after 3.1 is finalized. | **Periodic:*** **Yes:**
* **No:** Spreadtrum, Samsung, MediaTek

**Semi-persistent:*** **Yes:** Lenovo,
* **No:** Spreadtrum, Samsung, MediaTek

**Event-triggered/UE-initiated via UL MAC CE:*** **Yes:** Samsung, MediaTek
* **No:**
 |
| 3.3 | Whether using >1 TRS resources for TDCP measurement is supported in addition to only 1 TRS resource**FL Note**: This can be decided after 3.1 is finalized. | **Yes:** **No:**  |
|  |  |  |

Table 5B TDCP: summary of observation from LLS/SLS

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| --- | --- |
| **Company** | **LLS/SLS results** |
| **Issue #** | **Metric** | **Observation** |
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| **Summary**:  |

Table 6 Additional inputs: issue 3

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 5A, especially on the moderator proposals**
2. **Share additional inputs here if needed**
3. **More moderator proposals may be added in the next revision**
 |
| vivo | **Issue 3.2**We would like to check companies’ view on the following issue for P/SP reporting.Since maximum lags between four TRS resources in two consecutive slots is 14 symbols (or say 1 slot) and the values of correlation are [1, 0.97, 0.90] respectively corresponding to [3km, 30km, 60km], UE would not identify the minor difference taking noise and interference into account in practical algorithm unless AP TRS is triggered to compensate lacked occasions of P TRS. Hence it means to make the TDCP use case work, gNB has to trigger AP TRS to assist P TRS for this TDCP reporting. We are wondering how this works for periodic or semi-persistent CSI reporting as P or SP CSI report cannot be associated with aperiodic RS.Correlation vs maximum doppler shift |
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# References

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| --- | --- | --- | --- |
| 1 | R1-2209715 | Summary of OFFLINE discussion on Rel-18 MIMO CSI | Moderator (Samsung) |
| 2 | R1-2208441 | CSI enhancement for coherent JT and mobility | Huawei, HiSilicon |
| 3 | R1-2208495 | Enhanced CSI for CJT and High Doppler Operations | InterDigital, Inc. |
| 4 | R1-2208504 | CSI enhancement for high/medium UE velocities and CJT | ZTE |
| 5 | R1-2208541 | Discussion on CSI enhancement for high/medium UE velocities and coherent JT | Spreadtrum Communications |
| 6 | R1-2208628 | Discussion on CSI enhancement for high-medium UE velocities and coherent JT | vivo |
| 7 | R1-2208742 | Discussion of CSI enhancement for high speed UE and coherent JT | Lenovo |
| 8 | R1-2208794 | CSI enhancement for high/medium UE velocities and coherent JT | OPPO |
| 9 | R1-2208872 | On CSI Enhancement | Google |
| 10 | R1-2208893 | Potential CSI enhancement for high/medium UE velocities and coherent JT | LG Electronics |
| 11 | R1-2208947 | Discussion on CSI enhancements | CATT |
| 12 | R1-2209041 | On CSI enhancements | Intel Corporation |
| 13 | R1-2209090 | Further considerations on CSI enhancement for high/medium UE velocities and CJT | Sony |
| 14 | R1-2209140 | Discussion on CSI enhancement | NEC |
| 15 | R1-2209247 | Discussion on CSI enhancement | Mavenir |
| 16 | R1-2209258 | Discussion on CSI enhancement for high/medium UE velocities and CJT | xiaomi |
| 17 | R1-2209322 | Discussion on CSI enhancement for high/medium UE velocities and CJT | CMCC |
| 18 | R1-2209381 | CSI enhancement | Sharp |
| 19 | R1-2209494 | CSI enhancement | MediaTek Inc. |
| 20 | R1-2209545 | CSI enhancements for medium UE velocities and coherent JT | Fraunhofer IIS, Fraunhofer HHI |
| 21 | R1-2209570 | Views on Rel-18 MIMO CSI enhancement | Apple |
| 22 | R1-2209716 | Views on CSI enhancements | Samsung |
| 23 | R1-2209793 | Views on CSI Enhancements for CJT | AT&T |
| 24 | R1-2209852 | On CSI enhancements for Rel-18 NR MIMO evolution | Ericsson |
| 25 | R1-2209890 | Discussion on CSI enhancement | NTT DOCOMO, INC. |
| 26 | R1-2209969 | CSI enhancements for high/medium UE velocities and Coherent-JT | Qualcomm Incorporated |
| 27 | R1-2210063 | CSI enhancement for high/medium UE velocities and CJT | Nokia, Nokia Shanghai Bell |
| 28 | R1-2210105 | Discussion on CSI Enhancements for high/medium UE velocities and coherent JT | CEWiT |
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