**3GPP TSG RAN WG1 #109-e R1-2205423**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#4 on Rel-18 CSI enhancements: ROUND 4

**Document for:** Discussion and Decision

## Introduction

The scope given in the Rel-18 NR Evolved MIMO WID [1] 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** |
| 1.3 | Work scope: Rel-16/17 Type-II codebook/PMI components to be refined or reused for CJT extension1. SD and FD basis vector designs (not precluding adding new values of N1, N2, N3)
2. SD and FD basis selection schemes (not precluding per-TRP or joint-across-TRPs selection, this refers to, e.g. the combinatorial indication and two-step FD basis selection)
3. W2 coefficient quantization scheme
4. Non-zero coefficient selection and indication schemes
5. Strongest coefficient indication scheme
6. Supported parameter combinations (keeping same set of parameters, whether the legacy values are fully reused or possibly refined for, e.g. further overhead reduction) and parameter values (including, e.g. R, K0)
7. Per layer feedback

**FL Note**: Considering work scope and continuity with legacy design (some already being deployed), we should strive for maximum reuse of legacy designs. Although one may claim that evaluation is needed to ensure whether reusing as such results in desirable performance, the above parameters are primarily “format” issue. | **1 (SD/FD basis design):*** **Fully reuse legacy:** Huawei/HiSi (for R17), Lenovo, Samsung, Apple, DOCOMO, NEC, vivo, CMCC, Nokia/NSB, IDC, Fraunhofer IIS/Fraunhofer HHI, Intel, MTK, CATT, ZTE, CEWiT, IITK, Ericsson, Qualcomm, Xiaomi, AT&T, Sony
* **Refinement:** Huawei/HiSi (Joint SD-FD eigen-vector basis for R16)

**2 (SD/FD basis selection scheme):*** **Fully reuse legacy:** Samsung, Nokia/NSB, Apple, NEC, vivo, CMCC, IDC, ZTE, CEWiT, IITK, Ericsson, Xiaomi, AT&T, Sony
* **Refinement:** vivo (per TRP SD basis selection)

**3 (W2 quantization):*** **Fully reuse legacy:** Samsung, Apple, vivo, CMCC, Nokia/NSB (re. co-scaling, both reference amplitudes may need reporting for TRPs other than the strongest), Intel (same as Nokia), CATT, ZTE, CEWiT, IITK, Ericsson, AT&T
* **Refinement:** Xiaomi (TRP specific phase and amplitude)

**4 (NZC):*** **Fully reuse legacy:**
* **Refinement:** Huawei/HiSi (joint across TRPs), Lenovo, vivo (joint across selected TRPs), CMCC, CATT, ZTE (further study the bitmap is for each TRP or N TRPs, the maximal number of non-zero coefficients may be per TRP per layer), Spreadtrum, AT&T

**5 (SCI):*** **Fully reuse legacy:**
* **Refinement:** Huawei/HiSi (joint across TRPs), Samsung (strongest TRP), Nokia/NSB (FD basis ref), ZTE (FD basis ref), NEC (we also support strongest TRP indication), vivo (joint across TRPs), CMCC, IDC, CEWiT, Spreadtrum, IITK, Ericsson, Xiaomi (reference TRP), AT&T, Sony

**6 (Parameter combination):*** **Fully reuse legacy:**
* **Refinement:** Samsung, ZTE, Huawei/HiSi (R values), Lenovo,NEC (we also support R values), vivo (need evaluation), CMCC, Nokia/NSB, IDC, Fraunhofer IIS/Fraunhofer HHI, MTK, CATT, Ericsson, AT&T

**7 (Per layer feedback):*** **Fully reuse legacy:** Samsung, DOCOMO, vivo, CMCC, Nokia/NSB, Fraunhofer IIS/Fraunhofer HHI, CEWiT, IITK, Ericsson, Xiaomi, AT&T
* **Refinement:** Huawei/HiSi (receiver side information by per-RX feedback), ZTE
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**Proposal 1.E.1**: On the Type-II codebook refinement for CJT mTRP, the resulting codebook(s) are associated with *at least* the following parameters:

* + Parameters for basis reporting, including
		- The number of basis vectors: gNB-configured via higher-layer signaling
			* FFS: Whether it is layer-common or layer-specific, whether it is per TRP/TRP-group or common for all TRPs
		- Basis selection indicator(s): a part of CSI report
			* FFS: Whether it is layer-common or layer-specific, whether it is per TRP/TRP-group or common for all TRPs
	+ Quantized combining coefficients (W2): a part of CSI report
		- FFS: details of quantization scheme
	+ Number of non-zero coefficients and bitmap to indicate non-zero coefficients, including whether it is per TRP/TRP-group (separate) or across all TRPs/TRP-groups (joint): a part of CSI report
	+ Strongest coefficient indicator(s) (SCI(s)): a part of CSI report
		- FFS: One per TRP/TRP-group or common for all TRPs
		- FFS: Additional need for strongest TRP indicator

**Proposal 1.E.2**: 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
	+ For codebooks with per-TRP SD and joint FD basis (structure Alt2): indication of relative offset of reference FD basis per TRP with respect to a reference TRP
	+ Information related to the windows for FD basis
	+ Delay difference(s) across TRPs
* Specification entity corresponding to a TRP (e.g. port-group, NZP CSI-RS resource)
* For codebooks with per-TRP SD/FD basis (structure Alt1A/1B), whether to support co-amplitude/phase as a part of CSI report (explicit) or not (implicit)
* Design details of reference amplitudes and differential amplitudes in W2:
* Whether/how supported parameter combinations are refined from Rel-16/17

**Proposal 1.F**: 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):

* + Alt1. N is gNB-configured via higher-layer (RRC) signaling
		- The N configured TRPs are gNB-configured via higher-layer (RRC) signaling
		- N is the number of cooperating TRPs
		- 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
		- FFS: In addition to one transmission hypothesis, whether reporting multiple transmission hypotheses (with the same N value or possibly different N values) is supported
	+ Alt3. The UE reports CSI corresponding to K transmission hypotheses (FFS: supported value(s) of K)
		- The N configured TRPs are gNB-configured via higher-layer (RRC) signaling
		- N is the number of cooperating TRPs

FFS: Specification entity corresponding to a TRP (e.g. port-group, NZP CSI-RS resource)

Table 2 Additional inputs: issue 1

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Share your inputs, if any, on moderator proposals (minor changes from the latest version from Round 3 since we have agreed to support)**  |
| Qualcomm | Proposal 1.EMinor comment on “number of non-zero coefficients and bitmap…” where the bitmap cannot be “common” across TRPs – probably what want to say is separately or jointly indicated[Mod: OK]We’d like to add one note for the FFS co-amplitude/phase* Implicit co-amplitude/phase is not precluded

[Mod: OK]Proposal 1.FWe’d like to add one more option for UE-reported TRP selection in Alt2: “In this case, the selection of N out of NTRP TRPs is also reported (FFS: whether by using the SD basis indicators, or CRI, or with a new indicator, using bitmap or combinatorial)”[Mod: OK] |
| Mod V2 | **Group the FFSs into proposal 1.E.2**  |
| Samsung | Proposal I.E.2* 1st bullet, 2nd subbullet: reference FD basis can be only one (e.g. when Wf is joint). So suggest to delete ‘per TRP’

[Mod: OK]* 4th bullet: We prefer to study number of reference amplitudes (x=2+y), where 0<=y<=2N-2, where N = #cooperating TRPs. For the weaker TRPs, we don’t see the need for reporting 2 reference amplitudes per TRP

[Mod: OK]Proposal 1.F* Alt2, 2nd subbullet: TRP selection can also be indicated implicitly via existing parameters, e.g. amplitude or co-amplitude, K^NZ, bitmap etc. We suggest to add the following: “including implicit reporting using existing Rel16 UCI parameters”

[Mod: OK, added implicit. I don’t see how “existing Rel-16 UCI parameters” can be used since it is unlikely that Rel-18 CSI reporting includes any “existing” Rel-16 UCI parameter. So I didn’t add this.] |
| Lenovo | **Proposal 1.E.1:**We are fine with the proposal structure. Propose adding a sub-bullet under “Quantized combining coefficients”, as follows: **“FFS: quantization scheme details”**[Mod: OK]**Proposal 1.E.2**Support**Proposal 1.F**We prefer adding Alt3 corresponding to multi-hypothesis CSI reporting to maintain consistency with Rel-17 NCJT CSI reporting, as follows:Alt3. The UE reports CSI corresponding to K transmission hypotheses , where 1< K ≤ 2N-1* FFS: whether the K selected hypotheses are indicated via a combinatorial value or a bitmap

[Mod: OK, but check my added 2 bullets since I am sure someone (not FL ☺) will ask how N and N\_TRP are related] |
| Mod V8 | **Proposal 1.E.1 are 1.E.2 are quite stable.** **Some revisions based on inputs** |
| Spreadtrum | **Proposal 1.E.2:** For reference amplitudes, we would like to add one more alternative to consider a single reference amplitude for both polarizations per TRP. The reason is that, if reference amplitudes are per polarization as well as per TRP, there will be up to 8 reference amplitudes (including the strongest one(s)). Considering the tradeoff between performance and overhead, we may consider to adopt either per polarization or per TRP, but not both per polarization and per TRP.* Whether reference amplitudes and differential amplitudes are per TRP or across all TRPs, including:
	+ Whether reference amplitudes are polarization common or polarization specific
	+ Whether all of the reference amplitudes need reporting

The number of reference amplitudes in relation to the number of cooperating TRPs[Mod: I shortened this bullet and keep it general now. We can discuss more details next meeting] |
| CATT | **Proposal I.F:**We are open to discuss Alt 1,2,3. And we have the similar views as Lenovo that for CSI enhancement for CJT, it is reasonable to maintain consistency with Rel-17 NCJT CSI. Thus, extensions based on the R17 CSI NCJT framework can be at least discussed, e.g. multi-hypothesis CSI reporting, TRP-groups ports/resources and the pair indication for MTRP measurement hypothesis.We have two comments for the last proposal 1.F.1. Based the current proposal, since NTRP is a condition for both alternatives, we suggest to list ‘the FFS: Configuration of NTRP TRPs and the value of NTRP’ separately, not only for Alt 2.
2. Re the new Alt 3, we support to study reporting multiple hypothesis in principle. In our understanding, K should be small than N+1 because UE can report N CSIs for S-TRP and one CSI for CJT when N = NTRP for multiple hypothesis, similar like Rel-17 NCJT. In this case, the enhancement of reporting multiple hypothesis could be included in Alt 1. But when K is small and equal than 2N-1 for Alt 3, UE might report multiple CJT hypothesis, e.g. UE can report N CSIs for S-TRP and multiple CSIs for 2-TRP CJT, 3-TRP CJT and 4-TRP CJT for example NTRP=4, currently the case of N = NTRP is inaccurate and multiple N should be defined which is also regraded as UE-selected.

Based our understanding, the following updated proposal is suggested:**Proposal 1.F**: 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):* + Alt1. N is gNB-configured via higher-layer (RRC) signaling
		- The N configured TRPs are gNB-configured via higher-layer (RRC) signaling
		- In this case, N = NTRP
		- FFS: In addition to one transmission hypothesis, whether reporting multiple transmission hypotheses (with the same N value or possibly different N values) is supported
	+ Alt2. N is UE-selected and reported as a part of CSI report where N$\in ${1,..., NTRP}
		- 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: whether by using the SD basis indicators, CRI, a new indicator, or via an implicit mechanism)
		- ~~FFS: Configuration of N~~~~TRP~~ ~~TRPs and the value of N~~~~TRP~~~~, whether explicit or implicit~~
		- FFS: In addition to one transmission hypothesis, whether reporting multiple transmission hypotheses (with the same N value or possibly different N values) is supported
	+ ~~Alt3. The UE reports CSI corresponding to K transmission hypotheses, where 1< K ≤ 2N-1~~
		- ~~The N configured TRPs are gNB-configured via higher-layer (RRC) signaling~~
		- ~~In this case, N = N~~~~TRP~~
		- ~~FFS: whether the K selected hypotheses are indicated via a combinatorial value or a bitmap~~

FFS: Configuration of NTRP TRPs and the value of NTRP, whether explicit or implicitFFS: Specification entity corresponding to a TRP (e.g. port-group, NZP CSI-RS resource)[Mod: Lenovo wants to keep Alt3 as is and Alt1 is intended for 1 transmission hypothesis. Also the configuration of NTRP only applies to Alt2 since there is no NTRP for Alt1/3. Clarified.] |
| Xiaomi | **Proposal 1.E.1,** for the first FFS, it should be* + - * FFS: Whether it is per layer or layer-common

[Mod: OK]**Proposal 1.E.2,** support**Proposal 1.F,** for alt 3, we have two questions. First why K≤ 2N-1, may be K≤ $2^{N}$-1? Second, if replace K by N and replace N by NTRP, what is the difference between Alt 2 and Alt 3?[Mod: Alt1 is one hypothesis, Alt3 is multiple] |
| Nokia/NSB | **Proposal 1.E.1*** + On the first FFS there may be a typo “layer-common” rather than layer-specific. It may be worth clarifying that the selection of basis vectors may be layer-common or -specific, rather than the configured number of basis vectors, which is typically the same for all layers
		- The number of basis vectors: gNB-configured via higher-layer signaling
			* FFS: Whether the selection of basis vectors ~~it~~ is per layer or layer-common~~specific~~

[Mod: OK]**Proposal 1.E.2*** + For the relative offset of a reference FD basis (for structure Alt 2), to clarify the intention, it is proposed to study the indication of one FD basis offset per TRP with respect to a reference TRP (e.g. the strongest TRP) to maximise overlap between the FD basis vectors of all TRPs.
	+ For codebooks with per-TRP SD and joint FD basis (structure Alt2), indication of relative offset of reference FD basis ~~across all~~ per TRP~~s~~

[Mod: OK]**Proposal 1.F*** Regarding Alt 3, could the proponents please clarify, does the $i$-th transmission hypothesis, with $i=1,…,K$ correspond to $N\_{i}\leq N\_{TRP}$ active TRPs? In this case the total number of transmission hypotheses would be $\sum\_{k=1}^{N\_{TRP}}\left(\begin{matrix}N\_{TRP}\\k\end{matrix}\right)=2^{N\_{TRP}}-1$, which seems to be what Lenovo is suggesting.

[Mod: K is FFS now] |
| LG | We are generally fine with Proposal 1.E.1 and 1.E.2.**Proposal 1.F:** Is this understanding is correct? In Alt 1, UE reports CJT CSI for TRPs which are configured by RRC so that MTRP hypothesis is given by RRC and UE does not have flexibility to choose hypothesis. [Mod: only 1 hypothesis]In Alt 2, UE have flexibility to choose MTRP hypothesis by reporting N and also possibility of reporting multiple hypothesis is open.[Mod: Yes]In Alt 3, multiple MTRP hypothesis are indicated by gNB and UE reports CSIs corresponding to the multiple MTRP hypothesis. UE does not have flexibility to choose hypothesis.[Mod: No, UE can choose, same as Alt2. It’s just that N is fixed by RRC]Please let me know if I am missing something. |
| Huawei, HiSilicon | Proposal 1.E.1:* We think the DFT basis or eigenvector basis can be used for both separate SD+FD and joint SD/FD basis, therefore, we suggest the following update.

Note: Basis vectors comprise SD+FD (separately, analogous to Rel-16/17, DFT or eigenvector) or joint-SD/FD (e.g. DFT or eigenvector) depending on the down-selected codebook structure[Mod: Sorry my notes causes confusion, it is removed now. Anyway the basis selection issue is separate]Proposal 1.E.2:* There may be propagation difference between different TRPs, to compensate such delays, UE reporting of delay difference between signals from multi-TRPs would be helpful. So we suggest to add it for further study.

**Proposal 1.E.2**: For the Type-II codebook refinement for CJT mTRP, further study the following issues:* The need for the following additional parameters:
	+ …
	+ Delay difference of multiple TRPs

[Mod: OK]Proposal 1.F* For Alt.2, the selection of TRP can be via the selected number of NZC, for example, if #NZC for a TRP is 0, then it means the TRP is not selected and not reported.
	+ Alt2. N is UE-selected and reported as a part of CSI report where N$\in ${1,..., NTRP}
		- 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: whether by using the SD basis indicators, CRI, a new indicator, or via an implicit mechanism, or number of non-zero coefficients of W2)

[Mod: made FFS now – it seems there are other candidates. This can be discussed as next level details if Alt2 is chosen.]For the new Alt3, I suppose the K should be 1< K ≤ 2N-1. This may bring too much complexity for CJT, since the number of cooperating TRPs would be larger than that of NCJT, UE has to perform lots of operations, such as SVD composition, to different combinations of channels, which significantly increases UE complexity. If receiver side information feedback by per-RX reporting, then UE just measure the channel, and projects it to SD and FD basis. The SVD decomposition of channel can be avoided, and processes for different combinations of channels can also be avoided. In this way, the UE complexity can be significantly reduced.[Mod: K is FFS now. I tend to agree with you] |
| CMCC | We are generally ok with Proposal 1.E.1 and Proposal 1.E.2.For Proposal 1.F, we think the difference between Alt 2 and Alt 3 is that the N in Alt 2 is selected by UE while the K hypotheses in Alt 3 is selected by gNB. If our understanding is not correct, Alt 3 seems a special case of Alt 2.[Mod: Correct. The proponent of Alt3 wants to keep it separate from Alt2]Besides, I suppose the K in Alt3 should be 1<K≤ 2N-1, which seems to be what Lenovo suggested. |
| vivo | **Proposal 1.E.1:** Support with following editorial corrections as Nokia pointed out.* + - * FFS: Whether it is ~~per~~ layer-common or layer-specific

[Mod: OK]**Proposal 1.E.2:** For the 2nd sub-bullet of the 1st bullet, we are not sure whether “indication of relative offset of reference FD basis across all per TRPs” only applies for structure Alt2.For the 2nd sub-bullet of the last 2nd bullet “if polarization-specific reference amplitudes and differential amplitudes are across all TRPs”, does it imply legacy amplitude acquisition? If yes, we think the sub-bullet should be changed to “Whether the number of reference amplitudes is related to the number of cooperating TRPs”* Whether polarization-specific reference amplitudes and differential amplitudes are per TRP or across all TRPs, including:
	+ Whether reference amplitudes for both polarizations need reporting
	+ Whether ~~T~~ the number of reference amplitudes ~~in relation~~ is related to the number of cooperating TRPs

[Mod: I shortened this bullet and keep it general now. We can discuss more details next meeting]**Proposal 1.F:**In our opinion, the complexity of UE calculation with multiple measurement hypotheses for CJT is unacceptable.Besides, for Alt3, does the value of K depend on UE selection or gNB-configured? Meanwhile, we are not sure how the scope of K is determined as 1 to 2N-1.[Mod: Agree, K is FFS now] |
| MediaTek | A minor comment for clarification in Proposal 1.E.2 – we hope the receiver side information of left singular vectors is not an exhaustive one and we could potentially study other side information as well. An example of side information we are referring to is UE recommendation of scaling per TRP precoders in the codebook structure Alt 2. Since the per TRP precoders are no longer unitary in this structure, gNB scaling of these precoders for data transmission affects the desired signal power and inter-layer interference levels. UE computation of CQI by certain scaling and recommendation (report) of the same would help to improve performance. [Mod: Pros and cons can be discussed next meeting when we down select] |
| Nokia/NSB2 | **Proposal 1.E.1*** Small proposed correction for clarity: the #NZC/bitmap may be per TRP or across all TRPs (common may be confused as the same bitmap applied to all TRPs)
	+ Number of non-zero coefficients and bitmap to indicate non-zero coefficients, including whether it is per TRP/TRP-group (separate) or ~~common for~~ across all TRPs/TRP-groups (joint): a part of CSI report

[Mod: OK] |
| Sasmsung2 | Proposal I.E.1: FFS in 3rd bullet should be a subbullet of 2nd bullet, as shown below in yellow.**Proposal 1.E.1**: On the Type-II codebook refinement for CJT mTRP, the resulting codebook(s) are associated with *at least* the following parameters:* + Parameters for basis reporting, including
		- The number of basis vectors: gNB-configured via higher-layer signaling
			* FFS: Whether it is per layer or layer-specific
		- Basis selection indicator(s): a part of CSI report
			* FFS: whether it is per TRP/TRP-group or common for all TRPs
		- Note: Basis vectors comprise SD+FD (separately, analogous to Rel-16/17) or joint-SD/FD (e.g. DFT or eigenvector) depending on the down-selected codebook structure

[Mod: OK]Proposal I.E.2* 1st bullet, 2nd subbullet: relative offset is applicable to all codebook structures, so suggest to delete the text in beginning of the sentence:
	+ ~~For codebooks with per-TRP SD and joint FD basis (structure Alt2),~~ indication of relative offset of reference FD basis across allTRPs

[Mod: This is Nokia proposal and it is intended for Alt2 structure. So I am not changing this.]* 4th bullet: when ref amp is per TRP (i.e. pol-common for each TRP), then ref amp = co-amplitude. So, suggest to add the following:
	+ Whether reference amp = co-amplitude

[Mod: I shortened this bullet and keep it general now. We can discuss more details next meeting]Proposal 1.F* Alt3: in R17 NCJT CSI, candidate sTRP and mTRP CSI hypotheses are configured. Are we proposing the same? That is, NW configured candidate CJT CSI hypotheses and UE reports one or more than an 1 from the configured candidate hypotheses. If so, could we clarify it?
	+ The candidate CJT CSI hypotheses is/are RRC configured.

[Mod: This is next level details, can be discussed during down selection] |
| Lenovo 2 | **Proposal 1F:**@Moderator: In the proposed wording for Alt3, my suggestion was $1<K\leq 2^{N}-1$. Probably the superscript was not captured in the proposal, kindly advise@Xiaomi, Nokia, Huawei, CMCC, VIVO: Yes, it should be $K\leq 2^{N}-1$, probably the superscript was not captured due to paste style in word. I have pointed this out to the moderator@CATT: Regarding your comment on Alt3, we can further discuss the value of K. The inequality $1<K\leq 2^{N}-1$ serves as a bound to the possible values K. For NCJT, only one joint transmission hypothesis was supported since N=2, but in case N>2 is supported for CJT, more than one joint transmission hypothesis can be reported@Xiaomi, CMCC: Regarding discrepancy of Alt2, Alt3, K here refers to supported hypotheses and not number of TRPs. To give a simple example, if N=2, K=2N-1=3 hypotheses are possible (two single-TRP hypothesis and one joint transmission hypothesis). In that case, if we use a bitmap of length N=2 that is [1 1], it wouldn’t be clear which of the 3 hypotheses is selected, leading to ambiguity@LG: Regarding Alt3, we are open to either network-based or UE-based hypothesis selection@Huawei, vivo: We agree that for N>2, reporting CSI for all hypothesis can be complicated. For that reason we proposed the bound $K\leq 2^{N}-1$, i.e., UE may report CSI corresponding to a subset of the hypotheses. Moreover, some quantities may be calculated once for a given hypothesis, and reused for another one. We are open to discussion on further details on how the subset of hypotheses is selected, e.g., network-based, UE-based, or both@Samsung: We see your point, we are open to discussing network-based and UE-based hypothesis selection. In Rel. 17 NCJT, UE-based selection was also supported in Mode2. To summarize, we are OK to add FFS on whether/how the CSJT CSI hypotheses are selected |
| Mod V23 | **Revised proposals (wording revision and keeping some FFS more high level). Otherwise, they are stable in essence/content** |

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

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.3 | Fundamental time/Doppler-domain compression parameters:1. TD/DD basis vector length N4 (analogous to 2N1N2 and N3)
2. TD compression unit relative to slot length (analogous to the relation between FD compression unit and CQI sub-band, i.e. $p\_{υ}$ for FD compression)
3. The number of selected TD/DD basis vectors (analogous to L and M)
4. …

**FL Note**: While the exact details depend on the waveform (basis design) selection, some fundamental parameters are applicable for any waveform selection | **1 (TD/DD basis length):** Samsung, Nokia/NSB, IDC, Fraunhofer IIS/Fraunhofer HHI, Intel, CEWiT, Ericsson, Qualcomm, Sony**2 (TD compression unit):** Samsung, MTK, Qualcomm**3 (# selected basis vectors):** Samsung, Fraunhofer IIS/Fraunhofer HHI, Apple, Nokia/NSB, IDC, Intel, ZTE, Ericsson, Qualcomm, Sony |
| 2.6 | The use of legacy NZP CSI-RS to facilitate necessary measurements 1. P CSI-RS, e.g. periodicity and offset setting
2. SP CSI-RS, e.g. burst setting
3. AP CSI-RS, e.g. group triggering
4. TRS

**FL Note**: **Companies are encouraged to comment on how to use P/SP/AP CSI-RS for the purpose of CSI calculation involving Type-II with TD/DD compression.** CSI-RS enhancement is out of scope. However, how to use/refine the legacy/current CSI-RS resource setting to facilitate necessary measurements should be discussed as it can affect evaluation and detailed designs. | **P CSI-RS**: LG, MTK, Qualcomm**SP CSI-RS**: Samsung, LG, Lenovo, IDC, Fraunhofer IIS/Fraunhofer HHI, MTK, Qualcomm, Sony**AP CSI-RS**: Samsung**CSI-RS burst for AP and SP (multiple CSI-RS resources/samples):** Huawei/HiSi, Ericsson, CATT, Samsung, Nokia/NSB, DOCOMO (study), CMCC, Futurewei, Fraunhofer IIS/Fraunhofer HHI, Intel, MTK, ZTE, Qualcomm, Xiaomi, Sony**TRS**: CATT, Nokia/NSB (CSI-RS+TRS), vivo (CSI-RS+TRS), IDC, ZTE(CSI-RS+TRS) , CEWiT, Xiaomi, Sony (study) |

**Proposal 2.E.1**: On the Type-II codebook refinement for high/medium velocities, for codebook structures with TD or DD basis (Alt1 or Alt2 from codebook structure agreement), the codebook(s) include *at least* the following *additional* codebook parameters:

* Doppler-/time-domain (DD/TD) basis vector length
* Parameters for DD/TD basis vector selection, including
	+ The number of DD/TD basis vectors
	+ If applicable, Basis selection indicator(s)
		- FFS: restrictions on the basis vector selection
	+ If applicable, the total number of available DD/TD basis vectors (not needed orthogonal DFT basis set), whether explicitly or implied from another parameter (e.g. oversampling factor)

**Proposal 2.E.2**: For the Type-II codebook refinement for high/medium velocities, further study the following issues:

* The need for basis type indicator, if both a trivial basis (e.g. identity) and a non-trivial (e.g. DFT) basis are supported, and if so, whether implicit or explicit
* The need for

**Proposal 2.F**: 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 velocities

FFS: Whether specification support for jointly utilizing two types of CSI-RS time-domain behaviors is needed

Table 4 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Share your inputs, if any, on moderator proposals (minor changes from the latest version from Round 3 since we have agreed to support)** |
| Qualcomm | Proposal 2.E:It might be misleading to say the TD compression unit analogous to R for Rel-16 eType-II. R is named “*numberOfPMI-SubbandsPerCQI-Subband*” in spec, and there has been no agreement on the definition of CQI unit in time-domain. Maybe a simpler saying is “analogous to PMI subband in frequency domain”[Mod: OK]One more parameter to be considered: Time-location of the TD codebook, probably including the following two optionsOpt1: Relative to CSI-RS observations (burst);Opt2: Relative to CSI reference resource (Rel-15 reference resource as a starting point)[Mod: Before I include this, is it only for TD basis (Alt1 structure)?] |
| Mod V2 | **Minor revision** |
| Samsung | Proposal 2.E* We suggest to add an FFS.
	+ FFS: the relation b/w TD/DD basis vector length (say N4) and the CSI-RS measurement window (W), e.g. whether N4 is within W or can be outside W

[Mod: OK] |
| Lenovo | **Proposal 2.E:**The current wording of the FFS implies the possibility of toggling between two non-trivial basis types, which is not the intention. Is it possible to clarify this in the FFS, e.g., FFS: The need for basis type indicator ~~(if two types of basis are supported)~~ (to enable switching between a trivial and non-trivial bases), if so, whether implicit or explicit[Mod: OK]**Proposal 2.F:**Support |
| Qualcomm 2 | Re FL’s questionAccording to my understanding, this can apply to both Alt1 and Alt2 codebook structure. Besides, I don’t see the difference b/w $W\_{t}$ in Alt1 and $W\_{d}$ in Alt2 (some companies also pointed out this during Round2/3 discussions), could you please elaborate more on your thought to differentiate them?[Mod: Please check if this is captured in the second bullet of 2.E.2 from Samsung. I am not sure what time location of codebook is.] |
| Mod V8 | **Since the # FFS proposals is growing, I grouped the FFSs into proposal 2.E.2****Overall 2.E.1 and 2.F are stable.** |
| Qualcomm 3 | Thanks for FL’s updates.The FFS bullet 2 in the updated proposal 2.E.2 is aligned with our proposed opt1, which assumes the time-location (let’s say starting slot for instance) relative to (e.g. aligned with) the starting CSI-RS slot in W;Our proposed opt2, however, has different definition of time-location based on CSI reference resource, which can be more aligned with the mechanism of legacy releases (since time-location is part of the purpose of defining a reference resource)[Mod: I removed this issue from proposal 2.E.2 – we will address this in the next round 5. Please check MTK’s comment] |
| CATT | **Proposal 2.E.2**:We support the proposal in principle. We think the meaning of the CSI-RS measurement window (W) should be confirmed firstly.[Mod: I removed this issue from proposal 2.E.2 – we will address this in the next round 5. Please check MTK’s comment] |
| Xiaomi | We are fine with these proposals. |
| LG | We are fine with the updated proposal 2.E.2. It is good to study the relation between measurement window and time instances/duration TD basis represents.Proposal 2.E.1: from my understanding “FFS: restrictions on the basis vector selection” should be moved under the following bullet point. * + If applicable, Basis selection indicator(s)

[Mod: OK] |
| Nokia/NSB | **Proposal 2.E.1*** + We suggest moving the third bullet to P2.E.2 because the definition and need of this parameter do not seem clear at this stage. For example, does this parameter determine the DD/TD basis vector length ($N\_{4}$) as a function of some other parameter(?), in a similar way as $R$ determines $N\_{3}$ as a function of the number of CQI subbands?

**Proposal 2.E.2*** + We suggest adding another aspect for study or incorporate it in the second bullet, in case the $N\_{4}$ time intervals are outside the measurement window (UE-side extrapolation):
* The need to configure a time reporting window in addition to the CSI-RS measurement window, e.g. as formed by $N\_{4}$ time intervals outside the measurement window

[Mod: I removed this issue from proposal 2.E.2 – we will address this in the next round 5. Please check MTK’s comment] |
| Huawei, HiSilicon | We are fine with these proposals. |
| CMCC | Generally, we are OK with these proposals. |
| vivo | We are fine with these proposals. |
| MTK | We support the revised Proposal 2.E. The proposals from Qualcomm and Samsung can be separated into a different proposal from 2.E, as they are not related to the codebook structure: Proposal 2.G: On the Type-II codebook refinement for high/medium velocities, the application window is down selected from the following alternatives:Alt. 1: DD/TD unit(s) ends at R15 CSI reference resourceAlt. 2: DD/TD unit(s) after the CSI reporting slotAlt. 3: DD/TD unit(s) from a CSI-RS transmission occasion before R15 CSI reference resource until some time after the CSI reporting slot[Mod: I removed this issue from proposal 2.E.2 – we will address this in the next round 5.]@Mod: Regarding Qualcomm’s proposed parameter for time-location of the TD codebook, we have a similar question as Qualcomm: Why it may only be applied to TD basis (Alt1 structure)? Our current understanding is that the codebook structure $W\_{1}\tilde{W}\_{2}(W\_{f}⨂W\_{d})^{H}$can also be understood as $W\_{1}W\_{2}(W\_{f}⨂W\_{t})^{H}$. The difference between Alt 1 and Alt 2 is merely the location of the matrix for TD/DD compression. If that is not the case, we would like to add Alt 3 structure: $W\_{1}W\_{2}(W\_{f}⨂W\_{t})^{H}$.[Mod: Your understanding is correct. The two are equivalent.] |
| Samsung2 | @MTK: Proposal 2G: what is the application window? Does it include measurement window?[Mod: I removed this issue from proposal 2.E.2 – we will address this in the next round 5. Please check MTK’s comment] |
| Mod V23 | **Proposals are relatively stable even with revision. Removed some bullet points to next round 5** |

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

Table 5 Summary: issue 3

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
|  |  |  |

**Proposal 3.D**: The TRS-based TDCP reporting is down selected from the following alternatives:

* Alt1 (stand-alone): TDCP reporting comprises auxiliary feedback information to enable refinement of CSI reporting configuration, and/or codebook configuration parameters, and/or (to be confirmed in RAN1#110) gNB-side CSI prediction
	+ Aperiodic reporting is supported
	+ FFS: Whether periodic, semi-persistent and/or event-triggered (UE-initiated) reporting are supported
* Alt2 (non-stand-alone): TDCP reporting corresponds to a subset of the UCI parameters associated with Rel-18 Type-II codebook for high/medium velocities, reported by the UE and measured via TRS

Table 6 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Added proposal 3.D using the framework proposed by Lenovo** **Share your inputs, if any, on moderator proposals (minor changes from the latest version from Round 3 since we have agreed to support)** |
| Ericsson | Support proposal 3.D. Our preference is Alt1, but we are ok to down select later. |
| Samsung | We support Alt1. TDCP reporting is beneficial for various use cases. We prefer not to limit it to Type II codebooks only. So, we don’t support Alt2. |
| DOCOMO | We share Samsung’s view. Support Alt 1.  |
| Lenovo | Agree with the proposal wording, down-selection/refinement of alternatives can be discussed later |
| Mod V8 | **Proposal 3.D is stable** |
| CATT | Support the FL’s proposal. In this stage, we are open to discuss both alternatives.  |
| Xiaomi | According to discussion in Round3, we think both alternatives can be adopted. Thus, the main bullet can be revised asThe TRS-based TDCP reporting is down selected one or more from the following alternatives:[Mod: Down-selection doesn’t imply one only unless explicitly stated. So there is no need to add “one or more”] |
| LG | We prefer to put FFS on periodic reporting at this time. [Mod: OK] |
| Nokia/NSB | Support this proposal. Our preference is Alt1. In our view, the first 2 agreed main use cases for this feature are well served by Alt 1 in its current formulation. Alt 2 seems more relevant for the third use case about aiding gNB-side CSI prediction with Type-II reporting, but this is not a use case of interest for us.  |
| CMCC | Support Proposal 3.D and prefer Alt 1. |
| vivo | Prefer following update about Alt2.* Alt2 (non-stand-alone): TDCP reporting corresponds to a subset of the UCI parameters associated with ~~Type-II codebook~~ legacy PMI reported by the UE and measured via TRS

[Mod: I think this proposal (from Lenovo) is not for any PMI, but for Rel-18 Type-II Doppler codebook] |
| MTK | We support Alt1, but we are fine with down-selection in the next meeting. |
| Mod V23 | **Periodic is made FFS in Alt1. Clarification on Alt2. Otherwise stable** |