**3GPP TSG RAN WG1 #118bis R1-24XXXXX**

**Hefei, China, October 14th – 18th, 2024**

**Agenda item:** 9.13

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** [draft] Summary #1 on Rel-19 TEIs

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the discussions and proposals in AI 9.13 for Rel-19 TEI related discussion and following email discussion.

Based on the discussions summarized in Section 2, following TEI proposals are identified in AI 9.13. According to the guidance in [9], it should be checked first whether each TEI proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor so that the discussion on the TEI proposal can be prioritized over other TEI proposals. **Companies are encouraged to clarify which TEI proposal can be supported in the list below, i.e., please add your company name if you support the TEI proposal. Detailed feedback/question on each TEI proposal can also be provided in Section 2.**

* **TEI proposal #1: Maximal HARQ process numbers for TN in FR1 and FR2-1**
  + Supported by ZTE Corporation, CMCC, China Telecom, Ericsson, Nokia, Nokia Shanghai Bell, CATT, Verizon, Sanechips, Huawei, HiSilicon, China Unicom
* **TEI proposal #2: UE frequency hopping enhancement for positioning**
  + Supported by ZTE Corporation, China Unicom, Sanechips, Huawei, HiSilicon
* **TEI proposal #3: PUSCH antenna switching**
  + Supported by vivo, CMCC, China Unicom, Deutsche Telekom, Ericsson
* **TEI proposal #4: PDSCH DMRS enhancement for rank higher than 4**
  + Supported by vivo
* **TEI proposal #5: SRS beam configuration for positioning**
  + Supported by Huawei, HiSilicon, China Unicom, ZTE, Sanechips
* **TEI proposal #6: Link adaptation**
  + Supported by Ericsson
* **TEI proposal #7: SRS carrier switching with uplink Tx switching**
  + Supported by Qualcomm
* **TEI proposal #8: SRS carrier switching in UL CA**
  + Supported by Qualcomm
* **TEI proposal #9: Consideration on the power constraint for type II codebook**
  + Supported by Orange, ZTE, BT
* **TEI proposal #10: SR triggered SSSG fallback**
  + Supported by Qualcomm
* **TEI proposal #11: PTRS rate matching for multi-DCI based multi-TRP**
  + Supported by Qualcomm
* **TEI proposal #12: 8-Tx coherent precoder codebook enhancement**
  + Supported by Qualcomm
* **TEI proposal #13: Dynamic fallback for SRS antenna switching**
  + Supported by Qualcomm
* **TEI proposal #14: EPRE signaling for PDCCH**
  + Supported by Qualcomm
* **TEI proposal #15: Different TRS location in two consecutive slots**
  + Supported by Qualcomm
* **TEI proposal #16: Counting of active CSI-RS resources**
  + Supported by Nokia, Apple, MediaTek
* **TEI proposal #17: QCL assumption for periodic CSI-RS**
  + Supported by Nokia
* **TEI proposal #18: Counting of unusable PDCCH candidates**
  + Supported by Nokia
* **TEI proposal #19: PHR reporting triggering condition for a different UL waveform**
  + Supported by Nokia
* **TEI proposal #20: Closed loop power control for dynamic waveform switching**
  + Supported by Nokia

1. Discussion on Rel-19 TEI proposals
   1. Maximal HARQ process numbers for TN in FR1 and FR2-1

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [1] | Up to Rel-16, the maximal supported HARQ process number for both UL and DL is 16. In Rel-17 NTN, up to 32 HARQ process numbers are introduced to accommodate the long RTT duration, while the feature is only limited to NTN satellite bands and HAPS operation bands.   | ***max-HARQ-ProcessNumber-r17***  Indicates the maximal supported HARQ process numbers for UL and for DL respectively. For each value of *max-HARQ-ProcessNumber-r17*, value *u16d32* indicates the maximal supported HARQ process number is 16 for UL and 32 for DL, value *u32d16* indicates the maximal supported HARQ process number is 32 for UL and 16 for DL, value *u32d32* indicates the maximal supported HARQ process number is 32 for UL and 32 for DL. This field is only applicable for bands in Table 5.2.2-1 in TS 38.101-5 [34] and HAPS operation bands in clause 5.2 of TS 38.104 [35]. | Band | No | N/A | N/A | | --- | --- | --- | --- | --- |   In addition, 32 HARQ processes are also supported for 120kHz/480kHz/960kHz SCS for FR2-2 in Rel-17. A UE can also report up to 32 DL/UL cells that can be configured with 32 HARQ process numbers in CA scenario.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ***support32-DL-HARQ-ProcessPerSCS-r17***  Indicates whether the UE supports 32 HARQ processes in DL for each SCS in FR2-2 (i.e. SCS 120kHz/480kHz/960kHz).  A UE supporting 32 HARQ processes for 480/960 kHz SCS for DL shall support 32 as the maximum number of HARQ processes for 120 kHz SCS for DL in FR2-2. UE indicating support of this feature shall indicate support of *dl-FR2-2-SCS-120kHz-r17*. | Band | No | N/A | N/A | | ***support32-UL-HARQ-ProcessPerSCS-r17***  Indicates whether the UE supports 32 HARQ processes in UL for each SCS in FR2-2 (i.e. SCS 120kHz/480kHz/960kHz).  A UE supporting 32 HARQ processes for 480/960 kHz SCS for UL shall support 32 as the maximum number of HARQ processes for 120 kHz SCS for UL in FR2-2. UE indicating support of this feature shall indicate support of *dl-FR2-2-SCS-120kHz-r17*. | Band | No | N/A | N/A | | ***maxCC-32-DL-HARQ-ProcessFR2-2-r17***  Indicates the maximum number of component carriers that can be configured with 32 DL HARQ processes. Value n1 means maximum 1 component carriers, value n2 means maximum 2 component carriers, and so on.  UE supporting this feature shall indicate support of *support32-DL-HARQ-ProcessPerSCS-r17*. | BC | No | N/A | N/A | | ***maxCC-32-UL-HARQ-ProcessFR2-2-r17***  Indicates the maximum number of component carriers that can be configured with 32 UL HARQ processes. Value n1 means 1 UL HARQ process, value n2 means 2 UL HARQ processes, and so on.  UE supporting this feature shall indicate support of *support32-UL-HARQ-ProcessPerSCS-r17*. | BC | No | N/A | N/A |   Furthermore, up to 32 HARQ process numbers are also introduced for Rel-18 ATG with the following UE feature as agreed in RAN1#116bis. The feature is only limited to ATG operation bands.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 56. NR\_ATG | 56-3 | Increasing the number of HARQ processes | The maximal supported HARQ process number is X for UL and Y for DL |  | Yes | N/A | If UE does not support this feature, the HARQ process is number is limited. | Per UE | No | FR1 only | N/A | Candidate component values for (X,Y): {(16,32),(32,16),(32,32)}    Note: This UE feature group is applicable only for bands defined in Section 5.2J in TS 38.101-1 |   It is observed that the RTT duration is also very large in some FR1-FR2 TDD CA scenarios for TN. But the maximal supported HARQ process numbers is still kept as 16 according to existing specification. It is noted that the FR2 carrier in FR1-FR2 CA scenario in this contribution means a FR2-1 carrier.  **Problem statement: FR1 TDD PCell (30kHz) + FR2 TDD SCell (120kHz)**  For deployment scenario with FR1 TDD PCell + FR2 TDD SCell as shown in Figure 1, the DL performance for a cell-edge UE in FR2 SCell would be impacted by the coverage of the corresponding HARQ-ACK feedback. To ensure the UL coverage of HARQ-ACK for FR2 SCell, one typical way is to configure only one PUCCH cell group to allow HARQ-ACK of FR2 SCell is transmitted in PCell. In the appendix, we provide more analysis on the motivation of configuring one PUCCH group.    **Figure 1: Deployment scenario with FR1 TDD PCell + FR2 TDD SCell**  In the context of above deployment scenario, Figure 2 shows a typical FR1-FR2 TDD CA configuration, where PCell and SCell are configured with frame structure ‘DDDDDDDSUU’ and ‘DDDSU’ respectively. As it is shown, the HARQ-ACK corresponds to the PDSCH transmission in the slots highlighted by yellow/blue (29 D/S slots in total) is transmitted in slot U18 or U19. Then, at least 29 HARQ process number are needed based on the following scheduling restriction in TS 38.214. If only a maximum of 16 HARQ process numbers is supported, the FR2 DL peak rate for a UE will be reduced by almost 50%.   |  | | --- | | *TS 38.214 Clause 5.1*  *The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6].* |     **Figure 2: FR1-FR2 TDD-TDD CA deployment scenario #1, PCell and SCell with TDD configuration of ‘DDDDDDDSUU’ and ‘DDDSU’ respectively**  ***Observation 1:*** *In the FR1-FR2 TDD-TDD CA scenario with PCell and SCell configured with frame structure ‘DDDDDDDSUU’ and ‘DDDSU’ respectively, at least 29 HARQ process number are needed, and the FR2 DL peak data rate for a UE will be reduced by almost 50% if only a maximum of 16 HARQ process numbers is supported.*  Another deployment scenario of FR1-FR2 TDD CA is shown in Figure 3. Assuming the assigned HARQ -ACK timing *k1* is based on PDSCH processing capability 1, at least 19 HARQ process number is needed.    **Figure 3: FR1-FR2 TDD-TDD CA deployment scenario #2, PCell and SCell with TDD configuration of ‘DDDSU’**  ***Observation 2:*** *In the FR1-FR2 TDD-TDD CA scenario with PCell and SCell configured with frame structure ‘DDDSU’, at least 19 HARQ process number are needed.*  In the above scenarios, only the HARQ-ACK feedback latency is considered. However, the RTT also includes the additional processing time at gNB side between HARQ-ACK feedback and another PDSCH transmission. The additional processing time may include PUCCH processing time and other latency (e.g., interaction latency between different cells). Therefore, more HARQ process numbers are actually needed in above scenarios. In another aspect, even for FR1-FR2 TDD-TDD CA scenario with FR1 PCell configured with more UL slots, e.g., frame structure ‘DDDSUDDSUU, the HARQ process numbers may also be limited in practice.    **Figure 4: HARQ processing in one RTT**  ***Observation 3****: More HARQ process numbers are actually needed in one complete RTT duration with taking the processing time at gNB side into account.*  **UE implementation impact**  As mentioned above, a maximum of 32 HARQ processes has already been supported for 120kHz/480kHz/960kHz SCS of FR2-2 in Rel-17 FGs 24-8/24-8b/24-9/24-9b and extended to CA scenario. Compared to the UE capabilities defined for FR2-2, we haven’t identified any additional UE complexity required. Instead, supporting a maximum of 32 HARQ processes in FR1/FR2-1 may require less UE capability in terms of the HARQ buffer refreshing frequency.  ***Observation 4****: Supporting a maximum of 32 HARQ processes in FR1/FR2-1 does not require additional UE complexity compared to Rel-17 FGs 24-8/24-8b/24-9/24-9b defined for FR2-2.*  **Proposed solution:**  With above, one straightforward solution is to extend the NTN/ATG/FR2-2 feature to all bands in FR1 and FR2-1. This requires new UE capabilities and corresponding new RRC parameters. Therefore, we have the following proposal.  ***Proposal 1****: Support a maximum of 32 HARQ process numbers for TN in FR1 and FR2-1 in Rel-19.*   * *Introduce new UE capabilities, by duplicating the Rel-17 UE FGs 24-8/24-8b/24-9/24-9b defined for FR2-2 to FR1 and FR2-1.*   + *The reporting granularity of the UE capabilities is changed from ‘per BC’ to ‘per FSPC’.* * *Introduce new RRC parameters, harq-ProcessNumberSizeDCI-0-1-Ext-r19, harq-ProcessNumberSizeDCI-1-1-Ext-r19, harq-ProcessNumberSizeDCI-0-2-Ext-r19, harq-ProcessNumberSizeDCI-1-2-Ext-r19.* |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #1**

* **Support a maximum of 32 HARQ process numbers for TN in FR1 and FR2-1 in Rel-19.**
  + **Introduce new UE capabilities, by duplicating the Rel-17 UE FGs 24-8/24-8b/24-9/24-9b defined for FR2-2 to FR1 and FR2-1.**
    - **The reporting granularity of the UE capabilities is changed from ‘per BC’ to ‘per FSPC’.**
  + **Introduce new RRC parameters, harq-ProcessNumberSizeDCI-0-1-Ext-r19, harq-ProcessNumberSizeDCI-1-1-Ext-r19, harq-ProcessNumberSizeDCI-0-2-Ext-r19, harq-ProcessNumberSizeDCI-1-2-Ext-r19.**

This proposal is already supported by ZTE Corporation, CMCC, China Telecom, Ericsson, Nokia, Nokia Shanghai Bell, CATT, Verizon, Sanechips, Huawei, HiSilicon, China Unicom.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

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| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon | Yes | We support the proposal due to the following reasons:  1. Increasing the number of HARQ processes can improve the DL throughput in the CA scenario where the PUCCH is transmitted with small SCS and PDSCH is transmitted with large SCS, e.g. 30 kHz (FR1)+120kHz(FR2-1) or 15kHz(FR1)+60kHz(FR1).  2. As multi PDSCH scheduled by single DCI is supported in FR2-1 and multi PUSCH scheduled by single DCI is supported in FR1 and FR2-1, the DL/UL HARQ processes will be exhausted quickly. Before UE feedback HARQ-ACK for all of the HARQ processes, gNB cannot schedule new TBs on the same HARQ processes already scheduled. The transmission will be halted due to lack of HARQ processes.  3. As UE usually shares the baseband processing capability across different WIs. For example, for a UE supports 32 HARQ processes for NTN (likely be deployed in near future), the same processing capability can be easily reused in TN without significant change of implementation.  4. Since the reporting granularity of the FG(s) for 32 HARQ processes would be a finer granularity, i.e. per FSPC as proposed, companies have sufficient flexibility to report the capability for different CC/band/BC. |
| QC | Yes | We in general support the proposal with per SFPC UE capabilities. There are some low-level details like whether all 24-8/24-8b/24-9/24-9b-like capabilities need to be duplicated, and RRC configuration candidate values can be further discussed. |
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* 1. UE frequency hopping enhancement for positioning

Following proposal is made in the contribution.

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| [1] | In Rel-18, for positioning enhancements for RedCap UEs, Rx frequency hopping of DL PRS and Tx frequency hopping of UL SRS for positioning are supported with the maximum hop bandwidth for a single hop being 20MHz for FR1 and 100MHz for FR2. To improve positioning accuracy, the frequency hopping feature could also be applicable for non-RedCap UEs with limited UL SRS transmitting bandwidth capability or limited DL PRS processing bandwidth capability (e.g., 50MHz). The maximum bandwidth for a single hop can be extended to be larger than 20MHz for FR1 and larger than 100MHz for FR2 to support non-RedCap UE frequency hopping.  ***Observation 1:*** *For non-Redcap UEs with limited bandwidth capability, the feature of frequency hopping cannot be used to improve the positioning accuracy.*  Moreover, in Rel-18, bandwidth/carrier aggregation is introduced for achieving an equivalent larger bandwidth than the hopping bandwidth and therefore achieving higher accuracy. The maximum aggregated bandwidth of 2 PFLs/carriers for positioning which is supported by UE can be up to 200MHz in FR1 (for 30 kHz SCS) and up to 800MHz in FR2, and the maximum aggregated bandwidth of 3 PFLs/carriers for positioning which is supported by UE can be up to 300MHz in FR1 (for 30 kHz SCS) and up to 1200MHz in FR2. However, for UEs not supporting the bandwidth aggregation feature, the frequency resources of intra-band contiguous CCs cannot be used for positioning accuracy improvement. In order to make use of the intra-band contiguous CCs and the up-to-300MHz frequency resources in FR1, the maximum SRS bandwidth across all hops can be extended such that the SRS hops can span across intra-band contiguous CCs. In such case, the frequency resources can be effectively utilized for a UE only supporting the SRS Tx hopping feature but not supporting the SRS bandwidth aggregation feature.  ***Observation 2:*** *For UEs not supporting bandwidth aggregation feature, the frequency resources of intra-band contiguous CCs cannot be used for positioning accuracy improvement.*  UL SRS Tx frequency hopping is supported for both RRC\_CONNECTED state and RRC\_INACTIVE state. A UE can be configured to perform SRS Tx hopping separate from UL BWP where the UE may be configured with SCS, CP and bandwidth that are different from the UL active BWP (i.e., UL BWP for positioning SRS hopping). Also, there is no additional impact on measurement report since one TRP measurement is associated with one SRS resource ID, wherein the total bandwidth of all hops within that SRS resource is larger than a carrier/BWP bandwidth. The maximum SRS bandwidth across all hops can be 300MHz in FR1.  For DL, DL PRS Rx hopping across multiple PFLs can be realized by bandwidth aggregation configuration. For example, if a DL PRS bandwidth aggregation across multiple PFLs is configured, a UE can achieve large bandwidth via frequency hopping by implementation, wherein the UE only receive one PFL at one time.  Based on the above analysis, we propose to at least support SRS Tx hopping across carriers in both RRC\_CONNECTED state and RRC\_INACTIVE state.  ***Proposal 1:*** *Extend Rel-18’s DL and UL frequency hopping for DL-PRS reception and UL SRS for positioning transmission to non-RedCap UEs*   * *At least support the maximum SRS or DL PRS bandwidths across up to three intra-band contiguous carriers or PFLs respectively.*  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | xx-5-1 | PRS measurement with Rx frequency hopping within a MG and measurement reporting RRC\_CONNECTED ~~for RedCap UEs~~ | 1. Maximum DL PRS bandwidth across all hops  3. Maximum number of hops  4. Duration of DL PRS symbols N3 in units of ms a UE can process every T3 ms  5. RF Rx retune times between consecutive hops  6. Overlapping PRB(s) between adjacent hops | 13-1~~, one of {28-1, 48-1}~~ | Yes | n/a | PRS measurement with Rx frequency hopping within a MG and measurement report in RRC\_CONNECTED  ~~for RedCap UEs~~ is not supported | Per band | n/a | n/a | n/a | Component 1 candidate values:  FR1: {40, 50, 80, 100, 120, 140, 150, 160, 180, 200, 240, 300}  FR2: {100, 150, 200, 300, 400, 600, 800, 1000, 1200}  Component 3 candidate values: {2,3,4,5,6}  Component 4 candidate values:  T3: {8, 16, 20, 30, 40, 80, 160, 320, 640, 1280} ms  N3: {0.125, 0.25, 0.5, 1, 2, 4, 6, 8, 12, 16, 20, 25, 30, 32, 35, 40, 45, 50} ms  Component 5 candidate values:  FR1: {70us, 140us, 210us}  FR2: {35us, 70us, 140us}  Component 6 candidate values: {0, 1, 2, 4}  Note 1: The maximum DL PRS bandwidth per hop follows component 1 of FG 13-1  Note 2: DL PRS buffering capability follows component 2 of FG 13-1  Need for location server to know if the feature is supported. | | xx-5-1a | PRS measurement with Rx frequency hopping in RRC\_INACTIVE  ~~for RedCap UEs~~ | Support of PRS measurement with Rx frequency hopping in RRC\_INACTIVE ~~for RedCap UEs~~ | 41-5-1, 27-6 | Yes | n/a | PRS measurement with Rx frequency hopping in RRC\_INACTIVE ~~for RedCap UEs~~ UEs is not supported | Per band | n/a | n/a | n/a | Need for location server to know if the feature is supported. | | xx-5-1b | PRS measurement with Rx frequency hopping in RRC\_IDLE ~~for RedCap UEs~~ | Support of PRS measurement with Rx frequency hopping in RRC\_IDLE  ~~for RedCap UEs~~ | 41-5-1 | Yes | n/a | PRS measurement with Rx frequency hopping in RRC\_IDLE  ~~for RedCap UEs~~ is not supported | Per band | n/a | n/a | n/a | Need for location server to know if the feature is supported. | | xx-5-2 | Support of positioning SRS with Tx frequency hopping in RRC\_CONNECTED ~~for RedCap UEs~~ | 1. Maximum SRS bandwidth across all hops  2. Maximum number of hops  3. RF Tx retuning time between consecutive hops  4. Switching time between active BWP and frequency hop  5. Overlapping PRB(s) between adjacent hops  6. Support of {0,1,2,4} overlapping PRB(s) between adjacent hops  7. Maximum number of positioning SRS resources with Tx frequency hopping | 13-8~~, one of {28-1, 48-1}~~ | Yes | n/a | Positioning SRS with Tx hopping in RRC\_CONNECTED is not supported | Per band | n/a | n/a | n/a | Component 1 candidate values:  FR1: {40, 50, 80, 100, 160, 180, 190, 200, 240, 300}  FR2: {100, 150, 200, 300, 400, 600, 800, 1000, 1200}  Component 2 candidate values: {2,3,4,5,6}  Component 3 candidate values:  FR1: {70us, 140us, 210us}  FR2: {35us, 70us, 140us}  Component 4 candidate values:  {100us, 140us, 200us, 300us, 500us}  Component 7 candidate values:  Periodic: {1,2,4,8,16,32,64}  Aperiodic: {0,1,2,4,8,16,32,64}  Semi-persistent: {0,1,2,4,8,16,32,64}  Note: No additional UE requirements shall be specified for the case of Tx hopping with non-overlapping hops compared to the case of Tx hopping with overlapping hops, e.g., a UE is not responsible for keeping phase continuity across the hops in either case of overlapping or non-overlapping hops  Need for location server to know if the feature is supported | | xx-5-2a | Support of positioning SRS with Tx frequency hopping in RRC\_INACTIVE ~~for RedCap UEs~~ | 1. Maximum SRS bandwidth across all hops  2. Maximum number of hops  3. RF Tx retuning time between consecutive hops  4. Switching time between active BWP and frequency hop  5. Overlapping PRB(s) between adjacent hops  6. Support of {0,1,2,4} overlapping PRB(s) between adjacent hops  7. Maximum number of positioning SRS resources with Tx frequency hopping | 27-15b~~, one of {28-1, 48-1}~~ | Yes | n/a | Positioning SRS with Tx hopping in RRC\_INACTIVE is not supported | Per band | n/a | n/a | n/a | Component 1 candidate values:  FR1: {40, 50, 80, 100, 160, 180, 190, 200, 240, 300}  FR2: {100, 150, 200, 300, 400, 600, 800, 1000, 1200}  Component 2 candidate values: {2,3,4,5,6}  Component 3 candidate values:  FR1: {70us, 140us, 210us}  FR2: {35us, 70us, 140us}  Component 4 candidate values:  {100us, 140us, 200us, 300us, 500us}  Component 7 candidate values:  Periodic: {1,2,4,8,16,32,64}  Semi-persistent: {0,1,2,4,8,16,32,64}  Note: No additional UE requirements shall be specified for the case of Tx hopping with non-overlapping hops compared to the case of Tx hopping with overlapping hops, e.g., a UE is not responsible for keeping phase continuity across the hops in either case of overlapping or non-overlapping hops  Need for location server to know if the feature is supported | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #2**

* **Extend Rel-18’s DL and UL frequency hopping for DL-PRS reception and UL SRS for positioning transmission to non-RedCap UEs.**
  + **At least support the maximum SRS or DL PRS bandwidths across up to three intra-band contiguous carriers or PFLs respectively.**

This proposal is already supported by ZTE Corporation, China Unicom, Sanechips, Huawei, HiSilicon.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

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| Company | Suppport (Y/N) | Comment |
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* 1. PUSCH antenna switching

Following proposal is made in the contribution.

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| [2] | **Background**  Current NR spec supports flexible configuration of SRS resources for different purposes with usage defined as for *codebook, non-codebook, antenna switching*. However, the SRS resources for different usages are configured independently and not shared. SRS resources with usage for codebook and non-codebook are for PUSCH transmission, while SRS resources with usage antenna switching is for PDSCH transmission (channel reciprocity, TDD). Depending on UE capability SRS for antenna switching can be configured with 1T2R, 1T4R, 2T4R, 2T6R, 2T8R etc. gNB can configure a UE with SRS for codebook and SRS antenna switching independently, simultaneously, however the number of configured SRS resources in a set with usage for codebook is limited to 2 except for UL full power mode 2.  **Discussion**  Currently, antenna selection for PUSCH is UE implementation, and partially supported in spec by configuring multiple SRS resources for CB and NCB. UE implementation could vary significantly and may not be very dynamic. Network doesn’t know when and how PUSCH antenna switching is implemented at the UE which may lead to degraded network implementation. Network controlling TX antenna can improve antenna selection mechanism, dynamically selecting best antenna for SRS and PUSCH transmission, improving overall system performance.  Figure 2.1 shows evaluation results, the UE is equipped with 1Tx chain but 4 antennas, PUSCH antenna is switched from the antenna which is completely blocked (index 1) to another antenna which not blocked. Blocking occurs at dashed vertical line and reaction time means the time delay in switching to best antenna (not blocked) after the blocking occurs. The reaction time is the time period required for UE switching to better antenna by implementation. If the UE can instantly switch to better antenna (0ms reaction time), then the UE switches to better antenna for SRS transmission and the following PUSCH transmission. For example, for 80ms (or longer) reaction time, after antenna blocking happens (at dashed line 30ms), the UE takes 80ms to switch to better antenna, during this period the UE uses blocked antenna for SRS and the following PUSCH transmission. In this evaluation, only 1 SRS resource is assumed for CB based transmission. It can be noticed that longer the delay (reaction time) in PUSCH antenna switching performance gets worse.    Figure 2.1, impact of PUSCH antenna switching delay on performance  From above discussion and evaluation results, following observations can be made   * It is beneficial to support spec based PUSCH antenna switching * If SRS for antenna switching and for codebook (or non-codebook) share same resources, only minor spec change for 1T4R, 2T6R, 2T8R is needed.   **Proposals and potential spec impact**  Based on the motivation and discussion above, it is proposed to support more than 2 SRS resources in a set for usage codebook.  Proposal:   * Support to configure maximum of 4 SRS resources for codebook based transmission * Introduce following new UE capabilities   + Support of max 4 SRS resources in a set for codebook based UL transmission   38.214 Section 6.1.1.1  ..  For codebook based transmission, only one SRS resource can be indicated based on the SRI from within the SRS resource set. ~~Except when higher layer parameter~~ *~~ul-FullPowerTransmission~~* ~~is set to 'fullpowerMode2', t~~The maximum number of configured SRS resources for codebook based transmission is ~~2~~4. If aperiodic SRS is configured for a UE, the SRS request field in DCI triggers the transmission of aperiodic SRS resources.  .. |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #3**

* **Support to configure maximum of 4 SRS resources for codebook based transmission**
* **Introduce following new UE capabilities.**
  + **Support of max 4 SRS resources in a set for codebook based UL transmission.**

This proposal is already supported by vivo, CMCC, China Unicom, Deutsche Telekom, Ericsson.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

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| Company | Suppport (Y/N) | Comment |
| DOCOMO | Open, see comment | We are interested in UL related enhancement in general. But one question:  We understand this implies SRS for antenna switching is used for UL channel sounding, and the main UE architecture is xTyR with x<<y (like 1T4R). For the particular SRS, our understanding is that PCMAX can be quite different for different ports due to a term ∆TRxSRS, according to 38.101, defined as:   |  | | --- | | ∆TRxSRS is applied during SRS transmission occasions with *usage* in *SRS-ResourceSet* set as ‘antennaSwitching’ when  a) UE transmits SRS on the second SRS resource in every configured SRS resource set when the *SRS-TxSwitch* capability is indicated as 't1r2' or 't1r1-t1r2'  b) UE transmits SRS on the second, third and fourth SRS resources of the total 4 SRS resources from all configured SRS resource set(s) consisting of one SRS port when the *SRS-TxSwitch* capability is indicated as 't1r4' or, 't1r4-t2r4' or 't1r1-t1r2-t1r4' or, 't1r1-t1r2-t2r2-t1r4-t2r4'  c) UE transmits SRS from the SRS port pair on the second SRS resource in every configured SRS resource set consisting of two SRS ports when the *SRS-TxSwitch* capabilityis indicated as' t2r4' or ' t1r4-t2r4', or 't1r1-t1r2-t2r2-t2r4' or 't1r1-t1r2-t2r2-t1r4-t2r4', or  d) UE transmits SRS to a DL-only carrier  e) UE transmits SRS on the second, third, fourth, fifth, sixth, senventh and eighth SRS resources of the total 8 SRS resources from all configured SRS resource set(s) consisting of one SRS port when the *srs-AntennaSwitchingBeyond4RX-r17* capability is indicated as 't1r8' or 't1r8-t2r8', or  f) UE transmits SRS from the SRS port pair on the second, third and fourth SRS resource in every configured SRS resource set consisting of two SRS ports when the SRS-TxSwitch capability is indicated as ' t2r8' or ' t1r8-t2r8'.  For *SRS-TxSwitch* capabilities indicated as 't1r2', 't1r1-t1r2', 't1r4', 't1r4-t2r4', 't1r1-t1r2-t1r4', 't1r1-t1r2-t2r2-t2r4', 't1r1-t1r2-t2r2-t1r4-t2r4' or 't4r8', the following applies:  - The value of ∆TRxSRS is 4.5dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 3 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 or power class 1.5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB, or when UE indicating *txDiversity-r16*~~.~~.  - The value of ∆TRxSRS is 7.5dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 6 dB for bands whose FUL\_high is lower than the FUL\_low of n79 during SRS transmission occasions with configured SRS resources consisting of one SRS port when the device is capable of power class 2 in the band and ΔPPowerClass = 0 dB and not indicating *txDiversity-r16*. |   According to above, for non-first SRS resource, we understand SRS Tx power will be decreased by 3 to 7.5 dB.  And the above just impacts on PCMAX\_L,f,c – which is the lower bound of PCMAX,f,c to be referred to in RAN1 specification. It means UE can implement what it wants to do as long as it satisfies the range limit.  In that case, is it really possible for NW, by just measuring/comparing SRS power per port, to recognize which port is better for PUSCH transmission (whose power seems not to be impacted by the above specification)? |
| ZTE |  | It seems that this TEI has been discussed before. In our views, the following may need to be clarified, otherwise it is difficult for us to justify the necessity and NW-implementation impact of this TEI proposal.   * Q1: When/whether the SRS ports for CB from different resources can be different or not, for instance, if fully overlapping with SRS resource for AS, or a new RRC parameter/rule can be introduce for indicating that SRS ports for CB can be different ports from different resources. * Q2: Whether/when a gap between PUSCH scheduled by DCI format 0\_1/2 and PUCCH/PUSCH scheduled by DCI format 0\_0 is needed? How to assume the PUCCH port and PUSCH port scheduled by DCI format 0\_0  in such case. * Q3: Whether we can assume that there is a fix mapping between SRS for AS? For instance, after RRC reconfiguration, SRS for CB is fully overlapped from SRS resource #0 for AS to resource #3, can we assume that the antenna port for SRS for CB is switched from physical UL-Tx antenna port 0 to 3 accordingly. |
| Spreadtrum | See comments | Even though we agree that antenna switching is beneficial when part of the antennas are blocked, PUSCH antenna switching is UE implementation. From spec perspective, the configuration is for codebook based PUSCH transmission. The proposal doesn’t change the fact that PUSCH antenna switching is still UE implementation. We don’t know whether it’s proper to have an optimization which is defined for enhanced UE implementation, rather than the original function. |
| QC | No | In general, we think UE is at a better position to make the Tx antenna selection as UE knows all the information about its Tx antennas, RF conditions, power consumption, etc, which is why current spec leaves it up to UE implementation. If some enhancement is needed, we prefer let NW provide some information of SRS measurements to the UE to assist UE make antenna selection decision. Leaving the UE Tx antenna selection purely to NW is not direction to go in our view. |

* 1. PDSCH DMRS enhancement for rank higher than 4

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [2] | **Background**  Rel-15 NR spec supports various DMRS configurations for PDSCH based on usage scenario, such as different DMRS type depending on fast/slow selective fading in frequency domain, various *dmrs-AdditionalPosition* depending on fast/slow selective fading in time domain, sometimes taking low/high SNR region into account, single/double symbols indication depending on the transmission layers. The IE *DMRS-DownlinkConfig* in 38.331 is used to configure PDSCH DMRS including *dmrs-type*, *dmrs-AdditionalPosition*, *maxLength* which means semi static configuration. The field *Antenna port(s)* in DCI format 1\_1 is used to indicate the used DMRS port(s) dynamically, also can indicate single or double DMRS symbols when *maxLength* is configured as 2. Based on real field data, we observe that the parameter *dmrs-AdditionalPosition* is usually configured with *’pos1’* by RRC signaling for typical scenario, meanwhile the first OFDM symbol is reserved for PDCCH candidate transmission per slot and the other 13 symbols are allocated for PDSCH transmission with slot offset *k0=0*.  In massive MIMO deployment, for example, 64T64R antenna is typical deployment in TDD network, furthermore, operators are pursuing 128T128R for better performance. Meanwhile, larger terminal form factor such as foldable smartphone is getting popular, where there is more space for mounting 6Rx/8Rx more antennas. With larger number of antenna ports at gNB and more Rx antennas at the UE will significantly increase the higher ranks (or layers) of PDSCH. We have evaluated the rank distribution in different Tx/Rx assumptions at gNB as shown in the figure 3.1 below, where SU-MIMO with eigen-vector-based precoding is performed. According to the simulation results, it can be observed that the probability of rank larger than 4 increases significantly.  cid:image002.png@01DB0FF6.816FF090  Figure 3.1, rank distribution under various Tx/Rx antenna assumptions  **Discussion**  In order to ensure performance of channel estimation in real network, it is necessary to configure additional DMRS to support various scenarios, for example, channel measurement on two separated DMRS symbols can be combined to suppress noise in lower SNR region or interpolate to cope with high doppler. However, additional DMRS position in time domain will increase RS overhead especially in the case of higher rank, for example, DMRS type1 overhead will double for rank larger than 4 and DMRS type2 overhead will double for rank larger than 6.  It is well known that the PDSCH transmission with higher ranks (e.g. rank number>4) mostly occurs in lower speed and higher SNR scenarios, where additional DMRS position is not always necessary, in other words, only front loaded DMRS is enough for efficient channel estimation in some cases. The impact of DMRS overhead to throughput is listed in table below, here we assume the first OFDM symbol is reserved for PDCCH transmission and remaining 13 OFDM symbols are used for PDSCH transmission. In order to calculate the throughput gain, we take PDSCH transmission with rank 4 for DMRS type1 and rank 6 for DMRS type2 as baseline respectively, meanwhile, additional DMRS is assumed to be configured.  Table 3.1: throughput calculation   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Throughput | | Rank4 | Rank5 | Rank6 | Rank7 | Rank8 | | DMRS **type1** | *’with additional DMRS’* | 100%(baseline) | 102% | 1 22.7% | 143% | 163.6% | | *’without additional DMRS’* | N/A | 125% | 150% | 175% | 200% | | DMRS **type2\*** | *’ with additional DMRS’* | N/A | N/A | 100%(baseline\*) | 109.6% | 125% | | *’ without additional DMRS’* | N/A | N/A | N/A | 123.7% | 141.4% |   Note \*: Number of DMRS CDM groups without data=3  Based on the comparison in above table 3.1, if additional DMRS is configured semi-statically by higher-layer and rank adaption is indicated dynamically by DCI format, the throughput of PDSCH has significant loss when indicated rank is larger than 4 for DMRS type1 or larger than 6 for DMRS type2 compared to without additional DMRS.  **Proposals and potential spec impact**  Reconfiguration of additional DMRS is by RRC which is too slow to keep up with dynamic rank adaption and higher rank PDSCH transmission only happens in lower vehicular speed, dynamic indication of additional DMRS can improve the performance significantly.  Proposal:   * The UE assumes additional DMRS is absent in the case of RRC configures the additional DMRS and scheduled rank is larger than 4 for PDSCH. * Introduce a new UE capability. |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #4**

* **Support the following DMRS mapping and corresponding UE capability.**
  + **Additional DMRS is absent, when RRC configures the additional DMRS and the scheduled rank is larger than 4 for PDSCH.**

This proposal is already supported by vivo.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

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| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | We don’t think the proposal is useful.  Rel.18 eType1 DMRS ports supports rank 1-8 in single symbol DMRS. Rather than the TEI proposal#4, we think it is better to use Rel.18 eType1 DMRS because it has equal/smaller DMRS overhead than the proposal.    a) R18 eType1 DMRS ports b) TEI proposal#4 (R15 Type1)  However, if we apply the TEI proposal#4 to Rel.18 DMRS, we see the benefit of DMRS overhead reduction. |
| Spreadtrum | See comments | The case that scheduled rank is larger than 4 for PDSCH only happens when SU-MIMO is performed. However, MU-MIMO is more popular to increase cell throughput. We would like to see more views from operators. |
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* 1. SRS beam configuration for positioning

Following proposal is made in the contribution.

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| [3] | Existing problems For mmWave positioning with single TRP, usually RTT+AoA is a candidate solution. However, it is well acknowledged that the group delay for RTT can only be cancelled using the differential method under the TEG framework.  Therefore, exploring additional spatial propagation information to the LoS path is desirable, in which case the UE should use different Tx beams.  There exist two potential existing ways for that purpose.   * Solution 2-1: Network does not configure any spatial relation RS, and relies on UE implementation to select the SRS Tx beam. * Solution 2-2: Network configures different DL RS (from the same TRP) for each of SRS resources, and relies on UE DL measurement to select the SRS Tx beam.   On Solution 2-1, one problem is that the transmission of SRS may not be aligned with network expectation. For example, UE may choose to use the same Tx beam, instead of different Tx beams.  On Solution 2-2, the problem is that in indoor cases, some reflection (EO-Type 2 in ISAC channel model) happens close to the UE, e.g. wall or ground, which results in diverse AoA at UE but almost the same AoD at the TRP, as shown in Figure 1. Based on the earlier discussion, it is not possible to configure UE to transmit SRS using different beams if the spatial relation RS is the same.  BS  UE  Ground  Figure 1 Multiple Rx beams for the same Tx beam  ***Observation 3: For single TRP positioning, network expects to UE to explore additional spatial propagation information to the LoS path, but the feasibility through the existing configuration is low and opportunistic, which lowers the high accuracy performance achievability.***  ***Proposal 1: SRS spatial relation should be enhanced for single-TRP positioning in mmWave bands.*** Solutions For SRS spatial relation enhancement, there may exist different network expectations.   * If network expects to use multiple SRS resources for the Rx beam sweeping for the sake of UL AoA measurement, the UE should use the same Tx beam. * If network expects to explore additional spatial propagation information based on multiple SRS resources, the UE should use different Tx beams.   In our view, the simplest way to fix that would be introducing a new signaling from network indicating whether UE is expected to transmit SRS using the same Tx beam or different Tx beams for SRS resources, even when the spatial relation is configured.  ***Proposal 2: Introduce a new RRC parameter for a positioning SRS resource set, indicating whether the UE is expected to use the same or different spatial transmission filters for the positioning SRS resources.***   * + ***A per-band UE capability is introduced.*** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #5**

* **Introduce a new RRC parameter for a positioning SRS resource set, indicating whether the UE is expected to use the same or different spatial transmission filters for the positioning SRS resources.**
  + **A per-band UE capability is introduced.**
* **Endorse the following TP for clause 6.2.1.4 in TS 38.214.**

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| ========================= Unchanged parts =========================  6.2.1.4 UE sounding procedure for positioning purposes  When the SRS is configured by the higher layer parameter *SRS-PosResource* and if the higher layer parameter *spatialRelationInfoPos* is configured*,* it contains the ID of the configuration fields of a reference RS according to Clause 6.3.2 of [TS 38.331]. The reference RS can be an SRS configured by the higher layer parameter *SRS-Resource* or *SRS-PosResource*, CSI-RS, SS/PBCH block, or a DL PRS configured on a serving cell or a SS/PBCH block or a DL PRS configured on a non-serving cell. If the UE is configured for transmission of *SRS-PosResource* in RRC\_INACTIVE mode, the configured *spatialRelationInfoPos* is also applicable.  The UE is not expected to transmit multiple SRS resources with different spatial relations in the same OFDM symbol.  If the UE is not configured with the higher layer parameter *spatialRelationInfoPos* the UE may use a fixed spatial domain transmission filter for transmissions of the SRS configured by the higher layer parameter *SRS-PosResource* across multiple SRS resources or it may use a different spatial domain transmission filter across multiple SRS resources.  In RRC\_CONNECTED mode, the UE is only expected to transmit an SRS configured by the higher layer parameter *SRS-PosResource* within the active UL BWP of the UE.  When the configuration of SRS is done by the higher layer parameter *SRS-PosResource*, the UE can only be provided with a single RS source in *spatialRelationInfoPos* per SRS resource for positioning.  Subject to UE capability, the UE may be provided *useSameTxBeam* for an SRS resource set for positioning.  - If *useSameTxBeam* is set to 1, the UE is expected to use the same spatial domain transmission filter for the SRS resources for positioning configured with the same *spatialRelationInfoPos*.  - If *useSameTxBeam* is set to 0, the UE is expected to use different spatial domain transmission filters for the SRS resources for positioning configured with the same *spatialRelationInfoPos*.  For operation on the same carrier, if an SRS configured by the higher parameter *SRS-PosResource* collides with a scheduled PUSCH, the SRS is dropped in the symbols where the collision occurs.  Unless specified otherwise, the UE does not expect to be configured with *SRS-PosResource* on a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission.  Timing Error Group (TEG) at UE side is defined:  - UE Tx TEG is associated with the transmissions of one or more UL SRS resources for the positioning purpose, which have the Tx timing error difference within a certain margin.  ========================= Unchanged parts ========================= |

This proposal is already supported by Huawei, HiSilicon, China Unicom, ZTE Corporation, Sanechips.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

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| Company | Suppport (Y/N) | Comment |
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* 1. Link adaptation

Following proposal is made in the contribution.

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| [4] | In our testing of link adaptation with commercial NW and UE devices we encountered a problem with link adaptation for some devices, that degrades the downlink throughput in the system.  On the NW side, the target BLER for PDSCH transmissions is a parameter choice for the scheduler and the NW side target BLER is achieved using outer loop link adaptation (OLA), where the scheduled MCS for a UE is adjusted/fine-tuned using e.g., the historic ACK/NACK reported by the UE.  On the UE side, the UE shall report CQI according to the highest possible MCS with a BLER not exceeding 10% (if CQI Table 1 and 2 is configured) or 0,001% (if Table 3 is configured).  Our tests indicate that when the NW side target BLER target is different from the CQI BLER target, then throughput degrades for some devices compared to the case of aligned BLER targets. This should not be the case, since the CQI feedback according to BLER target, that is defined by specifications, should not be affected by the success or failure of ongoing PDSCH receptions.   1. Some UE devices seem to adapt the reported CQI based on the success/failure of ongoing PDSCH transmissions, which should not be the case as it causes interference with the convergence of the NW side outer loop link adaptation (OLA)   In Figure 1, is a time trace plot for the rank indicator (RI) and CQI for a commercial UE shown, captured at low SINR, using CQI Table 1 (10% BLER target) where the NW side BLER target is set to 10% and 1% respectively. It can be seen when NW BLER target and CQI BLER target is aligned (10%), then CQI report is stable (blue plot) and rank is also stable at RI=4 reporting.  However, when there is a mismatch as in the 1% case (orange plot), then the CQI and RI in the CSI report fluctuates heavily, which implies that the UE may (also) take the PDSCH ACK/NACK into account, since NW side OLA will lower the MCS to reach its 1% target, and the UE reacts to this and increase the CQI (which it shouldn’t).  グラフ  自動的に生成された説明グラフ  自動的に生成された説明  Figure 1 Rank indicator and time averaged CQI for a commercial UE when the CQI BLER target is 10% and the NW side BLER target is set to 10% (blue) and 1% (orange).  Another example is shown below where Table 3 is used (0,001% BLER target for CQI) and where the NW side BLER target is 10%. The reason why the NW side would like to use Table 3 is to extend the coverage, while still run with the “eMBB-range” BLER targets of 0,1% 1% or 10%.  Here it is seen that the UE is trying to lower the reported CQI (green curve) to reach its target 0,001% while at the same time the NW side is increasing the OLA offset (turquoise curve) to reach its target of 10%, hence the efforts by the UE and NW side adjustments are contradicting which causes unexpected events.  グラフ, ヒストグラム  自動的に生成された説明  Figure 2 Traces of parameters where CQI,RI is reported by the UE and OLA,BLER and MCS is parameters set by the NW side OLA.  Hence, there is a tug of war between NW OLA and UE CQI adaptation which causes disturbances and throughput degradation for the UE.  It is useful for app coverage (see Section 2) and cell edge UEs to use CQI table 3 (currently only for the 0,001% BLER target) without the very low URLLC based BLER target.  Also, based on the above observations of real world performance, it is useful if the NW side OLA BLER target and the UE side CQI BLER target is the same. Hence, we propose as a TEI-19:  Proposal 1 As a TEI-19, introduce an RRC parameter that indicates one target from a set of BLER targets [0.1, 0.01, 0.001, 0.0001, 0.00001] to be used for CQI reporting, independently of which CQI table is configured |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #6**

* **Introduce an RRC parameter that indicates one target from a set of BLER targets [0.1, 0.01, 0.001, 0.0001, 0.00001] to be used for CQI reporting, independently of configured CQI table.**

This proposal is already supported by Ericsson.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

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| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon | N | The motivation needs further justification: when a NW configures a CQI table 3 for e.g. coverage purpose while relaxes the target BLER, the achieved successfully decodable data (rate) will also be lower, which effectively means the coverage is not extended.  The issue needs more clarification: it is strange that a UE does not make CQI report based on the expected target BLER because normally it shall know that mismatch of CQI report vs scheduled MCS will lower its performance.  The technique needs to be further verified: even if the issue happens, it is not clear how the proposed solution can really restrict how UE derives the CQI w.r.t the BLER since it is UE implementation. |
| QC | No | Some history if my recollection is correct: Rel-16 URLLC discussed BLER for CQI calculation. The observation is that the BLER curve falls very quick with SNR so the SNR difference is very small between different BLER target, which is why those finer granularity BLERs (such as 0.01) for CQI were not introduced in Rel-16.  Now, coming back to this particular problem observed in field, we are open to have a discussion. But in our view, the root cause of the problem is some UEs implemented CQI calculation with an unnecessary input used to calculate CQI. Our view is that the correct fix is UE vendor change implementation (for future UEs) to stop to use that input in CQI calculation (By the way, for UEs already deployed, neither this proposal nor UE implementation based solution can fix them). We are not sure adding new CQI BLER target can solve the problem.  Plus, this proposal will force all UEs pass new CQI RAN4 tests, which seems unnecessary big burden for both standardization and implementation.  In summary, our view is this field problem can/should be fixed by UE implementation (to correct CQI calculation algorithm) transparent to 3GPP. |
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* 1. SRS carrier switching with uplink Tx switching

Following proposal is made in the contribution.

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| [5] | Uplink Tx switching between two uplink carriers was first specified in Rel-16, where the Tx chain would switch from one carrier to the other carrier when uplink switching is triggered. For the case of discussion in this subsection, let’s assume the following scenario, as shown in Fig. 1:   * UL Tx switching is configured between C1 and C2   + For example, (C1, C2) represents (carrier1, carrier2), i.e. C2 supports 2Tx where 1Tx can switch to CC1 * *SRS-CarrierSwitching* is configured between C2 and C3, where C3 is DL only   For this case, specification is not clear for the following aspects:   * Switching gap: RF tuning time depends on whether UE is supposed to switch from C1 to source (C2) and next switch from source to target (C3); or UE is capable to directly switch from C1 to C3. For this aspect, a new UE capability for switching gap may be needed. * Prioritization rules for SRS-CS: once RF tuning time is defined, following current specification overlapping is determined based on required time for SRS transmission plus switching time to/from target CC. Now the question is, if UE is not capable of simultaneous transmission of SRS-CS (including RF tuning times) and uplink transmission on C1 under Tx switching scenario, whether/how to update the prioritization rules in 38.214 Sec. 6.2.1.2 to consider uplink transmission on C1. Current prioritization rules do not consider the interaction between SRS-CS on target and uplink transmission on a band configured with ulTxswitch with source. * ulTxswitch state: UE and NW need to have same understanding on Tx switching state, after SRS-CS is performed. In the example shown in Fig.1, the state of Tx chain can be back to the that of before SRS-CS (1T+1T), or both Tx chains can go back to the source (0T+2T). This ambiguity needs to be discussed and resolved.   A screenshot of a computer  Description automatically generated  **Fig. 1:** **SRS-CS + ulTxswitch**  Based on the above discussion, the following is proposed:  ***Proposal 1: RAN1 to resolve ambiguities with SRS-CS+ulTxswitch for the following areas:***   * ***SRS-CS prioritization rules*** * ***Revisit switching times*** * ***Clarification of switching states after SRS-CS*** |
| [7] | In this scenario, the UE is configured with a set of CCs for uplink tx switching (2 CCs in the baseline) and one carrier with SRS carrier switching. This scenario is depicted in Figure 5 below:  CC1  CC2  CC3  UL Tx switching  SRS CS  TDD CC, no PUSCH/PUCCH  Figure 5 SRS carrier switching together with uplink Tx switching.  In this example, CC1 and CC2 are in an “uplink Tx switching” pair, while CC3 is a TDD carrier without PUSCH/PUCCH. CC3 is a target carrier for SRS carrier switching, with CC2 being the corresponding source carrier.  **Determination of switching time:**  For determining the switching time we differentiate between the following two cases:   * **Case 1**: The switching state before SRS carrier switching is triggered is such that the source carrier (CC2 in Figure 5) has enough ports to cover the transmission in the target carrier (CC3 in Figure 5). In this case, the switching entails the same operation as if CC1 did not exist and, therefore, the switching time should be given by *switchingTimeUL.* * **Case 2**: In this case, the source carrier does not have enough ports to cover the transmission in the target carrier. The switching in this case entails moving one of the ports from CC2 to CC3 and another one of the ports from CC1 to CC3 (for which there is no indicated capability), or one or two ports from CC1 to CC2 (for which also there is no indicated capability). We propose to define the switching time as *switchingTimeUL +* , with the uplink Tx switching time (which would be equivalent to moving the chains first from CC1 to CC2 during *+* , and then from CC2 to CC3 using *switchingTimeUL*).   **Switching state after SRS carrier switching:**  SRS carrier switching and uplink Tx switching follow a different framework: while SRS carrier switching is “state-less” (the transmit chains are returned immediately to the source carrier after SRS transmission), uplink Tx switching has state (the transmit chains remain in a carrier until another transmission is scheduled in a different carrier). Therefore, it is necessary to define what is the state of uplink Tx switching after the SRS transmission. For specification simplicity, and given the time to switch from CC3🡺CC1 will be larger than the time to switch from CC3🡺CC2 (as explained in the subsection above), we propose that after SRS carrier switching all the chains are returned to CC2.  **Simultaneous transmission:**  For this issue, we propose to introduce a new capability with a similar structure to *srs-SwitchingAffectedBandsListNR-r17*: for each pair of source-target carriers with SRS carrier switching, the UE indicates which other carriers are interrupted. We propose to separate whether the interruption applies to uplink, downlink or both.  If the new capability indicates that no simultaneous transmission is possible, the conflicting transmissions should be included in the prioritization rules of TS 38.214, 6.2.1.3.  In case the new capability indicates that simultaneous transmission is possible, the situation is a bit more complicated since the UE is still limited to 2 transmit chains overall. Therefore, even in the case where the UE indicates capability for simultaneous transmission, prioritization should be applied if the total number of ports across the multiple CCs exceeds 2:   * If the SRS transmission has 2 ports, then no simultaneous transmission in any other carrier is possible and, therefore, all the carriers operating in UL Tx Switching group are included in the prioritization. * If the SRS transmission has 1 port and there is a conflicting transmission with 2 ports, the carrier with the conflicting transmission is included in the prioritization. * If the SRS transmission has 1 port and there is a conflicting transmission with 1 port, both are transmitted simultaneously.   The above approaches are summarized in the following proposal:  **Proposal 5:** **For simultaneous configuration of SRS carrier switching and uplink Tx switching, for an SRS carrier switching pair between CC1 in B1 (source) and CC2 in B2 (target), with an N-port SRS transmission in CC2:**   * **For SRS switching time:**   + **If the SRS transmission in CC2 includes N SRS ports, and the UE is under the operation state in which N-port transmission can be supported in B1, the SRS switching time is given by *switchingTimeUL*** **corresponding to a switch between CC1 and CC2.**   + **Otherwise, the retuning time is given by *switchingTimeUL +* , with corresponding to an N-port transmission in CC1 from the current switching state** * **For switching state after SRS transmission:**   + **The switching state is such that all N transmit chains are returned to CC1 after the SRS transmission.**   + **The switching time from CC2 to CC1 is given by *switchingTimeUL*.** * **For simultaneous transmission:**   + **Introduce a new UE capability (similar to *srs-SwitchingAffectedBandsListNR-r17* but indicating separately UL and DL interruption) that indicates whether an SRS switch B1🡺B2 interrupts any other band in the band combination.**   + **For the case where the new capability indicates simultaneous transmission is not possible, physical channel prioritization as defined in TS 38.214, 6.2.1.3 always applies.**   + **For the case where the new capability indicates simultaneous transmission is possible, physical channel prioritization as defined in TS 38.214, 6.2.1.3, applies as follows:**     - **For a 2-port transmission in B2, all the carriers operating in UL Tx Switching are included in the prioritization.**     - **For a 1-port transmission in B2, a transmission in a third band B3 is included in the physical channel prioritization if the total number of ports across B2 and B3 exceeds 2.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #7**

* **For simultaneous configuration of SRS carrier switching and uplink Tx switching, for an SRS carrier switching pair between CC1 in B1 (source) and CC2 in B2 (target), with an N-port SRS transmission in CC2:**
  + **For SRS switching time:**
    - **If the SRS transmission in CC2 includes N SRS ports, and the UE is under the operation state in which N-port transmission can be supported in B1, the SRS switching time is given by switchingTimeUL corresponding to a switch between CC1 and CC2.**
    - **Otherwise, the retuning time is given by switchingTimeUL + N\_(Tx1-Tx2), with N\_(Tx1-Tx2) corresponding to an N-port transmission in CC1 from the current switching state.**
  + **For switching state after SRS transmission:**
    - **The switching state is such that all N transmit chains are returned to CC1 after the SRS transmission.**
    - **The switching time from CC2 to CC1 is given by switchingTimeUL.**
  + **For simultaneous transmission:**
    - **Introduce a new UE capability (similar to srs-SwitchingAffectedBandsListNR-r17 but indicating separately UL and DL interruption) that indicates whether an SRS switch B1 to B2 interrupts any other band in the band combination.**
    - **For the case where the new capability indicates simultaneous transmission is not possible, physical channel prioritization as defined in TS 38.214, 6.2.1.3 always applies.**
    - **For the case where the new capability indicates simultaneous transmission is possible, physical channel prioritization as defined in TS 38.214, 6.2.1.3, applies as follows:**
      * **For a 2-port transmission in B2, all the carriers operating in UL Tx Switching are included in the prioritization.**
      * **For a 1-port transmission in B2, a transmission in a third band B3 is included in the physical channel prioritization if the total number of ports across B2 and B3 exceeds 2.**

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon |  | The UE capability *srs-SwitchingAffectedBandsListNR* can indicate interrupted bands including the band sharing UL Tx chain with the source band of SRS carrier switching*.* As a result, it has been supported that a UE is configured with two-band UL Tx switching and SRS carrier switching on the third and the forth bands. In the example from proponents, the CC3 can be indicated as “affected” for the band pair {CC3, CC2}. |
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* 1. SRS carrier switching in UL CA

Following proposal is made in the contribution.

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| --- | --- |
| [5] | The main question to be addressed here is whether/how to extend UL CA capabilities to the case of simultaneous SRS-CS on target and UL transmission on another band, not impacted by SRS transmission on target. Consider Figure 2 as an example. If UE indicates 22-5d (or 22-5c) for simultaneous transmission of SRS for antenna switching and SRS for antenna switching for inter (or intra) band UL CA in that band combination, how/whether such capability is applicable when C0 is configured to be source, C1 is target (PUSCH-less) and C2 is inter (or intra) band with C1.  A screenshot of a computer  Description automatically generated  **Fig. 2:** **SRS-CS + ULCA**  ***Proposal 2: RAN1 to determine under what conditions UL-CA capabilities involving SRS transmission for antenna switching on target may be applicable between target and another CC.*** |
| [7] | This issue was brought up originally in [6, Section 2.2]. The scenario is as follows:   * CC2 is the source carrier for SRS CS in CC1. * CC4 is the source carrier for SRS CS in CC3.   The specification gap is to clarify (or add a UE capability) on whether the UE perform simultaneous switching and transmission from CC2🡺CC1 and CC4🡺CC3. This scenario is depicted in Figure 6:  A diagram of a rectangular object  Description automatically generated  Figure 6 ULCA + SRS CS with simultaneous switching (from [6])  **Proposal 4: RAN1 to solve the following specification gaps for SRS carrier switching during Rel-19 TEI:**   * **For uplink CA + SRS carrier switching:**   + **Define rules for simultaneous transmission across two target CCs for SRS carrier switching**   We propose to introduce a new Rel-19 UE capability with a similar structure to indicate whether the UE supports simultaneous switching of multiple source-target pairs. RAN1 can discuss whether the legacy capability can be reused (by also allowing to indicate bands that are DL-only with SRS CS) or a new capability with similar structure is to be introduced.  **Proposal 6: Introduce a new UE capability that indicates whether a UE can simultaneously perform SRS carrier switches (e.g. an SRS carrier switch CC1🡺CC2 and CC3🡺CC4)**   * **The new capability is per band combination.** * **Take as baseline the capability *srs-SwitchingAffectedBandsListNR-r17* for this indication.** * **Two SRS carrier switches are considered to be simultaneous if the SRS transmission (including RF retuning time) in both CCs totally or partially overlap in time.** * **A UE that indicates it is not capable of simultaneous SRS carrier switching among a set of switching pairs is not expected to be configured / scheduled with simultaneous SRS carrier switching in the set of switching pairs.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #8**

* **Introduce a new UE capability that indicates whether a UE can simultaneously perform SRS carrier switches (e.g. an SRS carrier switch CC1 => CC2 and CC3 => CC4).**
  + **The new capability is per band combination.**
  + **Take as baseline the capability srs-SwitchingAffectedBandsListNR-r17 for this indication.**
  + **Two SRS carrier switches are considered to be simultaneous if the SRS transmission (including RF retuning time) in both CCs totally or partially overlap in time.**
  + **A UE that indicates it is not capable of simultaneous SRS carrier switching among a set of switching pairs is not expected to be configured / scheduled with simultaneous SRS carrier switching in the set of switching pairs.**

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon | N | It has been covered by R17 UE capability (FG 39-3-2) *SwitchingAffectedBandsListNR*. If it is not indicated, the transmission on the CC2 is not impacted by the SRS transmission on CC4. Otherwise, concurrent SRS transmissions on CC2 and CC4 are allowed. Additionally, the other UE capability FG 22-5d is not applicable to any band indicated for SRS carrier switching. Therefore, the proposal seems unnecessary. Clarifications from proponents are appreciated. |
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* 1. Consideration on the power constraint for type II codebook

Following proposal is made in the contribution.

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| --- | --- |
| [6] | Fig. 3 illustrates the gain achieved by the proposal for the subcase , by taking into account the effective configuration of the gNodeB in terms of the power that can be transmitted from the configured APs.    Figure 3: Proposal evaluation for eType-II codebook for CDL-C 363ns  **Observation 6: If the UE is provided a power offset to determine the maximum EPRE per antenna port, the performance related to the CSI feedback is significantly improved.**  **Proposal 1: For computing the CSI of Enhanced Type II Codebook, Enhanced Type II Port Selection Codebook and their evolutions, namely, Further enhanced Type II port selection codebook, Enhanced Type II codebook for predicted PMI, Further enhanced Type II port selection codebook for predicted PMI, in order to fully exploit the local power constraints of each power amplifiers (PAs) in gNodeB, the UE should assume the RRC configured power offsets/constraints per CSI-RS antenna port while calculating CSI feedback.**   * **Introduce** **RRC Information Element DeltaPower containing an offset *DeltaPowerPerAP* (for each CSI-RS antenna port for channel measurement for CSI computation of the enhanced Type-II codebooks listed above such that the PDSCH EPRE P across the antenna ports assumed by the UE verifies**  * + **is the nominal EPRE** **across the antenna ports,**   + **is the precoder, from a non-constant modulus codebook, coefficient associated to antenna port and spatial layer,** * **Note:** above does not imply specific PA architecture implementation in gNodeB   **Proposal 2: For computing the CSI of Enhanced Type II Codebook, Enhanced Type II Port Selection Codebook and their evolutions, namely, Further enhanced Type II port selection codebook, Enhanced Type II codebook for predicted PMI, Further enhanced Type II port selection codebook for predicted PMI, in order to fully exploit the local power constraints of each power amplifiers (PAs) in gNodeB, the UE should assume the RRC configured power offset/constraint per CSI-RS antenna port while calculating CSI feedback.**   * **Introduce a single RRC parameter such that the** **PDSCH EPRE P across the antenna ports assumed by the UE is where**  * + **is the nominal EPRE across the antenna ports,**  * + **is the precoder, from a non-constant modulus codebook, coefficient associated to antenna port and spatial layer,**   **for CSI computation of the enhanced Type-II codebooks listed above.**   * **Note:** above does not imply specific PA architecture implementation in gNodeB   **Observation 7: The proposal includes the legacy CSI computation, for example, in absence of the RRC power offset(s) Information Element, the CSI computation by the UE considers the global power constraint only, i.e., the (maximum) nominal EPRE across the antenna ports.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #9**

* **For enhanced type II codebook, enhanced type II port selection codebook, and their evolutions, introduce the following RRC parameter.**
* **Opt1: RRC parameter DeltaPower containing an offset *DeltaPowerPerAP* (for each CSI-RS antenna port such that the PDSCH EPRE P across the antenna ports assumed by the UE verifies for CSI computation.**
* **Opt2: RRC parameter such that the PDSCH EPRE P across the antenna ports assumed by the UE is for CSI computation.**

**Where is the nominal EPRE across the antenna ports, and is the precoder, from a non-constant modulus codebook, coefficient associated to antenna port and spatial layer.**

This proposal is already supported by Orange, ZTE, BT.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Apple | N | We acknowledge that the per antenna/CSI-RS port power limitation may exist for some operators. However, the proposed solution can significantly increase the UE implementation complexity and not suitable for Rel-19 TEI. |
| Huawei, HiSilicon |  | There are several issues regarding the proposal.  It’s very difficult for gNB to configure one particular , because at different slots, network may use different due to power boosting of some channels (PDCCH, PDSCH for some particular UE etc.). This will make the UE calculation of power allocation is different from the real power allocation, resulting in performance loss.  UE complexity of CSI processing will be increased a lot if LPC is considered. |
| Orange |  | @HW, Apple  Proposal 1 and 2 offer an additional complexity which is low. The UE additional complexity is to compute for each rank conditional on the selected PMI and for each sub-band  the power backoff  given by the formulas and for proposal 1 and 2, respectively. This power backoff is then used to optimize the MCS and the rank in order to maximize the throughput @BLER\_target 10%. Note that the PMI selection where lies most of the complexity is NOT impacted.  @HW  It is very difficult to configure the nominal EPRE across the antenna ports, but we do it. For a high number of TXRUs, the solution to over-dimension the PA such that the LPCs can be neglected does not sound cost efficient. The proposal aim is to allow some trade off here.  “GPC@UE + backoff @BS ΔP\_0=x dB” corresponds to a CSI computation at the UE which considers the GPC only, the gNodeB applies directly the feedback CSI but needs to correct the transmission power such that the transmit power per antenna port do not exceed with x=0, 1, 1.5, 2, 3 dB.    If the feedback CSI is mismatched from a power perspective, the gNodeB needs to over-dimension more its PAs compared to the matched case. |
| Lenovo/ MotM |  | Agree with Apple, HW. We acknowledge the issue however the proposed solution further complicates the process and limits the NW flexibility in dynamically changing this RRC configured per port PCO |
| ZTE | Y | We identify the benefit for DL CSI, while considering the margin of TX power for gNB antenna port. Regarding UE complexity, it may be much relevant to final CQI calculation and can be well handled. |
| Spreadtrum | N | We also have similar view as Apple and Lenovo. Besides, our initial thought is that the power backoff can be added to a CSI-RS resource by gNB implementation when the CSI-RS resource is transmitted for Type-II codebook calculation. |
| Qualcomm |  | We are not sure what is expected for UE to utilize of each port, for the proposed config.  We have two understandings:   1. Restrictions on PMI coefficient when UE does SVD. 2. Mainly impact CQI report, and improve link adaptation convergency faster with more accurate CQI/MCS.   If it is 1), we think UE complexity is very high, and would like the proponent companies to elaborate more;  If it is 2), we have questions for the performance curve: How to understand SE v.s. SNR curve for link adaptation simulation? |

* 1. SR triggered SSSG fallback

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | In Rel-17, when PDCCH skipping is configured for a UE, an SR transmission from the UE during a PDCCH skip duration can override the previous PDCCH skipping indication, allowing the UE to resume PDCCH monitoring.  In addition to PDCCH skipping, Rel-17 introduces search space set group (SSSG) switching, another UE power-saving feature for licensed bands. For instance, a UE configured with two SSSGs may have the first SSSG set for frequent PDCCH monitoring and the second SSSG for sparse PDCCH monitoring. In heavy traffic situations, the UE may be instructed to monitor PDCCH according to the first SSSG. Conversely, for power saving, the UE may be instructed to monitor PDCCH according to the second SSSG. If an SR is pending while the UE is monitoring PDCCH according to the first (dense) SSSG, the UE would receive a PDCCH scheduling an UL transmission soon after the SR transmission. However, if the UE is monitoring PDCCH according to the second (sparse) SSSG, the next PDCCH monitoring occasion would be far apart from the SR occasion, increasing the latency of the first PUSCH transmission after the SR. Furthermore, after the UE transmits a BSR on the first PUSCH, it will expect additional UL grants to clear the buffer if the first UL grant is insufficient. Thus, unless the UE is instructed to switch to the first SSSG by the PDCCH carrying the first UL grant, the latency for the entire UL traffic burst would increase.  To address the UL latency issue, the SR overriding (SRO) feature for PDCCH skipping should be extended to SSSG switching. This means that an SR transmission should be allowed to override SSSG switching as well as PDCCH skipping to avoid delaying the UL transmission.  In Figure 1, the relationship between power saving gain over the baseline and latency is shown for the three PDCCH monitoring adaptation schemes. In Figure 1(a), it is observed that at the same power saving gain, SRO significantly improves the UL latency of SSSG switching. Additionally, with SRO, SSSG switching achieves the same power saving gain vs. latency trade-off as PDCCH skipping. Interestingly, in Figure 1(b), it is observed that SRO can also improve the DL latency of SSSG switching.  (a)  (b)  Figure 1: Power saving gain vs. latency: (a) uplink latency, (b) downlink latency.  Proposal 1: If a UE is instructed to monitor PDCCH according to search space sets with a group index other than a designated index, the UE stops PDCCH monitoring according to search space sets with the group index and start PDCCH monitoring according to search space sets with the designated group index from the first slot that is at least symbols after the last symbol of a PUCCH carrying an SR. |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #10**

* **Support the following search space set group switching.**
  + **If a UE is instructed to monitor PDCCH according to search space sets with a group index other than a designated index, the UE stops PDCCH monitoring according to search space sets with the group index and start PDCCH monitoring according to search space sets with the designated group index from the first slot that is at least symbols after the last symbol of a PUCCH carrying an SR.**

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon |  | There are proposals in Rel-17/18 CR discussion (R1-2408709) to propose the same thing. We can discuss this issue there.  We are open to discuss this but some technique issue needs to be resolved at the same time. If the SR is miss-detected or falsely detected, it would cause the gNB and UE have miss-alignment with respect to the used SSSG. This should be resolved/minimized at the same time if the proposal is adopted e.g. by requiring SSSG#1 (the sparsely monitored SSSG) as the subset of search spaces of SSSG#0 (the densely monitored SSSG). |
|  |  |  |
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* 1. PTRS rate matching for multi-DCI based multi-TRP

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [7] | For two overlapping PDSCHs in Rel-16 mDCI based mTRP, it is already ensured that there is no collision among DMRS-DMRS, DMRS-data, and data-DMRS. In addition, network needs to ensure DMRS symbol alignment.  However, PTRS of one PDSCH always overlaps with data of another PDSCH in case of overlapping PDSCHs. This degrades the performance in FR2 especially for higher MCS, which is the main target use case for multi-DCI based multi-TRP, i.e., throughput enhancements. Obviously, the need for clean PTRS to match the performance of DMRS channel estimation is critical for FR2 in high throughput / high MCS scenarios.  To address this issue, PDSCH of one TRP needs to be rate-matched around PTRS of the other TRP as illustrated in Figure 1. For this, multiple options are imaginable. We briefly discuss these options below, and then propose our preferred solution.  As a first option, UE can decode both DCIs, and determine the REs containing PTRS for each of the two TRPs. Based on that, PDSCH of one TRP is rate matched around PTRS of the other TRP too. However, this option is not preferred as it has reliability issues. That is, if UE misses the DCI of one TRP, the PDSCH of the other TRP cannot be decoded too due to incorrect rate matching assumption. Furthermore, this means that UE needs to process two DCIs first in order to be able to decode either of the two PDSCHs, which increases UE complexity and is also not consistent with Rel-16 restriction of “When the UE is scheduled with full/partially/non-overlapped PDSCHs in time and frequency domain, the full scheduling information for receiving a PDSCH is indicated and carried only by the corresponding PDCCH”.  As a second option, each scheduling DCI can indicate the presence/absence of PTRS from the other TRP as well as the rate matching pattern if other TRP’s PTRS is present. That is, the indication becomes self-contained in the scheduling DCI. This option is preferred since it does not have any reliability issue and is consistent with Rel-16 principle mentioned above.  **Observation 2: To address the issue discussed above, a preferred solution is to indicate rate matching pattern for PTRS of the other TRP (of the other overlapping PDSCH) to make the scheduling DCI self-contained.**  It should be noted that for ideal backhaul case, there is no issue at the network side for indicating such information. For non-ideal backhaul, TRPs can coordinate semi-statically, which is similar to Rel-16 restrictions with respect to no DMRS-DMRS and DMRS-data collision as well as DMRS alignment.  Such indication (rate matching pattern for PTRS of the other TRP) comes at the cost of signaling overhead (DCI overhead). Hence, a proper trade-off between the flexibility of such indication and DCI overhead would be needed to efficiently address the issue for practical scenarios.  The location of PTRS REs of the other TRP is a function of FDRA of the other PDSCH (determines frequency density of PTRS, and RBs with PTRS REs), MCS of the other PDSCH (determines time density of PTRS), and associated DMRS port of the other PTRS (determines RE offset within RB). Obviously, indicating all of these in a scheduling DCI about the other overlapping PDSCH is not a practical choice, i.e., full flexibility is not realistic. Hence, we need to focus on the most useful / practical scenarios. For this, we suggest the following:   * Focus on fully-overlapping PDSCHs. With this assumption, the RBs that contain PTRS REs for a given TRP are the same as the RBs that contain PTRS REs for the other TRP. This is because both RB indexing as well as frequency density of PTRS would be the same for both PDSCHs. This scenario is anyway the most practical deployment choice for multi-DCI based multi-TRP for throughput enhancement. * The PTRS time density () of the other TRP for the purpose of rate matching is RRC-configured to the UE. This way, network can configure this parameter based on the worst-case assumption (densest PTRS in time domain) in case of overlapping PDSCHs, which may be different than the densest possible PTRS in time when two PDSCHs are non-overlapping (e.g., if network uses higher MCS for non-overlapping PDSCHs).   With the restrictions above that effectively result in unique determination of RB-symbol level PTRS pattern, there are 11+1=12 possibilities for PTRS RE within an RB for the other PDSCH (11 possible REs offsets excluding the RE offset of PDSCH’s own PTRS, and another possibility to indicate that the PTRS is not present for the other PDSCH). This indication requires 4 bits in scheduling DCI. While we are open to discussions to further reduce the flexibility by adding more restrictions in order to decrease the DCI overhead further, we think 4 bits in scheduling DCI is a reasonable choice for this functionality. These 4bits of a new DCI field “Rate matching indicator for interfering PTRS” can be interpreted as shown in Table 1.  Table 2: DCI field “Rate matching indicator for interfering PTRS”.   |  |  | | --- | --- | | Value of the fields “Rate matching indicator for interfering PTRS” | RE offset relative to in 38.211 Section 7.4.1.2.2 | | 0 | This value indicates no rate matching (i.e., interfering PTRS is absent) | | 1 | 1 | | 2 | 2 | | … | … | | 11 | 11 | | 12 | reserved | | … | … | | 15 | reserved |   Hence, we have the following proposal for this issue:  **Proposal 2:** **Support DCI format 1\_1 that schedules a PDSCH to indicate a set of REs for rate matching through a new DCI field “Rate matching indicator for interfering PTRS”.**   * **This feature is enabled by a new RRC configuration and is subject to a new UE capability.**   + **Note 1: This feature can be configured in a CC that is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*.**   + **Note 2: The set of REs correspond to PTRS REs of another PDSCH that fully overlaps with this PDSCH. However, the rate matching for this PDSCH is followed irrespective of whether UE detects another DCI scheduling the other PDSCH.** * **The set of REs for rate matching is determined as follows:**   + **OFDM symbols for the set of REs are based on the set of time indices defined in Section 7.4.1.2.2 of 38.211 by replacing with a new RRC parameter that configures one value among {1,2,4}.**   + **Subcarriers for the set of REs are given by , where**     - **is given by the DCI field “Rate matching indicator for interfering PTRS” based on Table 1 above.**   **All other parameters are defined in Section 7.4.1.2.2 of 38.211.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #11**

* **Support DCI format 1\_1 that schedules a PDSCH to indicate a set of REs for rate matching through a new DCI field “Rate matching indicator for interfering PTRS”.**
  + **This feature is enabled by a new RRC configuration and is subject to a new UE capability.**
    - **Note 1: This feature can be configured in a CC that is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*.**
    - **Note 2: The set of REs correspond to PTRS REs of another PDSCH that fully overlaps with this PDSCH. However, the rate matching for this PDSCH is followed irrespective of whether UE detects another DCI scheduling the other PDSCH.**
  + **The set of REs for rate matching is determined as follows:**
    - **OFDM symbols for the set of REs are based on the set of time indices defined in Section 7.4.1.2.2 of 38.211 by replacing with a new RRC parameter that configures one value among {1,2,4}.**
    - **Subcarriers for the set of REs are given by , where**
      * **is given by the DCI field “Rate matching indicator for interfering PTRS” based on the following table.**
      * **All other parameters are defined in Section 7.4.1.2.2 of 38.211.**
* Table: DCI field “Rate matching indicator for interfering PTRS”.

|  |  |
| --- | --- |
| Value of the fields “Rate matching indicator for interfering PTRS” | RE offset relative to in 38.211 Section 7.4.1.2.2 |
| 0 | This value indicates no rate matching (i.e., interfering PTRS is absent) |
| 1 | 1 |
| 2 | 2 |
| … | … |
| 11 | 11 |
| 12 | reserved |
| … | … |
| 15 | reserved |

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | We don’t think the main target of multi-DCI based multi-TRP is for FR2.  The main target of multi-DCI based multi-TRP is non-ideal backhaul between TRPs. Thus, the proposed solution using fast/timely DCI information exchange between TRPs is difficult.  For non-synchronized MTRP scenario, the full-overlapping PDSCHs are not synchronized. Thus, the effectiveness of PTRS rate matching could not fully resolve the interference issue. |
| Huawei. Hisilicon | N | We have some concerns on the TEI CR.   1. It introduces an RRC configured time density of PTRS in addition to legacy MCS based time density. As the quality of the channel may change dynamically, RRC configured time density would lead to performance degradation on PTRS estimation comparing to legacy MCS based time density of PTRS. 2. It does not solve the issue: how one TRP can know the PTRS RB density of the other TRP. PTRS RB density is calculated based on RB allocation of PDSCH which is dynamical. One TRP cannot know such dynamic information of the other TRP, as mDCI mTRP targets for non-ideal backhaul scenario.   The spec impact is big as, in addition to rate match of PDSCH, it also changes both time and frequency resource mapping rule of PTRS. |
| Spreadtrum | N | It is not clear on the performance loss when PTRS overlaps with data from another TRP. Also, since PTRS rate matching will reduce the available RE for data, it is not clear how much the scheduling performance can be improved with PTRS rate matching. |
| QC | Y | @DCM @Huawei, the main target use case for mDCI mTRP is for throughput enhancement, it is targeted for both non-ideal backhaul and non-ideal backhaul. That’s why we introduce both separate HARQ-ACK feedback and joint HARQ-ACK feedback for mDCI mTRP in Rel.16.  @ Huawei, regarding your concern on how one TRP can know the PTRS RB density of the other TRP. For ideal backhaul case, there is no issue at the network side for indicating PTRS rate matching pattern. For non-ideal backhaul, TRPs can coordinate semi-statically, which is similar to Rel-16 restrictions with respect to no DMRS-DMRS and DMRS-data collision as well as DMRS alignment.  In addition, we think this issue is critical because currently PTRS of one PDSCH always overlaps with data of another PDSCH in case of overlapping PDSCHs. This degrades the performance in FR2 especially for higher MCS, which is the main target use case for multi-DCI based multi-TRP, i.e., throughput enhancements. |

* 1. 8-Tx coherent precoder codebook enhancement

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [7] | Rel-18 8Tx coherent codebook was designed to be DFT codebook. The codebook is specified with the following two caveats.   * The size of codebook size for the case of (N1=4, N2=1) is 120, which is less than 128. There are unused codepoints with 7 bits in DCI anyway. * In the codebooks for both cases of (N1=4, N2=1) and (N1=2, N2=2), there are redundant precoders which are essentially identical (with only column swap).  |  |  |  |  | | --- | --- | --- | --- | |  | #precoders in current spec | # redundant precoders in current spec | Gap to codebook size 128 | | (N1=4, N2=1) | 120 | 13 | 21 | | (N1=2, N2=2) | 128 | 17 | 17 |   There were study results (e.g., R1-2310133) in Rel-18 WI showing DFT codebook is vulnerable to Tx phase misalignment. To improve the robustness of the codebook, we could utilize those unused codepoints and replace those duplicated precoders by non DFT precoders.  **Proposal 3: Adopt the following update to 8Tx full coherent codebook**   * **Remove the 13 redundant precoders in 8 TX fully coherent codebook with (N1=4, N2=1). Add 21 nonDFT precoders to the codebook as in Table 3.** * **Remove the 17 redundant precoders in 8 TX fully coherent codebook with (N1=2, N2=2). Add 17 nonDFT precoders to the codebook as in Table 4.**   Table 3: UL 8Tx size 128 hybrid CB (107 DFT precoders + 21 nonDFT precoders) for ULA (N1=4, N2=1) layout   |  |  |  |  | | --- | --- | --- | --- | | Rank | # precoders | Constructed Hybrid codebook | | | DFT precoders | NonDFT precoders | | Rank 1 | 16 | Size 16: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0 | | Rank 2 | 47 | Size 32: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, , | Size 15: | | Rank 3 | 27 | Size 24: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, , | Size 3: | | Rank 4 | 15 | Size 12: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, , | Size 3: | | Rank 5 | 8 | Size 8: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0 | | Rank 6 | 8 | Size 8: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0: | | Rank 7 | 4 | Size 4: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0: | | Rank 8 | 3 | Size 3: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0: | | Sum | 128 | 107 | 21 |     Table 4: UL 8Tx size 128 hybrid CB (111 DFT precoders + 17 nonDFT precoders) for UPA (N1=2, N2=2) layout   |  |  |  |  | | --- | --- | --- | --- | | Rank | # precoders | Constructed Hybrid codebook | | | DFT precoders | NonDFT precoders | | Rank 1 | 16 | Size 16: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0 | | Rank 2 | 45 | Size 32: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, , | Size 13: | | Rank 3 | 26 | Size 24: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, , | Size 2: | | Rank 4 | 14 | Size 12: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, , | Size 2: | | Rank 5 | 8 | Size 8: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0 | | Rank 6 | 8 | Size 8: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0: | | Rank 7 | 8 | Size 8: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0: | | Rank 8 | 3 | Size 3: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0: | | Sum | 128 | 111 | 17 | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #12**

* **Adopt the following update to 8Tx full coherent codebook.**
  + **Remove the 13 redundant precoders in 8 TX fully coherent codebook with (N1=4, N2=1). Add 21 nonDFT precoders to the codebook as in Table 1.**
  + **Remove the 17 redundant precoders in 8 TX fully coherent codebook with (N1=2, N2=2). Add 17 nonDFT precoders to the codebook as in Table 2.**

Table 1: UL 8Tx size 128 hybrid CB (107 DFT precoders + 21 nonDFT precoders) for ULA (N1=4, N2=1) layout

|  |  |  |  |
| --- | --- | --- | --- |
| Rank | # precoders | Constructed Hybrid codebook | |
| DFT precoders | NonDFT precoders |
| Rank 1 | 16 | Size 16: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0 |
| Rank 2 | 47 | Size 32: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, , | Size 15: |
| Rank 3 | 27 | Size 24: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, , | Size 3: |
| Rank 4 | 15 | Size 12: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, , | Size 3: |
| Rank 5 | 8 | Size 8: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0 |
| Rank 6 | 8 | Size 8: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0: |
| Rank 7 | 4 | Size 4: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0: |
| Rank 8 | 3 | Size 3: CodebookMode=1, N1=4, N2=1, O1=1, O2=1, | Size 0: |
| Sum | 128 | 107 | 21 |

Table 2: UL 8Tx size 128 hybrid CB (111 DFT precoders + 17 nonDFT precoders) for UPA (N1=2, N2=2) layout

|  |  |  |  |
| --- | --- | --- | --- |
| Rank | # precoders | Constructed Hybrid codebook | |
| DFT precoders | NonDFT precoders |
| Rank 1 | 16 | Size 16: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0 |
| Rank 2 | 45 | Size 32: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, , | Size 13: |
| Rank 3 | 26 | Size 24: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, , | Size 2: |
| Rank 4 | 14 | Size 12: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, , | Size 2: |
| Rank 5 | 8 | Size 8: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0 |
| Rank 6 | 8 | Size 8: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0: |
| Rank 7 | 8 | Size 8: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0: |
| Rank 8 | 3 | Size 3: CodebookMode=1, N1=2, N2=2, O1=1, O2=1, | Size 0: |
| Sum | 128 | 111 | 17 |

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | It was proposed in Rel.18 8Tx, but no agreement was made.  Regarding to the evaluation result, we think companies had different views on “DFT codebook is vulnerable to Tx phase misalignment” in Rel-18. |
| ZTE | N | Share the same views as DOCOMO. |
| Spreadtrum | N | There’s no urgent need to optimize the 8 Tx codebook, we don’t prefer to have this enhancement. |
| Qualcomm | Yes | To Docomo: “DFT codebook is vulnerable to Tx phase misalignment” – this is similar to the UE assisted CJT CB calibration that Rel-19 is specifying. If DL DFT codebook is sensitive to Tx phase error, the same would happen at UL. Plus, UL Tx phase alignment current requirement at RAN4 is pretty loose, which allowed +/- 180 degrees. This essentially means no Tx phase alignment at UL Tx in our view. |

* 1. Dynamic fallback for SRS antenna switching

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | For a scenario of uplink switching, a UE needs to switch Tx chain between FDD carrier and TDD carrier(s) based on scheduling DCIs received on FDD and TDD carrier respectively. In an example scenario of one FDD carrier plus one TDD carrier configured for a 2Tx UE. One Tx chain will switch between FDD carrier and TDD carrier. With this Tx chain switching, the TDD carrier can be with 1 Tx or 2Tx from time to time.  SRS AS can be enabled on TDD carrier(s) in a Tx switching scenario. When periodic 2T4R SRS AS is configured, the UE needs to switch periodically both Tx chains to TDD carrier(s) just to send the SRS. Due to both Tx are switched to TDD carrier(s), there is no Tx chain to perform uplink transmission on FDD carrier.    Figure 7: An example that 2T4R SRS AS block FDD UL.  A solution to resolve this issue is allowing UE to fallback from 2T4R to 1T4R dynamically, based on the uplink Tx switching status. In other words, a UE performs the uplink Tx switching procedure nominally as if there is no SRS antenna switching is configured. When the UE needs to do SRS antenna switching on a TDD carrier, it simply checks how many Tx chain currently available on the TDD carrier (based on the uplink Tx switching). If 2Tx chains are available for the TDD carrier, it performs 2T4R. Otherwise, the UE performs 1T4R antenna switching on that TDD carrier.  **Proposal 7:  For a UE supporting UlTxSw and 2T4R SRS antenna switching, subject to a dedicated UE capability, the UE dynamically fallback to 1T4R antenna switching based on UlTxSw status, i.e., the UE performs 2T4R antenna switching on TDD carrier(s) if 2T are available; otherwise the UE performs 1T4R antenna switching.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #13**

* **For a UE supporting UlTxSw and 2T4R SRS antenna switching, support the UE dynamic fallback to 1T4R antenna switching based on UlTxSw status subject to a dedicated UE capability**
  + **i.e., the UE performs 2T4R antenna switching on TDD carrier(s) if 2T are available; otherwise the UE performs 1T4R antenna switching.**

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon | N | Given that the UL traffic on FDD band is dynamic, the proposed dynamic fallback may happen irregularly, which makes gNB-side implementation over-complicated.  If UL traffic on FDD band is the one being attached great importance, a simple solution is just configure 1T4R; while if SRS transmission on TDD band is the one, a simple solution is just configure 2T4R (taking the SRS periodicity into consideration, the mentioned ‘overlap’ will not happen that frequently), which means the proposed issue is not essential. |
| QC | Y | To Huawei: Of course, gNB can do static configuration as in your comment. But the motivation of the proposal is providing more flexibility to better utilize the resources on both TDD and FDD. |
|  |  |  |

* 1. EPRE signaling for PDCCH

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | In current specification TS 38.213 Section 4.1, the EPRE ratio between SSS and coreset 0 PDCCH DMRS is specified as the following.  A UE assumes that reception occasions of a physical broadcast channel (PBCH), PSS, and SSS are in consecutive symbols, as defined in [4, TS 38.211], and form a SS/PBCH block. The UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE. The UE may assume that the ratio of PSS EPRE to SSS EPRE in a SS/PBCH block is either 0 dB or 3 dB. If the UE has not been provided dedicated higher layer parameters, the UE may assume that the ratio of PDCCH DMRS EPRE to SSS EPRE is within -8 dB and 8 dB when the UE monitors PDCCHs for a DCI format 1\_0 with CRC scrambled by SI-RNTI, P-RNTI, or RA-RNTI.  However, for other DCIs, the EPRE ratio between SSS and PDCCH DMRS are not specified. Therefore, in theory, NW can set arbitrary power offset between SSS and PDCCH DMRS, which creates problem for UE’s PDCCH reception, as UE doesn’t know how to set AGC appropriately for those DCIs reception.  To solve this issue, first of all, it is needed to specify EPRE ratio to cover all DCIs. Secondly, it is preferred to define specific allowed EPRE ratio values or introduce tightened range smaller than [-8,+8]dB.  With the above rationale, we have the following proposal.  **Proposal 8: Specify EPRE ratio between SSS and PDCCH DMRS which applies to all DCI formats and all RNTIs.**   * **Separate ratios can be configured for CSS and UESS to a UE.**   Besides the unknown EPRE between SSS and PDCCH DMRS, the EPRE between PDCCH DMRS and PDCCH data is also unknown, which degrades the PDCCH demod/decode performance with an unknown SNR difference between PDCCH DMRS tone and PDCCH data tone. One side note is that EPRE between PDSCH DMRS and PDSCH data was specified.  To solve this issue, we have the following proposal.  **Proposal 9: Specify EPRE ratio between PDCCH DMRS and PDCCH data and network to indicate the EPRE ratio to UE.**   * **Separate ratios can be configured for CSS and UESS to a UE.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #14**

* **Specify the following EPRE ratio.**
  + **EPRE ratio between SSS and PDCCH DMRS which applies to all DCI formats and all RNTIs.**
  + **EPRE ratio between PDCCH DMRS and PDCCH data.**

**where NW can configure the separate EPRE ratios for CSS and UESS to a UE.**

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | We don’t think the proposal is necessary in this later release.  For radio link failure purpose, only zero/small EPRE ratio b/w SSS and PDCCH DMRS/data (e.g., 0dB) is assumed in TS38.133. In this sense, there is no choice for NW practically to set relatively larger EPRE ratio (e.g., 10dB) in order to properly maintain radio link by using radio link monitoring. |
|  |  |  |
|  |  |  |

* 1. Different TRS location in two consecutive slots

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | In current specification, when TRS is configured on two back-to-back slots, the same TRP location pattern has to be used on the two slots, as shown in the following (highlighted in green).  Each CSI-RS resource, defined in Subclause 7.4.1.5.3 of [4, TS 38.211], is configured by the higher layer parameter *NZP-CSI-RS-Resource* with the following restrictions:  - the time-domain locations of the two CSI-RS resources in a slot, or of the four CSI-RS resources in two consecutive slots (which are the same across two consecutive slots), as defined by higher layer parameter *CSI-RS-resourceMapping*, is given by one of  - , , or for frequency range 1 and frequency range 2,  - , , , , ,  or  for frequency range 2.  This is an unnecessary constraint which reduces the pull-in range of the frequency offset estimation based on the TRS. For a UE which does frequency offset estimation across two slots jointly, the pull-in range is given by the following equation  Where is the time difference between a pair of TRS symbols , is the greatest common divisor (GCD) of the set of over all possible pairs {j,k}.  The above pull-in range can be easily proved as the following.  First of all, based on maximum likelihood (ML) estimation, for two TRS pilots on two OFDM symbols with OFDM symbols apart from each other, the frequency offset estimator is the following, as studied in [9],  where, is the cross-correlation between the pilots and .  The estimation has a limited “pull-in range” since it can only estimate errors such that  Because the estimator cannot distinguish between and due to the periodicity of the exponential . In other words, inserting and into will generate the same detection metric outcome.  Now, extending the ML estimator to a scenario of M (>2) TRS pilots on distinct OFDM symbols , the estimator is the following  where is the set of all 2-combinations in , is the time difference between the symbols . are the linear combining weights.  With the above estimator, one can see that the estimator cannot distinguish between and , as they will generate the same output if one plug them into this equation .  Now, with the establishment of , one can easily see that with current NR specification, across two slots, there are only 4 possible different values, which are 4, 10, 14, 18 OFDM symbols as illustrated in below figure, which is generated using TRS location pattern {4,8}. Using different TRS location patterns will generate the same 4 values of 4, 10, 14, 18 OFDM symbols, due to the same TRS location patterns across two slots. With the 4 values, , which yield pull-in range where T is the duration of an OFDM symbol.  A math equations on a grid  Description automatically generated  Figure 8: Illustration the 4 possible values with the same TRS location pattern for TRS across 2 slots.  A math equations on a grid  Description automatically generated with medium confidence  Figure 9: Illustration the 4 possible values with different TRS location patterns across TRS across 2 slots.  Now, if we simply allow different TRS patterns (without introducing new TRS location pattern in specification), we can reduce to 1. For example, using TRP pattern {4,8} on slot 1 and {5,9} on slot 2, , which yield pull-in range where T is the duration of an OFDM symbol. The pull-in range of TRS is doubled.  **Observation 3: Allow different TRS location patterns (without introducing new location pattern) across two consecutive slots can double the pull-in range of frequency offset estimation for TRS.**  With the above observation, the following proposal is proposed.  Each CSI-RS resource, defined in Subclause 7.4.1.5.3 of [4, TS 38.211], is configured by the higher layer parameter *NZP-CSI-RS-Resource* with the following restrictions:  - the time-domain locations of the two CSI-RS resources in a slot, or of the four CSI-RS resources in two consecutive slots (which are the same across two consecutive slots only if UE is not configured with higher layer parameter [*SupportDifferentTRSpatternAcrossSlots*]), as defined by higher layer parameter *CSI-RS-resourceMapping*, is given by one of  - , , or for frequency range 1 and frequency range 2,  - , , , , ,  or  for frequency range 2.  **Proposal 10: Subject to a dedicated UE capability, support different TRS location patterns (without introducing new location pattern) across two consecutive slots for TRS, with the following TP adopted.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #15**

* **Subject to a dedicated UE capability, support different TRS location patterns (without introducing new location pattern) across two consecutive slots for TRS, with the following TP adopted in 38.214.**

|  |
| --- |
| ========================= Unchanged parts =========================  Each CSI-RS resource, defined in Subclause 7.4.1.5.3 of [4, TS 38.211], is configured by the higher layer parameter *NZP-CSI-RS-Resource* with the following restrictions:  - the time-domain locations of the two CSI-RS resources in a slot, or of the four CSI-RS resources in two consecutive slots (which are the same across two consecutive slots only if UE is not configured with higher layer parameter [*SupportDifferentTRSpatternAcrossSlots*]), as defined by higher layer parameter *CSI-RS-resourceMapping*, is given by one of  - , , or for frequency range 1 and frequency range 2,  - , , , , ,  or  for frequency range 2.  ========================= Unchanged parts ========================= |

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | If the TEI proposal#15 is subject to a dedicated UE capability, gNB should send one legacy TRS resource for a UE who does not support the proposal and send another new TRS resource (with different TRS location patterns) for a UE who support the proposal. It increases additional TRS overhead, hence we don’t think the proposal is useful. |
| Lenovo/ MotM | Y | The TRS is a collection of one-port CSI-RS resources, and the TRS with different location patterns can be realized via two legacy TRSs that are tracked by two legacy UEs/UE groups. We believe this proposal is sound to capture FO for UEs moving at high speed, due to the current limitation on Doppler estimation via legacy TRS config |
| ZTE | N | It is too late for real field deployment (TRS should be cell-specific and applied to different release UE(s) from network perspective), even though we identify some potential performance gain. |
| Spreadtrum | N | The current spec on TRS configuration works well. We don’t think it’s necessary on further enhancement. |
| QC | Y | The use case is like Lenovo mentioned: high speed transmission scenario while UE switch between different RRHs. |

* 1. Counting of active CSI-RS resources

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [8] | Specific UE capabilities provide the gNB indication of UE’s support for simultaneous active NZP-CSI-RS resources per component carrier, as well as an aggregate limit over all component carriers when carrier aggregation is applied.  For aperiodic CSI reporting the way the active NZP-CSI-RS resources are counted is from the end of the triggering DCI to the end of CSI report transmission. However, for periodic and semi-persistent CSI reporting a NZP-CSI-RS resource is considered active all the time when a CSI reporting associated to it is active. This is counterintuitive when reflecting it against the 38.214 definition of a CSI processing unit utilization as it is natural that a periodic NZP-CSI-RS is not actually loading a CPU any longer than an aperiodic NZP-CSI-RS.  In addition, when the same NZP-CSI-RS resource is used in multiple CSI reporting configurations then that one resource is counted as multiple active CSI-RS resources. This is inefficient on its own, but with the Rel-18 Network Energy Saving feature where the same approach is extended to the NES CSI reporting sub-configurations this over-counting can become prohibitive.  Eliminating these active NZP-CSI-RS counting inefficiencies would allow for a larger number of CSI-RS configurations while not actually requiring the UE to process any more CSI-RSs simultaneously.  It can be noted that for A-CSI-RS the resource is only considered active during the timeline of the one A-CSI reporting procedure, starting from the end of the triggering DCI and ending at the end of the PUSCH delivering the CSI report, while for P-CSI-RS the resource is considered active all the time even if the periodicity maybe large. Similarly for SP-CSI-RS, the CSI-RS resource is active over the whole duration when SP-CSI-RS is activated even if the periodicity maybe large.  The fact that the P-CSI-RS and SP-CSI-RS resources are counted as always active puts pressure on the UEs to support a larger number of simultaneously active NZP-CSI-RS resources while low UE capability restricts the network operation. The low cap on the aggregate number of active NZP-CSI-RS resources across all component carriers further hinders the usage of carrier aggregation.  For aperiodic NZP-CSI-RS the CSI-RS resource is only considered active from the end of the triggering PDCCH to the end of the PUSCH with the CSI report. This is in a typical case the same slot as the slot of the CSI-RS. I.e. already in Rel-15 the UE needs to be able to consider an CSI-RS resource as inactive in one slot, and activate in in the next slot in which it measures a CSI-RS.  **Observation 1-4: A CSI-RS resource that is used for A-CSI reporting can be inactive in a slot prior to the NZP-CSI-RS, and allocated as active in the NZP-CSI-RS slot.**  It should be possible to extend the A-CSI-RS active resource counting to periodic and semi-persistent NZP-CSI-RS as well and count them active from the slot of the NZP-CSI-RS to the transmission of the CSI report.  Another alternative would be to count the CSI-RS resource as active for a fixed time period from the slot of the CSI-RS, which could be seen more natural as the CSI-RS resource is not doing anything after the CSI report has been constructed, even if the actual time to transmit the report is farther in the future.  **Proposal 1-1: For periodic NZP-CSI-RS counting, consider a NZP CSI-RS resource as “active” from the slot of the CSI-RS**   * **Alt 1: to the slot of the corresponding CSI report** * **Alt 2: for a fixed number of slots determined by the longest CSI computation time for the SCS**   **Proposal 1-2: For semi-persistent NZP-CSI-RS counting, consider a NZP CSI-RS resource as “active” from the slot of the CSI-RS**   * **Alt 1: to the slot of the corresponding CSI report** * **Alt 2: for a fixed number of slots determined by the longest CSI computation time for the SCS**   RAN1#93 in May 2018 made the following agreement that lead to the 38.214 statement that counts the one NZP-CSI-RS resource as N active NCP-CSI-RS resources if it is referred to by N CSI report settings.  **Agreement [RAN1#93, May 2018]**   * For the purpose of simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41 and 2-43, CSI-RS ports within one CSI-RS resource, as well as the CSI-RS resource, are counted N times if the CSI-RS resource is referred by N ~~resource~~ Report settings   **Corresponding TS38.214 statement:** *If a CSI-RS resource is referred N times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted N times*.  This may have been justified at the time to simplify the UE implementation and speed the time to market, but over time it maybe assume that UE implementations have been optimized further and for processing burden (and corresponding power consumption) reduction it is more beneficial to process one NZP-CSI-RS only once for multiple CSI reports rather than process it multiple times. If the UE implements the CSI-RS processing this way it is not able to indicate that to the gNB and when the same NZP-CSI-RS is used by multiple CSI reporting settings the UE’s capability cannot be exploited at the fullest.    Figure 2: Example of using a P-CSI-RS for both P-CSI and A-CSI reports leads to counting the same CSI-RS as two active CSI-RS resources.  The Rel-15 double-counting was made worse with Rel-18 NES inheriting the solution.  **Proposal 1-3: For the purpose of simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41 and 2-43, CSI-RS ports within one CSI-RS resource, as well as the CSI-RS resource, is counted as one resource even if the CSI-RS resource is referred by *N* resource Report settings**  **Proposal 1-4: For the purpose of simultaneous CSI-RS reception in Network Energy aving UE features 42-1/1a/1b/1c, and 42-2/2a/2b/2c,** **CSI-RS ports within one CSI-RS resource, as well as the CSI-RS resource, is counted as one resource even if the CSI-RS resource is referred multiple times**  The agreements on what to adopt in the specifications should be the primary focus of the discussion, and the way the UE capabilities are defined should take place during or at the end of that discussion.  **Proposal 1-5: Consider the above text proposals as a starting point for developing the specification changes**  **Proposal 1-6: Discuss how to define the UE capabilities for the different aspects of NZP-CSI-RS resource counting.**   * **E.g. split the counting of periodic/semi-persistent CSI-RS as active and counting of CSI-RS as active multiple times into two (or three if periodic and SP would be separated) separate capabilities, and further separate the latter one for non-NES and NES cases.** |

Based on the above contribution, following TEI proposals can be discussed in RAN1#118bis meeting.

### **TEI proposal #16-1**

* **For periodic and semi-persistent NZP-CSI-RS counting, consider a NZP CSI-RS resource as “active” from the slot of the CSI-RS.**
  + **Alt 1: to the slot of the corresponding CSI report.**
  + **Alt 2: for a fixed number of slots determined by the longest CSI computation time for the SCS.**

This proposal is already supported by Nokia, Apple, MediaTek.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | Y | From operators’ perspective, any solutions that can reduce active CSI-RS counting would be welcome. We prefer Alt2. Considering P/SP CSI-RS may be associated with A-CSI report, the slot of the corresponding CSI report might be any slots, which leads to that configured/activated P/SP CSI-RS is always active (same as legacy) by Alt1. |
| Apple | Y | We prefer Alt 2. Regarding Alt 2, further discussion is still needed to determine the number of slots. |
| Huawei, HiSilicon | N | This will degrade the performance of CSI measurement, as in current spec, UE can performance measurement and refine the CSI based on every CSI-RS occasion. The proposal will force UE to perform CSI-RS based on reference CSI-RS occasion only, which degrades performance.  There is also the case that the reference CSI-RS resource is before the DCI triggering the CSI report, with the proposed counting UE has to buffer every CSI-RS resource, which further increases the UE buffer requirement.  The benefit to current spec is not clear either. If counting of active periodic CSI-RS is a problem then network can configure aperiodic CSI-RS, which can have the same functionality as the proposal, and can also reduce the overhead. |
| Lenovo/ MotM | Y | We also prefer Alt2. Even if the UE is to reuse CSI-RS measurement from prior CSI-RS occasions beyond the CSI-RS counting range, these “past” CSI-RS measurements are mainly aggregated to a channel covariance measure that is stored in the UE side, and re-processing of this CSI measurement separately is not well motivated. If UE vendors have different views based on their own implementations, their assumptions can be considered |
| ZTE |  | We are open to discuss that, and then, in our views, Alt-2 can be assumed as a starting point. But, the longest CSI computation time for the SCS may be relevant to enabled CSI report setting, and then, some further study should be made. From our preference, for forward compatibility, we prefer to a fix value which can be indicated by UE capability signaling, rather than being based on a rule. |
| Spreadtrum | Y | We think it’s beneficial to align the definition of active time interval for CSI-RS resource and UE processing timeline. We also think Alt2 is more appropriate. |
| Qualcomm | N | For Alt1, existing spec has no correspondence b/w CSI-RS occasion and report, for example   * Each CMR/IMR, and the report, can have different periodicities; * P-CMR/-IMR can be configured with AP-report   For Alt2, existing spec has no correspondence b/w each occasion of each CMR/IMR   * So, does Alt2 mean to count ARC active duration as lasting, after every CMR and IMR, for a fixed duration (e.g. timeline Z’)? This seems not to be the definition of CSI timeline.   We tend to think proposal 16-1 is more like a totally new framework on ARC (or CPU), and much larger than a TEI. |

### **TEI proposal #16-2**

* + **For the purpose of simultaneous CSI-RS reception in UE features 2-33, 2-36, 2-40, 2-41 and 2-43, CSI-RS ports within one CSI-RS resource, as well as the CSI-RS resource, is counted as one resource even if the CSI-RS resource is referred by N resource Report settings.**
  + **For the purpose of simultaneous CSI-RS reception in Network Energy saving UE features 42-1/1a/1b/1c, and 42-2/2a/2b/2c, CSI-RS ports within one CSI-RS resource, as well as the CSI-RS resource, is counted as one resource even if the CSI-RS resource is referred multiple times**

This proposal is already supported by Nokia, Apple, MediaTek.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | Y |  |
| Apple | Y |  |
| Huawei, HiSilicon | N | UE has different kind of processing for different kind of CSI reports, e.g., for SINR, type-I codebook, type-II codebook, UE’s processing of CSI measurements is different. It’s no reasonable to assume UE processing this only once to produce all kinds of CSI reports. |
| Lenovo/ MotM |  | We agree on the second sub-bullet only, since for NES the UE is computing the same report quantities for the same resource, however this may not be the case elsewhere |
| ZTE |  | For first bullet, for current spec, the interpretation for FG 2-33 ‘**simultaneous CSI-RS reception**’ is clear (i.e., not relevant to the number of associated CSI report setting), and no further discussion is needed. Then, for the rest, we are open to hear other’s views.  For second bullet, looks reasonable. But as above mentioned, we believe that the clarification is what we assume by default. |
| Spreadtrum |  | This proposal allows UE to process more CSI-RS ports/resources without increasing UE capability. We are fine to further study. |
| Qualcomm |  | Open with lower-down the “overcounting” with some restriction.  We agree the use case elaborated by the proponent, that a same P-CSI-RS referred by two reports (P and AP) with the same content (both Type-I), is overcounted as twice.  But the proposal here has a much wider scope than the use case.  We can be open further discuss this proposal, at least with the following restriction on the N reports:   * Same report content e.g. codebook Type, same frequency config (wideband/subbands) * Same IMR for the N reports   The N reports can differ regarding reported manner: P/AP/SP, and report periodicities.  In short, we think ARC should count for number of “CSI processes”.  Not support the NES proposal based on the above logic, since different subsets of ports of a same CSI-RS, are associated with different CSI processes. |

* 1. QCL assumption for periodic CSI-RS

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [8] | UE behaviour is undefined if the TCI state is not indicated for periodic CSI-RS as agreed by majority companies in RAN1#118 discussion [2]. Therefore, TCI state must always be provided in *qcl-InfoPeriodicCSI-RS* in *NZP-CSI-RS-Resource* for the UE to apply corresponding QCL relation(s) for target periodic CSI-RS. This implies that in case of beam change, periodic CSI-RS must be updated via RRC reconfiguration resulting in signalling overhead and delay. In some cases, such signalling may be unnecessary, e.g. CSI-RS for channel measurement may follow active TCI state of PDCCH without updating its QCL info and . Periodic TRS is typically used as a source RS for PDCCH and other channels, thus its TCI state needs to be updated via RRC mechanism for beam change.  It is proposed to lift mandatory RRC reconfiguration of periodic CSI-RS for CSI acquisition and let it follow active TCI state of PDCCH, i.e. indicated TCI state, by omitting *qcl-InfoPeriodicCSI-RS* in corresponding *NZP-CSI-RS-Resource*. This can be conditional on UE capability, however even absence of this field for a specific resource may act as indication to the UE to apply QCL assumptions for that resource. This approach is similar to that of aperiodic CSI-RS, where UE uses QCL information included in the "indicated" DL only/Joint TCI state when *qcl-info* or *qcl-info2*, are absent in *CSI-AperiodicTriggerStateList* and *applyIndicatedTCI-State* or *applyIndicatedTCI-State2* are not configured*.*  **Proposal 2-1: If *qcl-InfoPeriodicCSI-RS* is absent for periodic CSI-RS resource for CSI, UE can assume that the indicated TCI state is applied for that resource.**  **Proposal 2-2: Consider below TP for the specification change corresponding to Proposal 2-1 in 5.1.5 of TS 38.214:**  5.1.5 Antenna ports quasi co-location  <<omitted text>>  For periodic/semi-persistent CSI-RS other than CSI, if the UE is configured with *dl-OrJointTCI-StateList*, the UE can assume that the indicated *TCI-State* is not applied.  For periodic CSI-RS resource for CSI, if *qcl-InfoPeriodicCSI-RS* is absent and the UE is provided with dl-OrJointTCI-StateList and the indicated TCI state is associated with the PCI of the serving cell, the UE can assume that the indicated TCI state is applied.  <<omitted text>> |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #17**

* **Support the following QCL assumption for periodic CSI-RS resource.**
  + **If *qcl-InfoPeriodicCSI-RS* is absent for periodic CSI-RS resource for CSI, UE can assume that the indicated TCI state is applied for that resource.**

This proposal is already supported by Nokia.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | This issue was discussed in RAN1#118 in R1-2407373.  In Rel.17, it was discussed whether to apply indicated TCI to P-CSI-RS and whether to define QCL assumption for P-CSI-RS when TCI state is not configured.  We have technical concern on the proposal. P-CSI-RS is monitored by multiple UEs in practical, it is impossible to update QCL assumption by DCI/MAC CE for one UE. |
| ZTE | N | This issue has been discussed for several releases and topics. In short, we have strong concerns if the time-domain offset of periodic CSI-RS can NOT be updated simultaneously along with the indicated TCI. |
| Spreadtrum | N | We don’t prefer to change the TCI state of periodic CSI-RS resource dynamically. |
|  |  |  |

* 1. Counting of unusable PDCCH candidates

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [8] | With DCI formats x\_0/x\_1/x\_2 a UE-specific search space can be configured to monitor DCI formats {0\_0 and 1\_0}, {0\_1 and 1\_1}, {0\_2 and 1\_2}, {0\_1 , 0\_2, 1\_1 and 1\_2}, i.e. a search space is always configured with both DL and UL formats. The PDCCH candidates of a search space are then common for the DCI formats the search space is configured with. In the typical case where formats x\_1 (or x\_2) are used instead of the fallback formats, the UL and DL DCI formats are of different size, and each PDCCH candidate consumes two blind decodes.  The number of BDs the UE supports is a function of subcarrier spacing number of component carriers configured for CA. The common SS is consuming part of the BD budget whether it is needed or not. However, in TDD it is fairly typical that UL slots are scheduled with PDCCHs on a sub-set of DL slots only, e.g. in a slot format, the gNB could choose to schedule the UL slot only from one DL slot, and this would be reflected in the configured k2 values in the TDRA table. Still the UE is assumed to scan through all the PDCCH candidates in all the D slots and the S slot even if it actually is aware of the fact that only one of them will ever see a PUSCH-scheduling DCI that actually can schedule a PUSCH.    Figure 3: Example of a TDD structure where not all slots are eligible to schedule both link directions  **Observation 3-1: In TDD it is typical that only a sub-set of DL slots can carry the PDCCH scheduling the UL slot(s)**  In some scenarios, the number of PDCCH candidates could be increased while keeping the same PDCCH blocking. For example, when UE is configured with a certain frame structure in TDD and set of k0/k2 values, it can implicitly deduce that some slots may contain only DL DCI and do blind decoding in that slot for DL DCI only. This way, the UE can save energy by not checking unnecessary PDCCH candidates and the network may e.g. allocate common search space with SIB scheduling / paging etc. to those slots without needing to budget CSS BDs and USS UL DCI BDs in the same slot.  **Proposal 3-1: A PDCCH candidate is not counted for monitoring if the candidate cannot schedule a PDSCH/PUSCH in any valid DL/UL slot with any configured k0/k2 value.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #18**

* **Support the following counting rules for PDCCH candidates.**
  + **A PDCCH candidate is not counted for monitoring if the candidate cannot schedule a PDSCH/PUSCH in any valid DL/UL slot with any configured k0/k2 value.**

This proposal is already supported by Nokia.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, HiSilicon | N | The technical benefit needs to be justified further.  From UE perspective, power saving is not significant since only several channel decoding attempts can be saved, demodulation has to be done anyway. Further, this can already be achieved by implementation, i.e., the UE can simply skip these PDCCH candidates according to the semi-statically configured K0/K2.  Additionally, SIB and paging scheduling are infrequent. Even though there are saved PDCCH candidates, they are not that useful since the UE supports at most 2 unicast DCIs scheduling DL at each PDCCH monitoring occasion per CC. |
| Spreadtrum | N | We share similar view as Huawei. It has significant complexity increase on PDCCH monitoring, but needs more justification on the benefit. |
| Qualcomm | N | It is unclear to us whether the proposal has essential benefit (i.e., how many UL PDCCH candidates can be excluded in a slot and how often that allows the UE to monitor additional search space sets) or without this proposal, there is any essential scheduling issue in the field (i.e., how often a UE’s DL data cannot be scheduled because the UE does not use this opportunistic slot to monitor DL scheduling PDCCH). Our understanding based on early experience is this is not a typical issue.  Also, benefit of UE complexity and power reduction can be realized by UE implementation. |

* 1. PHR reporting triggering condition for a different UL waveform

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [8] | Rel-18 introduced a dynamic waveform switching (DWS) feature that allows gNB to dynamically indicate, in the scheduling DCI, a waveform to be used for a dynamic grant PUSCH. In order to assist gNB on waveform selection, it was further agreed that a UE supporting DWS feature may also report an assisting information in form of PHR. Specifically, whenever the UE reports a PHR for a PUSCH, it also reports a of an assumed PUSCH, which has the same parameters compared to the PUSCH except the waveform. It can be observed that, since the assisting information ( of an assumed PUSCH) is provided every time the PHR is reported, this would lead to a considerable overhead.  **Observation 4-1: Reporting the assisting information ( of an assumed PUSCH) for every PHR would lead to a considerable overhead.**  In order to avoid reporting overhead, multiple conditions should be considered for triggering the report of assisting information. In Rel-18, RAN decided not to discuss this aspect due to time limitation. However, this aspect can be considered in Rel-19 to complete the feature. The conditions could be ones that make the report of assistance information being meaningful to gNB. For example, UE only considers reporting if there is a change in pathloss (PL) and a change in PH difference between the two waveforms compared to the previous report. Otherwise, if there is no change in PL and PH difference between the two waveforms (or if the change is very small), reporting also PH related information of target waveform may not provide gNB any additional information for waveform selection.  Observation 4-2: If there is no change in PL and PH difference between the two waveforms compared to the previous report (or if the change is very small), reporting also PH related information of target waveform may not provide gNB any additional information for waveform selection.  **Proposal 4-1: The report of assistance information, are triggered when the following conditions are satisfied:**   * **There is a change in PL compared to that in previous report.** * **There is a change in PH difference between the two waveforms compared to that in previous report.** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #19**

* **Support the following conditions for the trigger of assistance information reporting.**
  + **There is a change in PL compared to that in previous report.**
  + **There is a change in PH difference between the two waveforms compared to that in previous report.**

This proposal is already supported by Nokia.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | Procedure-wise, it doesn’t fit to “TEI in RAN1”. We understand this proposal try to define new trigger condition for PHR with PCMAX for assumed PUSCH when DWS is configured, which we believe should also be considered to be captured in 38.321 by RAN2 experts.  Technical-wise, we don’t quite understand the motivation. PCMAX just consumes one Octet in the PHR MAC CE, so don’t see a strong problem from reporting overhead perspective. In this case, assuming PUSCH carrying PHR MAC CE might fail to be received in real field, do we really need to be so sensitive about such small overhead information? |
| Huawei, HiSilicon |  | OK to discuss it but we suggest different solutions with consideration of minimized RAN2 spec impacts.  Solution#1: the UE can be configured with both the legacy PHR MAC-CE and the R18 PHR MAC-CE for DWS, where the first one PHR is configured with smaller reporting cycle and the second one with much larger reporting cycle. If both PHR MAC-CEs are triggered to be reported in the same PUSCH, only the R18 PHR is reported.  Solution#1-2: With both R18 PHR MAC-CE and the legacy PHR MAC-CE configured, add an PHR event for R18 PHR reporting that is triggered as long as the DWS field in scheduling DCI is flipped. |
| Spreadtrum | N | We have similar view as DOCOMO. Reporting overhead is not big problem.  In R18, the trigger condition of assistance information reporting has been discussed in RAN1 and RAN2. New PHR triggers mechanisms was precluded in RAN#100. It is not necessary to discuss it again.  We support reusing existing PHR trigger only to avoid further impact on specification. |
| QC |  | Open to supporting a new trigger. However, for us, overhead is not a concern; we are motivated by ensuring the gNB receives the information in a timely manner.  The triggers that’s most useful is when the PH difference is > 0 dB and the PH for the current waveform is 0 dB, i.e., no more additional power is available for one waveform, but the other waveform continues to offer more power.  Sympathize with DCM’s views. Triggers are typically in RAN2 domain, and this trigger too may have to be captured in the RAN2 specs. |

* 1. Closed loop power control for dynamic waveform switching

Following proposal is made in the contribution.

|  |  |  |
| --- | --- | --- |
| [8] | Still in the context of Rel-18 dynamic waveform switching (DWS), however this section discusses an issue when DWS feature is used with closed loop power control (CLPC). This issue was not properly discussed in Rel-18 due to time limitation.  Let us recall the following power control equation in TS 38.213, wherein TPC command values are accumulated in .  [dBm]  As shown in the below text excerpt from TS 38.213, Clause 7.1.1, if UE reaches maximum transmission power at PUSCH transmission occasion and, at the same time, the accumulated TPC command value for is greater than or equal to zero, UE must set for even if the TPC command in the DCI scheduling may be larger than 0.  TS 38.213, Clause 7.1.1:   |  | | --- | | <<omitted text>>  If the UE has reached maximum power for active UL BWP of carrier of serving cell at PUSCH transmission occasion and , then  <<omitted text>> |   A diagram of a diagram of a diagram  Description automatically generated with medium confidence  Figure 5-4. Illustration of the issue when DWS feature is used with CLPC.  Figure 5-1 illustrates an example of the issue when DWS feature is used with CLPC. Let’s denote . It can be observed from the figure that, if a UE was indicated with CP-OFDM (i.e, Transform precoder indicator field = 1) and reached maximum transmit power for a PUSCH transmission at , and the UE is then indicated with DFT-s-OFDM (i.e., Transform precoder indicator field = 0) for another PUSCH transmission at , the UE could not transmit with max power of DFT-s-OFDM for the PUSCH transmission at due to the aforementioned restriction that must be equal to in this case. In other words, any TPC command received for boosting power for the PUSCH transmission at could not be accumulated. This would invalidate the benefit brought by the DWS feature at , i.e., exploiting the power gap offered by DFT-s-OFDM waveform, as shown in Figure 1. Note that this example assumes the max power of DFT-s-OFDM is higher than that of CP-OFDM, which is the main motivation for DWS to DFT-s-OFDM at . Note also that we assume in this example (i.e., a lower bound for the gap). However, in practice, the gNB would apply smaller number of resource blocks and MCS in case of switching from CP-OFDM to DFT-s-OFDM (due to coverage shortage anticipation), which leads to , and thus a bigger gap could not be exploited.  Observation 5-1: In the current specifications, if a UE was indicated with CP-OFDM (i.e, Transform precoder indicator field = 1) and reached maximum transmit power for a PUSCH transmission at , and the UE is then indicated with DFT-s-OFDM (i.e., Transform precoder indicator field = 0) for another PUSCH transmission at , the UE cannot transmit with max power of DFT-s-OFDM for the PUSCH transmission at .  One straightforward way to overcome this issue is to simply let UE set only if it reaches maximum power at . Otherwise, the TPC commands are accumulated for , i.e., . Note that since the issue only happens when DFT-s-OFDM is indicated at , the above constraint can be limited to the case when “transform precoder indicator field” is set to 0 at only, to minimize the specification impact.  **Proposal 5-1: For a UE that is dynamically indicated with DFT-s-OFDM waveform (i.e., transform precoder indicator field is set to 0) at , the UE sets only if it reaches maximum power at . Otherwise, the TPC commands are accumulated for at .** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#118bis meeting.

### **TEI proposal #20**

* **Support the following transmission power determination.**
  + **For a UE that is dynamically indicated with DFT-s-OFDM waveform (i.e., transform precoder indicator field is set to 0) at , the UE sets only if it reaches maximum power at . Otherwise, the TPC commands are accumulated for at .**

This proposal is already supported by Nokia.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Huawei, Hisilicon | N | The observation 5-1 seems not true because the TPC in the DCI scheduling the PUSCH at is still valid and can enable higher Tx power of than . The only impacted TPC are those received before , which is provided by optional feature group common DCI like DCI 2\_3. In this case, waveform is not changed and the UE still stick to CP-OFDM waveform and shall ignore the TPC. Therefore, the proposal seems unnecessary. |
| Spreadtrum | N | We think it is not an essential issue. The PUSCH power control adjustment state can be accumulated at the subsequent transmission occasion to reach the max power of DFT-s-OFDM. |
| QC |  | Understand the motivation, but not sure if this is absolutely necessary. TPCs that arrive after TO\_i can still be accumulated and applied to the new waveform. Not accumulating a few TPCs that arrive in the middle of a pair of TOs is not going to be catastrophic. Overall impact to system may be rather marginal. |
|  |  |  |

1. Proposal for online session

To be updated

1. Conclusion

To be updated

Reference

[1] R1-2407811 On Rel-19 TEI proposals ZTE Corporation, Sanechips

[2] R1-2407884 Rel-19 TEI proposals vivo

[3] R1-2408177 Enhancement of positioning SRS beam configuration Huawei, HiSilicon, China Unicom, ZTE, Sanechips

[4] R1-2408366 Link adaptation TEI-19 Ericsson

[5] R1-2408493 Rel-19 TEI proposal on remaining ambiguities with SRS carrier switching Apple

[6] R1-2408590 CSI Acquisition Improvement for Type-II codebook Orange, ZTE, BT

[7] R1-2408873 Rel-19 TEI proposals Qualcomm Incorporated

[8] R1-2408958 Proposals for TEI19 Nokia

[9] RP-191602 Handling of TEI & contribution submission in RAN WGs for NR and LTE 3GPP RAN TSG and WG1/2/3/4 Chairmen

[10] RP-210826 Handling of TEI CRs ETSI MCC

Appendix: TEI guidance in [10]

**A. TEI Work Item codes shall only be used for small technical enhancements and improvements.**

This is how TEI was and is defined and it means that bigger topics should be done in an own WI.

**B. A TEI CR set shall be fully completed within one TSG cycle/quarter in all affected WGs.**

This requirement from TR 21.900 was never challenged. It also clarifies that only complete sets can be approved.

**C. TEI Work Item codes shall not be used where another appropriate Work Item code exists.**

This repeats the rule from TR 21.900 and it means that TEI cat.F CRs shall be an exception. Note: The CR author is supposed to find out which former CR introduced an error in the spec and the cat.F correction should then use the same WI code. So in theory, cat.F TEI CRs should only be needed to correct cat.B/C TEI CRs of the past.

D. Inter-TSG aspect:

**D1. Normally, for TSG SA/CT work that requires cat.B/C CRs from RAN WGs a RAN WI is required..**

This is what RAN applied in the last decade (if not longer). This also covers the strong discouragement of cross TSG TEI CRs expressed in RP-191602 slide 3.

**D2. In case the RAN work triggered via a TSG SA/CT WI\* is small and it affects only one RAN WG, then the RAN WG CR(s) shall use the WI code\* of the TSG SA/CT WI that triggered this work.   
NOTE: \*: provisional WI codes, companion WIDs/"mini-WIDs" are not meant here but already TSG approved proper WIs.**

This is what RAN applied in the last decade. Note: As TSG RAN has no agenda items for all SA/CT WIs, this sort of CRs were usually submitted under a TEI agenda item but for traceability we shall not use a TEI WI code on such a CR.  
(Note: D2. could work also in the other direction, i.e. if there is a RAN WI for which is turns out that only a small change would be needed in one SA WG or one CT WG. But you better consult TSG SA/CT before trying this approach.)

**D3. It is not possible to trigger work in RAN WGs via TEI CRs coming from TSG SA/CT or SA/CT WGs. The same applies for the reverse direction.**

Otherwise "small" (TEI) but affecting multiple TSGs would contradict each other. (Apart from this, inter-TSG TEI CRs would also not work well together for cat.B/C CRs if SA/CT use a companion WID but RAN does not.).

E. Inter-RAN WG aspects:

Section E. is addressing the problem that multiple RAN WGs work on the same feature but it is still intended to not have an own WI for this but to cover this feature under cat.B/C TEIxx (this is challenging time-wise and coordination-wise and therefore not a recommended approach but it is not forbidden). As RAN5 has introduced specific rules regarding the testing of TEI CRs, see RP-200931 [5] and since they use a different WI code (TEIxx\_Test) and testing work is usually coming at a later stage, this section E. is considering linked TEI CRs of RAN1/2/3/4.

In a similar way: RAN1/2/3/4 Core part work happens usually in the same time interval while RAN4 Perf. part work usually happens at the end of or after the RAN4 Core part work. In other words, having a TEI CR package that combines Core and Perf. part work requires a very careful timing to not violate requirement B.

RP-191602 [2] provided some guidance on Cross-WG TEI CRs in RAN WGs:

- Cross WG TEI CRs are strongly discouraged

- RAN1/2 TEI proposals with RAN4 impact to core requirements are strongly discouraged

- **RAN2 impact of RAN1/4-led TEI CRs shall be limited to RRC signalling of configuration parameters and UE capabilities (no MAC impact, no RRC procedural impact, etc.)**

Note: Ideally one RAN WG would take the decision about whether a TEI feature should be introduced or not and other RAN WGs then accept this decision and contribute their TEI CRs.

But as this guidance was not forbidding Cross-WG TEI CRs in RAN WGs some more requirements had to be defined how to guarantee traceability, consistency and visibility of this sort of CRs.

The basic requirements discussed in section E. were endorsed by TSG RAN in RP-202867 [7] but further clarification/guidance is provided here.

**E.1 It is mandatory to fill out the "other specs affected" for all CRs, i.e. either Yes or No shall be ticked and  
 if Yes is ticked at least the TS/TR shall be indicated and this for the present WG and all other WGs that have CRs linked to the present CR.  
 TEI CRs missing this information or having wrong information shall not be approved.**

These requirements were always there. But some clarification is required.

- "other specs affected" is used to link CRs that belong together which is essential for cat.F CRs and for cat.B/C TEI CRs to guarantee that a complete set of CRs is approved. Note: For cat.B CRs of other WIs, we have an extra RAN agenda item for each of them and we usually approve all stage 3 CRs together. But for closed WIs or TEI CRs we have normally just one agenda item collecting a larger number of CRs and then the relation of the CRs becomes unclear if "other specs affected" is not filled out properly.  
 NOTE: Other specs affected should also list inter-TSG related CRs if it is clear that these CRs can only be applied together. This usually involves a conditional approval at TSG level

- "Other core specifications" under "Other specs affected" on the CR cover: Going back to RAN #46 of Dec.2009 where TSG RAN decided to have separate Core part WIs and Perf. part WIs (in RP-091374) you can see from comparing with CR form v9.6 that the term "Other core specifications" is only intended to distinguish those specs from "Test specifications" and "O&M specifications" but not to exclude Perf. part related specs from "Other specs affected": This means as long as CR form is not updated "Other core specifications" should cover Core part specifications AND Perf. part specifications as defined in TSG RAN.

- "Test specifications" under "Other specs affected" on the CR cover: Testing under TSG RAN is either done in RAN4 or in RAN5. Since RAN5 has separate WIs for testing that usually are also just started after RAN4 work is completed, it would not make much sense to reference RAN5 specs on a RAN4 CR as it is clear that the RAN5 CR will just follow later (here it is more appropriate to review the corresponding RAN5 WI when it becomes available).  
 Examples where it could make sense to fill out this field: For RAN4 CRs to a WI that involve BS testing for the same WI/a linked CR. For CRs to SI TRs to which RAN4 and RAN5 contribute together with CRs. For a cat.B/C TEI CR of RAN1/2/3/4 that has a corresponding CR in RAN5 under TEIx\_Test.

- "O&M Specifications" under "Other specs affected" on the CR cover: O&M specifications are handled by SA5. SA5 has usually separate WIs for their changes and RAN CRs are not submitted to TSG SA or SA5, therefore the benefit of this field is higher within TSG SA. Nevertheless, there may be cases of tighter cooperation of RAN WGs with SA5 (like Minimization of drive tests) where it will be beneficial to indicate a related SA5 change coming to the same TSG meeting.

- What needs to be done if WGx is assuming that TS/TR ab.cde of WGy is affected but they are not sure?  
 WGx should list under "other comments" on the CR cover: "WGx thinks that also TS/TR ab.cde of WGy could be impacted by this CR." Depending on the probability WGx would tick Yes (and mention the spec) or No.  
 CR proponents shall check this with WGy (e.g. by sending an LS from WGx to WGy, submitting a Tdoc in WGy, talking to the chairman of WGy) so that at the TSG meeting where WGx submits this CR for approval it is either clear that there is no impact or that the WGy CR is available as well for approval.  
 NOTE: MCC has the possibility to correct CR covers before RAN submission (e.g. remove a potential impact comment if it turned out that there is no impact). But CR proponents need to inform MCC about this.  
 Incomplete CR sets (i.e. WGx CR there but linked WGy CR not available) can not be approved at TSG level and since cat.B/C TEI CRs have to be completed within one quarter, this is time critical.   
 Therefore very good preparation of cat.B/C TEI CRs which affect multiple WGs is essential.

**E.2 Each TEI cat.B/C CR and each TEI cat.F/A CR that corrects functionality related to an earlier TEI cat.B/C CR shall have a unique TEI identifier in square brackets [ ] at the end of the CR title on the CR cover sheet.  
 TEI cat.B/C CRs without such a unique TEI identifier cannot be approved at RAN.**

This principle was endorsed in RP-202867 [7] and further guidance for this approach is provided here:

- The TEI identifier should be short (4 to 18 characters using letters and/or digits or using \_ or - but avoiding blanks or other special characters which will complicate searches) and characterize the CR.

- The originating company takes care that related CRs in other WGs use the same TEI identifier.

- Unique identifiers are not added retroactively: Cat.F/A CRs for TEIs which did not have a unique identifier by RAN #91e will not get a unique identifier.

- Apart from plain TEI CRs, the unique TEI identifiers shall also be applied to NR\_newRAT-Core, TEIxx CRs because NR\_newRAT-Core was the huge WI for 5G.

- As the unique idendifiers are part of the CR title, they will be automatically stored in the CR database. Therefore CR authors have to make sure that the complete CR title in 3GU is in line with the title on the CR cover.

- For cases where it is not 100% clear whether a linked CR was agreed in another WG, it is the task of the CR author to double-check the situation in the week after the WG meeting and to inform MCC in case any updates of CR titles are required otherwise they risk that not properly linked CRs are rejected at RAN level.

**E.3 WG chairman reports report to TSG RAN about all agreed and technically endorsed cat.B/C TEI CRs of the last quarter. For each unique TEI identifier all related CRs of the considered WG are listed plus the corresponding CRs in the other WGs (if there are any) or the potential impacts on other WGs.**

How this is done is up to the chairman (e.g. it can be a slide with a table like the examples below, it can be an extra Excel table included in the zip file of the WG status report). The WG chairman could request inputs from MCC (Tdoc list filtered for agreed/endorsed TEI CRs) and all CR authors of the WG who had agreed/endorsed TEI CRs (to clarify whether there were related CRs in other WGs) and this could be condensed in such an overview.

Examples:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [HDUPLEX\_unpaired] | Modification to half duplex in unpaired spectrum | Rel-16 | R1-211234 (38.213, cat.C) | R2-2112345 (38.331 cat.C) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [intRAT\_HO\_NR\_ENDC] | Introduction of inter-RAT handover NR to ENDC | Rel-16 | R2-2123456 (38.306, cat.B)  R2-2123457 (38.331, cat.B) | potential impact on 38.133 for .... ? |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [E2E\_delay\_meas] | E2E delay measurement for QoS monitoring for URLLC | Rel-16 | R3-211234 (38.413, cat.B)  R3-211235 (38.423, cat.B)  R3-211236 (38.463, cat.B) | none |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [DRX\_coord] | Introduction of DRX coordination | Rel-16 | R4-2123456 (38.133, cat.B) | R2-2112345 (38.331, cat.B) |

- what's the main goal of this activity? To have a checkpoint in each WG (RAN1/2/3/4) where after the WG meeting it is checked whether a complete CR set is available for all cat.B/C TEI features for TSG RAN; by comparing the tables of different WGs a cross-check is possible.

- should this activity be limited to cat.B/C TEI CRs only? It would be useful to also list cat.F/A TEI CRs to correct formerly as cat.B/C TEI introduced features (corresponding CRs will have [ ] at the end of the Tdoc title and CR proponents will inform the WG chairman if there were any agreed/endorsed CRs lile this)

- what about CRs for WI code combinations like "<WI code>, TEIxx"?  
 These CRs appear when <WI code> was a WI of a Rel-yy with yy<xx.  
 These CRs are usually well identified via <WI code> and would therefore not need any more tracking.  
 But one exception should be made for <WI code> = NR\_newRAT-Core as this was the generic NR WI that introduced the whole 5G and if we do not track "NR\_newRAT-Core, TEIxx" as well, it could be used as a way to bypass this tracking activity.

- How big is the expected effort: Double-checking TEI16 CRs of 2020, we had about 110 cat.B/C CRs from RAN1/2/3/4 together with ~50% TEI16, ~25% "NR\_newRAT-Core, TEIxx" and ~25% other WI code, TEI16 CRs. So this means ~20 CRs per TSG RAN meeting plus a few cat.F/A corrections to former cat.B/C TEIxx CRs.

- What is TSG RAN supposed to do with the tables of TEI CRs from the WG chairmen? The impacts on other WGs have to be carefully reviewed (the earlier the tables from the WG chairmen are available the better, ideally at latest 1 week after the WG meeting): If WGx expected a CR from WGy but WGy did not provide such a CR, then there are 2 possibilities: The CR from WGy was not needed (then this will be documented e.g. in the RAN minutes or in a revised WG chairman's report) or WGy did not manage to conclude on a CR which means we have an incomplete CR set that cannot be approved. It is then up to TSG RAN to discard the incomplete CR set or to request a company CR for the WGy spec (if it is easy to solve) or to consider the start of a new WI (if the problem is more complex).

**E.4 MCC will support this tracking activity with a list of TEI CRs for a considered release that were handled at RAN and that have the unique TEI identifier.**

- The resulting Tdoc list of each RAN meeting includes already a complete list of all CRs handled in this meeting. An additional list will be added after RAN #92e listing the TEI CRs with unique TEI identifiers in [ ].  
 After RAN #93e, a further list will be appended to the TEI CR list so that in the end a list for all TEI cat.B/C CRs (and their corresponding cat.F/A corrections) will develop that allows easy search and filtering for new TEI features.

- Such a list could be generated per release and will allow an improved visibility and tracing of new TEI features.  
 Note: Due to the unique TEI identifiers and the proper documentation as outcome of the RAN meetings, also 3GU will allow to search for TEI CR sets.