**3GPP TSG RAN WG1 #118 R1-2406633**

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

**Agenda item:** 8.1

**Source:** Moderator (Samsung)

**Title:** Summary for Rel-18 MIMO CSI maintenance

**Document for:** Discussion and Decision

## Introduction

This contribution includes the summary for maintenance issues on Rel-18 CSI enhancements for MIMO Evolution.

## Summary of companies’ proposals and views

**Proposal 1.A**: For the Rel-18 Type-II codebook refinement, adopt the following TP for TS 38.214

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| TS 38.214 |
| **Reason for change:** |
| TS38.214 describes Rel-18 Type-II CJT CBSR based on an agreement in RAN1#112bis-e (that a UE must be configured with at least 1 CBSR), which was later superseded by RAN2 decision allowing no CBSR configuration (since N1,N2 configuration is taken out from CBSR IE).  |
| **Summary of change:** |
| Updating the description in TS 38.214 following CBSR configuration structure in TS 38.331. |
| **Consequences if not approved:** |
| Misaligned configuration/description in TS 38.214 and TS 38.331. |
| **Text proposal:** |
| 5.2.2.2.8 Enhanced Type II codebook for CJT<Unchanged part omitted>The bitmap parameter *n1-n2-codebookSubsetRestrictionList-r18* is configured ~~per CSI-RS resource and~~ for ~~at least one of~~ the $N\_{TRP}$ CSI-RS resources, and it is configured as described in Clause 5.2.2.2.5, where only the bit values '00' or '11' of Table 5.2.2.2.5-6 are configurable. If corresponding element for codebook subset restriction in parameter *~~n1-n2-codebookSubsetRestrictionList-r18~~* *cbsr-list-r18* is not configured for a CSI-RS resource, no restriction is applied to the selection of vectors $v\_{m\_{1,j}^{\left(i\right)},m\_{2,j}^{(i)}}$ corresponding to that resource.<Unchanged part omitted> |
| **Support/fine**: NEC**Not support**:**FL assessment**: This TP seems correct. Despite the agreement in RAN1#112bis-e, RAN2 has decided otherwise a few meetings ago to change the IE structure for CBSR (and N1,N2) which does not require the UE to be configured with CBSR for at least one resource. Therefore, aligning the description between 38.214 and 38.331 is needed. |

**Proposal 1.B**: For the Rel-18 Type-II codebook refinement, adopt the following TP for TS 38.214

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| TS 38.214 |
| **Reason for change:** |
| In Rel-18 enhanced type II for CJT and predicted PMI on PUSCH, part 2 CSI is organized into three groups, i.e., Group 0, Group 1 and Group 2. Group 0 includes indices $i\_{1,8,l} (l=1, …,υ)$, which indicates the strongest coefficient in each layer and is determined as:$i\_{1,8,l}=\left\{\begin{matrix}\sum\_{I=0}^{i\_{1}^{\*}}κ\_{1,I,0}^{(3)}-1&υ=1\\i\_{l}^{\*}&1<υ\leq 4\end{matrix}\right. $ for CJT, and $i\_{1,8,l}=\left\{\begin{matrix}\sum\_{I=0}^{2Lτ\_{1}^{\*}+i\_{1}^{\*}}κ\_{1,I,0}^{(3)}-1&υ=1\\2Lτ\_{l}^{\*}+i\_{l}^{\*}&1<υ\leq 4\end{matrix}\right.$ for predicted PMI, where $κ\_{1,I,0}^{(3)}$ is part of the non-zero bit maps reported.In both cases, for rank=1 (i.e.,$υ=1$)*,*  $i\_{1,8,l}$ depends on the non-zero bit map $k\_{1,I,0}^{(3)}$, which is reported in Group 1 and Group 2. In case of omission and parameters in Group 1 and Group 2 are dropped, the non-zero bit map $k\_{1,I,0}^{(3)}$ would not be reported. When rank 1 is reported, the strongest coefficient indices $i\_{l}^{\*}$ and $τ\_{l}^{\*}$ (in case of predicted PMI) cannot be determined at the gNB based on the reported $i\_{1,8,1}$, which is a problem.  |
| **Summary of change:** |
| The same formula of $i\_{1,8,l}$ for rank >1 is also used all ranks including rank =1, i.e.,For CJT, $i\_{1,8,l}=i\_{l}^{\*}, v=1,2,3,4.$For predicted PMI: $i\_{1,8,l}=2Lτ\_{l}^{\*}+i\_{l}^{\*}, v=1,2,3,4.$ |
| **Consequences if not approved:** |
| The strongest coefficient for rank 1 cannot be determined in case of omission of the non-zero bit map. |
| **Text proposal:** |
| 5.2.2.2.8 Enhanced Type II codebook for CJTFor 4 antenna ports {3000, 3001, …, 3003}, 8 antenna ports {3000, 3001, …, 3007}, 12 antenna ports {3000, 3001, …, 3011}, 16 antenna ports {3000, 3001, …, 3015}, 24 antenna ports {3000, 3001, …, 3023}, and 32 antenna ports {3000, 3001, …, 3031} per CSI-RS resource, and the UE configured with $N\_{TRP}\in \{1,2,3,4\}$ CSI-RS resources in a resource set for channel measurement and with higher layer parameter *codebookType* set to 'typeII-CJT-r18'<Unchanged parts omitted>The strongest coefficient of layer $l=1,…, υ$ is identified by $i\_{1,8,l}\in \left\{0,1,…,2\sum\_{j=1}^{N\_{0}}L\_{σ\_{j}}-1\right\}$ and is obtained as follows, ~~where, for~~ $υ=1$~~,~~ $κ\_{1,I,0}^{(3)}=k\_{1,i,0,j}^{(3)}$ ~~and index~~ $I$ ~~is such that~~ $I=2\sum\_{k=1}^{j-1}L\_{σ\_{k}}+i$ $i\_{1,8,l}=\left\{\begin{matrix}\sum\_{I=0}^{i\_{1}^{\*}}κ\_{1,I,0}^{(3)}-1&υ=1\\i\_{l}^{\*}&1<υ\leq 4\end{matrix}\right. $$$i\_{1,8,l}=i\_{l}^{\*}$$for $l=1,…, υ$.<Unchanged parts omitted>5.2.2.2.10 Enhanced Type II codebook for predicted PMIFor 4 antenna ports {3000, 3001, …, 3003}, 8 antenna ports {3000, 3001, …, 3007}, 12 antenna ports {3000, 3001, …, 3011}, 16 antenna ports {3000, 3001, …, 3015}, 24 antenna ports {3000, 3001, …, 3023}, and 32 antenna ports {3000, 3001, …, 3031} per CSI-RS resource, the UE configured with $K\in \{4,8,12\}$ aperiodic CSI-RS resources or with a single periodic or semi-persistent CSI-RS resource in the resource set for channel measurement and with *codebookType* set to 'typeII-Doppler-r18'<Unchanged parts omitted>The strongest coefficient of layer $l=1,…,υ$ is identified by $i\_{1,8,l}\in \left\{0,1,…,2LQ-1\right\}$, which is obtained as follows, ~~where, for~~ $υ=1$~~,~~ $κ\_{1,I,0}^{(3)}=k\_{1,i,0,τ}^{(3)}$ ~~and index~~ $I$ ~~is such that~~ $I=2Lτ+i$ $i\_{1,8,l}=\left\{\begin{matrix}\sum\_{I=0}^{2Lτ\_{1}^{\*}+i\_{1}^{\*}}κ\_{1,I,0}^{(3)}-1&υ=1\\2Lτ\_{l}^{\*}+i\_{l}^{\*}&1<υ\leq 4\end{matrix}\right.$$$i\_{1,8,l}=2Lτ\_{l}^{\*}+i\_{l}^{\*} ;l=1,…,v. $$<Unchanged parts omitted> |
| **Support/fine**: Ericsson**Not support**:**FL assessment**: This TP is technically sound. However, this change doesn’t seem essential since UCI omission is intended as an emergency measure (not expected to be used frequently) – especially for rank-1 where PMI payload is smaller.  |

**Proposal 1.C**: For the Rel-18 Type-II codebook refinement, adopt the following TP for TS 38.214

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| TS 38.214 |
| **Reason for change:** |
| In current TS 38.214, only the most recent occasion of NZP CSI-RS is used for channel measurement or interference measurement when *timeRestrictionForChannelMeasurements* or *timeRestrictionForInterferenceMeasurements* is set to "*Configured*", which is not correct for Type II Doppler based CSI reporting, where multiple occasions are needed. |
| **Summary of change:** |
| Clarifying separate UE channel/interference measurement derivation behavior for CSI computation of Type II Doppler based CSI reporting and all other CSI reportings in TS 38.214 5.2.2.1. |
| **Consequences if not approved:** |
| Incorrect behaviors on channel/interference measurement derivation to compute CSI for CSI reporting for Type II Doppler CSI reporting |
| **Text proposal:** |
| 5.2.2.1 Channel quality indicator (CQI)<Unrelated part are omitted>If the higher layer parameter *timeRestrictionForChannelMeasurements* in*CSI-ReportConfig* is set to "*Configured*", except for *codebookType* set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE shall derive the channel measurements for computing CSI reported in uplink slot *n* based on only the most recent, no later than the CSI reference resource, in cell DTX active period of a serving cell if cell DTX is activated, occasion of NZP CSI-RS (defined in [4, TS 38.211]) associated with the CSI resource setting on the serving cell. If the *codebookType* is set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE shall derive the channel measurements for computing CSI reported in uplink slot *n* based on *KP* most recent, no later than the CSI reference resource, in cell DTX active period of a serving cell if cell DTX is activated, occasions of NZP CSI-RS associated with the CSI resource setting on the serving cell.<Unrelated part are omitted>If the higher layer parameter *timeRestrictionForInterferenceMeasurements* in *CSI-ReportConfig* is set to "*Configured*", except for *codebookType* set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE shall derive the interference measurements for computing the CSI value reported in uplink slot *n* based on the most recent, no later than the CSI reference resource, in cell DTX active period of a serving cell if cell DTX is activated, occasion of CSI-IM and/or NZP CSI-RS for interference measurement (defined in [4, TS 38.211]) associated with the CSI resource setting on the serving cell. If the *codebookType* is set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE shall derive the interference measurements for computing the CSI value reported in uplink slot *n* based on *KP* most recent, no later than the CSI reference resource, in cell DTX active period of a serving cell if cell DTX is activated, occasions of CSI-IM and/or NZP CSI-RS for interference measurement associated with the CSI resource setting on the serving cell.<Unrelated part are omitted> |
| **Support/fine**: CATT**Not support**:**FL assessment**: It is unclear if this TP is essential. If the NW configures a UE with Type-II Doppler CB (and a “burst-type” CMR), it doesn’t seem likely the NW configures the UE with measurement restriction which interferes with the needed measurement.  |

Table 1 Additional inputs: issue 1

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the above proposals** |
| NEC | Thank you FL for the moderating.For **Proposal 1.A**, please allow me to list the current TS 38.331 for convenience.

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| CodebookConfig-r18 ::= SEQUENCE { codebookType CHOICE { type2 CHOICE { typeII-CJT-r18 SEQUENCE { n1-n2-codebookSubsetRestrictionList-r18 N1-N2-CBSR-List-r18, paramCombination-CJT-r18 INTEGER (1..7), paramCombination-CJT-L-r18 SEQUENCE (SIZE (1..4)) OF INTEGER (1..5), restrictedCMR-Selection-r18 ENUMERATED {enable}, valueOfO3-r18 ENUMERATED {n1, n4} OPTIONAL, -- Need R numberOfPMI-SubbandsPerCQI-Subband-r18 INTEGER(1..2), typeII-RI-Restriction-r18 BIT STRING (SIZE (4)), codebookMode-r18 INTEGER (1..2) },…irrelavant part omittedN1-N2-CBSR-List-r18 ::= CHOICE { two-one-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (8))}, two-two-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (27))}, four-one-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (16))}, three-two-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (35))}, six-one-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (24))}, four-two-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (43))}, eight-one-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (32))}, four-three-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (59))}, twelve-one-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (48))}, four-four-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (75))}, eight-two-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (75))}, sixteen-one-r18 CHOICE {no-cbsr-r18 NULL, cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (64))}} |
| ***n1-n2-codebookSubsetRestriction,*** ***n1-n2-codebookSubsetRestrictionList***Number of antenna ports in first (*n1*) and second (*n2*) dimension and codebook subset restriction (see TS 38.214 [19] clause 5.2.2.2.3). Value *no-cbsr* means no codebook subset restriction is configured for the n1-n2 pair.If a codebook subset restriction is configured for the n1-n2 pair, the number of elements in *cbsr-list* in *n1-n2-codebookSubSetRestrictionList* is up to the number of elements of *nzp-CSI-RS-Resources* in *NZP-CSI-RS-ResourceSet(s)* indicated by *nzp-CSI-RS-ResourceSetList* in the *CSI-ResourceConfig* indicated by *resourcesForChannelMeasurement* in the *CSI-ReportConfig* in which the *CodebookConfig* is included. An element in the list corresponds to the element at the same position in *nzp-CSI-RS-Resources*. |

For **Proposal 1.B**, we share similar view as FL assessment, the UCI omission for rank 1 is corner case, while we can be open to introduce RRC configuration (as Ericsson proposed) for the new formula of SCI in Rel-18 (but not for previous releases) if majority thinks it’s necessary.  |
| Google | Proposal 1.A: Firstly, we think the words “~~per CSI-RS resource and~~” should not be removed. These words are necessary to clarify the configuration is for each TRP instead of across TRPs. Instead, it seems the following additional change would be necessary.If corresponding element for codebook subset restriction in parameter *~~n1-n2-codebookSubsetRestrictionList-r18~~* *cbsr-list-r18* is not configured ~~for a CSI-RS resource~~, no restriction is applied to the selection of vectors $v\_{m\_{1,j}^{\left(i\right)},m\_{2,j}^{(i)}}$ corresponding to the $N\_{TRP}$ CSI-RS resources ~~that resource~~.Proposal 1.B: We are not sure how critical the issue is. But it seems better to change the grouping rule for CSI omission? |
| NEC2 | @Google, thank you for the discussion.Re Proposal 1.B ““~~per CSI-RS resource and~~” should not be removed”, my understanding is that RAN2 has extract “n1-n2” out of legacy CBSR configuration, the IE “*n1-n2-codebookSubsetRestrictionList-r18*” is actually a list, which is configured for the $N\_{TRP}$ CSI-RS resources, not per CSI-RS resource, so removing it seems more suitable.The additional changed part is fine to us. |
| Apple | **Proposal 1.A**In principle, the CR looks good to me. One minor thing is that *cbsr-list-r18* should be *N1-N2-CBSR-List-r18* or we keep *n1-n2-codebookSubsetRestrictionList-r18***Proposal 1.B**We believe this is related to the legacy R16 eType II codebook, and the other CR submitted to this meeting, (R1-2407097 and R1-2407097). Even during the R16 maintenance, it was proposed to use the same SCI for RI=1 and RI>1, however, such proposal was quickly dismissed since it needs to revert the existing agreement. We do not have strong opinion. But in general, when UCI omission happens, the CSI is anyway not that useful since, in principle, when UE calculates the CSI, UE does not need to consider or optimize for the case of the UCI omission. We would rather to remove complicated UCI omission rule than optimizing it.  |
| Samsung | **Proposal 1.A**Support the TP. Agree with Apple’s minor comment. It seems *N1-N2-CBSR-List-r18* is correct. Also, since RAN2 decided to use 1-bit value for hard-amplitude restriction, we suggest to change the following text revision as well:“where only the codepoint of the bit values '00' or '11' of Table 5.2.2.2.5-6 ~~are~~ is configurable using one-bit value.”**Proposal 1.B**Not support, due to the following reasons:* This TP is non-essential and is merely an optimization, since UCI omission is an emergency scheme to handle a “rare event” (when ULRA is not sufficient) with extremely low probability, especially for rank 1, as commented by the FL. This can easily be avoided assuming a proper ULRA from the NW (the ULRA must at least correspond to rank 1).
* Besides, this TP is against the previous agreement on UCI parameter, yellow highlighted text in table below, as Apple also mentioned above.

***Table 1C: UCI parameter list for Rel-16 based***

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| --- | --- | --- | --- |
| **Parameter** | **UCI** | **Details/description** | **Status** |
| # NZ coefficients | Part 1 | RI ({1,…, RIMAX}) and *KNZ,TOT* (the total number of non-zero coefficients summed across all the layers and all N CSI-RS resources, where *KNZ,TOT* {1,2,…, 2*K*0} are reported in UCI part 1  | Complete |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15 | Complete |
| CSI-RS resource selection bitmap | Part 1 | *Only reported when NTRP >1:* *NTRP*-bit bitmap to indicate the UE recommendation of *N* CSI-RS resources* Non-existent if the value of *N* is RRC-configured to NTRP
 | Complete |
| Indication of number of SD basis vectors {*L*1, …, *LNTRP*} | Part 1 | UE recommendation selecting one of the *NL* RRC-configured value combinations ($\left⌈log\_{2}(N\_{L})\right⌉$-bit indicator)* Non-existent if *NL*=1
 | Complete |
| N Bitmap(s) per layer | Part 2 | For RI=1-4: for layer *l* and CSI-RS resource *n*, size-$2L\_{n}M\_{v}$where *n* denotes the *n*-th CSI-RS resource  | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | RI=1: A $\left⌈log\_{2}K\_{NZ}\right⌉$-bit indicator for the strongest coefficient index $\left(l^{\*},m^{\*},n^{\*}\right)$RI>1: See Table 1E below | Complete |

***Table 3C: UCI parameter list for Rel-16 based***

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| --- | --- | --- | --- |
| Parameter | UCI | Details/description | Status |
| # NZ coefficients | Part 1 | RI ({1,…, RIMAX}) and *KNZ,TOT* (the total number of non-zero coefficients summed across all the Q selected DD basis and across all the layers, are reported in UCI part 1  | Complete  |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15  | Complete  |
| Wideband CQI for the second TD CQI | Part 2 | Only applicable for X=2 (same format as CQIs for 2CW when RI>4 in R15)  | Complete |
| Subband CQI for the second TD CQI | Part 2 | Only applicable for X=2 (same format as CQIs for 2CW when RI>4 in R15)  | Complete |
| Q Bitmap(s) per layer | Part 2 | Q bitmaps where each bitmap has the same format/design as R16 eType-II | Complete  |
| Strongest coefficient indicator (SCI) | Part 2 | RI=1: A $\left⌈log\_{2}K\_{NZ}\right⌉$-bit indicator for the strongest coefficient index $\left(l^{\*},m^{\*},d^{\*}\right)$RI>1: See Table 3E below | Complete  |

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| Mod V6 | **Added proposal 1.C from CATT (apology for missing it in V0)** |
| Ericson | **Proposal 1.A:**Ok**Proposal 1.B**We hear the arguments about UCI omission not happening frequently. But we have to keep in mind that the gNB may request CSI for multiple CCs and it may not be always possible to allocate enough resources in all of the CCs. Having said that, RAN1 has already specified the UCI omission procedure, and it is broken for the case we pointed above. We hope everyone agrees that the spec is broken (regardless of how frequent the UCI omission is). Rather than leaving it broken, it would be good to fix this since we are still in maintenance phase in Rel-18.**Proposal 1.C:**Agree with FL that for Type II Doppler CSI, the gNB is not likely to configure measurement restriction. So the TP is not needed. |
| Qualcomm | **Proposal 1.A:**Ok in general.Maybe some small comments on English: How can something in the RRC parameter (already there) be not configured?Therefore, seems the following wording looks better?

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| …If ~~corresponding element for codebook subset restriction in~~ parameter *~~n1-n2-codebookSubsetRestrictionList-r18~~* *cbsr-list-r18* ~~is~~ does not ~~configured~~ comprise element for a CSI-RS resource, no restriction is applied to the selection of vectors $v\_{m\_{1,j}^{\left(i\right)},m\_{2,j}^{(i)}}$ corresponding to that resource. |

Copied the parameter below: cbsr-list-r18 SEQUENCE (SIZE (1..4)) OF BIT STRING (SIZE (xx))**Proposal 1.B**While we agree the intension is correct in logic, we don’t think codebook is broken.When UCI omission happens, the codebook anyway already becomes useless, so we don’t need to bother with some optimization for such a corner&useless case.**Proposal 1.C:**This CR is not needed.* Firstly, like FL and some companies mentioned, it is not a reasonable implementation for NW to configure timeRestriction for Type-II-Doppler CSI;
* Besides, a corresponding logic is, if NW configures such unreasonable timeRestriction, then NW takes consequence.
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| Samsung | **Proposal 1.C**Agree with FL. In fact, we already discussed on it during the work item phase, and it was common understanding that time restriction is not needed for Doppler CSI reporting, since it has to use past (burst) measurements for channel prediction upon UE implementation. If time restriction is needed, the NW should not configure Doppler CSI reporting. |

# References

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| --- | --- | --- | --- |
| 1 | R1-2406564 | Draft CR on CBSR configuration for CJT in TS38.214 | NEC |
| 2 | R1-2406565 | Discussion on CBSR configuration for CJT | NEC |
| 3 | R1-2407101 | Draft CR for 38.214 on enhanced type II CB for CJT and predicted PMI | Ericsson |
| 4 | R1-2407102 | Discussion on corrections to enhanced type II CB for CJT and predicted PMI | Ericsson |
| 5 | R1-2406347 | Correction on channel measurements derivation for computing CSI | CATT |
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