**3GPP TSG RAN WG1 #113 R1-230xxxx**

**Incheon, Korea, May 22nd – May 26th, 2023**

**Agenda item:** 9.15

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

**Title:** [draft] Summary #1 on Rel-18 TEIs

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the discussions and proposals in AI 9.15 for Rel-18 TEI related discussion.

Note that R1-2304433 submitted in AI 9.15 is to be discussed in agenda item 5, as announced by RAN1 chair. Based on the discussions summarized in Section 2, following TEI proposals are identified in AI 9.15. According to the guidance in [8], 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: UE capability with up to 6-layer DL MIMO**
	+ Supported by OPPO, CMCC, China Telecom, NTT DOCOMO, Lenovo, China Unicom, Qualcomm
* **TEI proposal #2: PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI**
	+ Supported by ZTE, China Telecom, Sanechips
* **TEI proposal #3: Enhanced PDCCH reception for mDCI based mTRP**
	+ Supported by Qualcomm
* **TEI proposal #4: Enhancement for scheduling request**
	+ Supported by Qualcomm
* **TEI proposal #5: UE reporting of power offset for SRS antenna switching**
	+ Supported by Qualcomm
* **TEI proposal #6: RAT-independent Positioning Enhancements**
	+ Supported by Qualcomm
* **TEI proposal #7: Enhancement for HARQ multiplexing on PUSCH**
	+ Supported by Huawei, HiSilicon, Ericsson, China Unicom
* **TEI proposal #8: Pathloss RS for Type 1 CG-PUSCH**
	+ Supported by Xiaomi, China Unicom, OPPO, ZTE
* **TEI proposal #9: Extended CP support for NR MBS**
	+ Supported by CBN, China Telecom, China Unicom, CATT, Huawei, HiSilicon, ZTE, Sanechips
1. Discussion on Rel-18 TEI proposals
	1. UE capability with up to 6-layer DL MIMO

Following proposal is made in the contribution.

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| [5] | **Background**In Rel-15 NR, the MIMO schemes with up to 8 layers were introduced to boost the DL throughput. Based on UE capability, NW may configure MIMO transmission with up to 8 layers for a UE. According to the existing RRC signaling, the number of MIMO layer can be configured as 1, 2, 3, 4, 5, 6, 7, or 8.

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| PDSCH-Config ::= SEQUENCE { dataScramblingIdentityPDSCH INTEGER (0..1023) OPTIONAL, -- Need S dmrs-DownlinkForPDSCH-MappingTypeA SetupRelease { DMRS-DownlinkConfig } OPTIONAL, -- Need M dmrs-DownlinkForPDSCH-MappingTypeB SetupRelease { DMRS-DownlinkConfig } OPTIONAL, -- Need M ..., [[ maxMIMO-Layers-r16 SetupRelease { MaxMIMO-LayersDL-r16 } OPTIONAL, -- Need M minimumSchedulingOffsetK0-r16 SetupRelease { MinSchedulingOffsetK0-Values-r16 } OPTIONAL, -- Need M …}MaxMIMO-LayersDL-r16 ::= INTEGER (1..8) |

Meanwhile, the existing UE capability signaling allows a UE to report the support of up to 2-layer DL MIMO, up to 4-layer DL MIMO or up to 8-layer DL MIMO.

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| FeatureSetDownlinkPerCC ::= SEQUENCE { supportedSubcarrierSpacingDL SubcarrierSpacing, supportedBandwidthDL SupportedBandwidth, channelBW-90mhz ENUMERATED {supported} OPTIONAL, maxNumberMIMO-LayersPDSCH MIMO-LayersDL OPTIONAL, supportedModulationOrderDL ModulationOrder OPTIONAL}MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers} |

For the practical deployment, it is common for smartphones to use 4 Rx or 2Rx antennas for typical bands. Thus, the current commercial smart phones can only support DL MIMO with up to 4 layers. ***Observation 1: The current commercial smart phones can only support DL MIMO with up to 4 layers.*** As hardware and design improve, some advanced smartphones are starting to trend towards using more Rx antennas to improve the DL performance. For example, some foldable phones have already implemented 6 Rx antennas. That brings in the following benefits to 5G system:* B1: A more advanced receiver exploiting more Rx antennas to mitigate interference for DL MIMO transmission with up to 4 layers that can
* B2: providing higher peak data rate through supporting higher number of DL MIMO layers (e.g., 5 or 6 layers). Fig.1 illustrates the LLS performance for DL MIMO schemes. “rank4” and “rank6” in the figure refer to the dynamic rank adaptation with up to 4 layers and up to 6 layers, respectively.

***Observation 2: Compared to 4-layer DL MIMO, 6-layer DL MIMO can offer higher data rate and better user experience.*** Figure 1. Performance comparison of up to 4-layer and up to 6-layer DL MIMOThe benefit B1 can be achieved by advanced implementation of chipset with no spec impact. But, unfortunately, the benefit B2 cannot be obtained under the current specification. According to the existing UE capability signaling, a UE not supporting 8-layer DL MIMO can only report either “twoLayers” or “fourLayers”. With reporting either one, the system is not able to configure 6-layer DL MIMO transmission to the UE, even though the UE is capable of 6-layer DL MIMO. During the discussion in the last meeting, there was a proposal that a UE reports the support of 8-layer DL MIMO but will only report the rank with up to 6. However, this implementation-based solution has some problems. The first one is that “cheating” network is not aligned with the basic principle of UE capability in 3GPP. The second one is UE cannot meet some other requirements specified by 3GPP or regulator (e.g., the requirements of 8-layer DL MIMO peak data rate, other test use cases in RAN4/RAN5). ***Observation 3: The current NR spec cannot allow UE to support DL MIMO with up to 6 layers if it cannot support 8-layer DL MIMO.***  Based on the above discussion, the main restriction of existing UE capability is the relatively coarse granularity, i.e., only 2-layer, 4-layer and 8-layer are supported. A finer granularity for the DL MIMO layers will encourage more advanced commercial smart phones to provide higher data rate as UE don’t need to jump from 4 layers to 8 layers directly. ***Observation 4: Allowing smart phones to support 6-layer DL MIMO will encourage UE vendors to provide advanced commercial smart phones with higher data rates.*** **Solution**Therefore, in order to achieve higher DL throughput by fully exploiting the capability of UE with 6-layer DL MIMO, it is proposed to introduce a new UE capability so that an advanced smart phone with 6 or more Rx antennas can report its support of up to 6-layer DL MIMO transmission.***Proposal 1: Introduce a new candidate value, sixLayers, for the UE capability of supported maximal number of DL MIMO layers to support up to 6-layer DL MIMO transmission**** ***Prerequisite feature group is FG 2-1***
* ***“Need for gNB to know whether the feature is supported by the UE” is “Yes”***
* ***Reporting type is per FSPC***
* ***“Mandatory/Optional” is Optional with capability signalling***
* ***Note1: R15 NR has already supported the candidate values of twoLayers, fourLayers and eightLayers via the RRC parameter MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}. It’s up to RAN2 for the signaling design of the corresponding UE capability.***
* ***Send an LS to RAN2 for necessary signalling design***

The key point of Proposal 1 is to introduce a new candidate value of UE capability so that UE vendors can provide some new types of advanced smart phones, which is more powerful than the current commercial smart phones. All the configuration mechanisms and transmission schemes are reusing existing ones. That is to say, no new mechanism/scheme/feature is introduced. ***Observation 5: Proposal 1 doesn’t introduce any new NR feature(s). That is to say, the smart phone will reuse NR existing mechanisms/schemes.*** During the last meeting, some companies suggested RAN4 work for this TEI. As we discussed above, the smart phone will reuse NR existing mechanisms/schemes. In our views, whether/how any RAN4 work is needed or not for legacy NR mechanism/schemes is a separate discussion.***Observation 6: Whether/how any RAN4 work is needed or not for legacy NR mechanism/scheme/feature is a separate discussion.***  |
| [6] | In the current UE capability signalling maxNumberMIMO-layersPDSCH for DL MIMO, there is an unnecessary limitation. * The allowed values for maxNumberMIMO-layersPDSCH are {twoLayers, fourLayers, eightLayers} where sixLayers are missing. Given that there is no product on market to support more than fourLayers for DL MIMO, the caveat is not a problem for now. But in the future, this is a problem for UE vendors to build new devices beyond 4 layers, because the new devices have to support up to 8 layers directly. It is quite challenging to build device which improves from supporting max of 4 layers to max of 8 layers directly. It is beneficial, from both market demand and UE implementation perspective, to allow UE vendors improve devices from max of 4 layers to max of 6 layers, then to max of 8 layers.

To address the limitation, a very simple proposal is made, which is adding value 6 in the candidate value list of maxMIMO-LayersPDSCH. In RAN1#112, several companies mentioned there is RAN4 impact due to this proposal. However, one should notice that there is RAN4 impact for other TEI proposal as well. To way to avoid RAN4 impact in Rel-18, for the following agreed TEI proposal in RAN#112 is simply adding a note “Not to define RAN4 RRM requirement, including core/performance in Rel-18”, as in the following agreement. Similar approach can be adopted for this TEI proposal on maxNumberMIMO-layersPDSCH.

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| --- |
| **Agreement*** Introduce 1-symbol PRS with legacy comb sizes.
	+ UE expects the suitable expected RSTD windows provided by LMF such that peak ambiguity is addressed. Otherwise no measurement accuracy requirements are expected to be met.
	+ Not to define RAN4 RRM requirement, including core/performance in Rel-18
	+ Send an LS to RAN2 and RAN3 to ask necessary signalling enhancements
 |

With the above analysis, we make the following proposal. Proposal 2: Add a new UE capability of maxMIMO-LayersPDSCH-r18 with candidate values {2,4,6,8}.

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| --- | --- | --- | --- | --- |
|  | **Description** | **Per** |  | **Candidate values** |
| **maxMIMO-LayersPDSCH-r18** | **Supported maximum number of DL MIMO layers** | **FSPC** |  | **{2,4,6,8}** |

**Note: Not to define RAN4 requirements for maxMIMO-LayersPDSCH-r18=6, including core/performance in Rel-18.**  |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Company | Suppport (Y/N) | Comment |
| Moderator |  | Regarding the FFS in the last sub-bullet, if 6Rx is considered for 6 DL MIMO layers, RAN4 requirements may need to be defined according to the discussion in the last RAN1 meeting. Companies are also encouraged to provide their views on whether these notes 2/3 are necessary or not.  |
| DOCOMO | Y | Support the proposal. We believe the proposal is useful in real network, because if we can configure up to 6 layer DL MIMO, we can improve DL peak throughput compared to up to 4 layer DL MIMO. The issue of the current spec. is that UE cannot report supporting of 6 layer DL MIMO even if UE supports 6 layers. Simple extension of the UE capability signaling to include 6 layers can solve the issue.For the FFS part,* We believe Note2 should be removed. From our perspective, we don’t think we should mention 6Rx or 8Rx in the proposal. Since 6 layers for 6 Rx is not supported in Rel.18 RAN4, it can be supported in future RAN4 releases. 6 layers for 8 Rx can be discussed as a part of Rel.18 RAN4 work. Even if we keep the Note2, we think the current Note2 should be updated to clarify keeping the rule that 4 layers is mandatory for the bands where 4Rx is mandatory except for RedCap (same comment as RAN1#112).
* We think Note3 is not needed, but we are fine to keep the note3.
 |
| QC | Y | For Note2: We are open to discuss how to modify the note2 to address DCM and other companies’ comments. To clarify on the intention of Note3: eventually, RAN4 requirements for 6-layer DL MIMO would be needed. But it is up to RAN4 to decide when to do it (e.g. in Rel-19). Just following the note added for 1-symbol PRS TEI agreement in last meeting, we are OK to not define RAN4 requirement in Rel-18.  |
| CATT | N | In our view, it’s not feasible to support this without defining RAN4 requirements correspondingly. Furthermore, this feature has major impacts to other working group, and may not suitable for a TEI. |
| Samsung | N | We don’t support the proposal. So far, none of devices support 6RX, and there is no RAN4 requirement on 6RX UE. Hence, we cannot decouple RAN4 requirement with this issue, and there is no chipset supporting 6RX, the alternative way to implement is to take 8RX UE implementation and use it by downgrading, which will only result in UE fragmentation issue without any benefit.  |
| ZTE |  | In our views, “6Rx UE” related note should be removed, otherwise it definitely has RAN4 impact. Then, we are wondering whether the 8Rx UE should inidicate that it can support 8-layer or 4-layer directly.  |
| MediaTek | N | We are still not convinced about this proposal. We see a lack of practically realisable gains from extending from 4 to 6 layers, and we don’t believe that the additional ecosystem effort in enabling a 6 MIMO layers UE capability is justified. 6Rx for smartphone was already de-prioritised for Rel-18 RAN4 package. Overall we do not consider this critical enough to justify it as a Rel-18 TEI.  |
| Nokia, NSB | Y with changes | We agree with DOCOMO’s points, and would delete notes 2 and 3. We do see the point of potentially needing 6-Rx requirements and a test-case for 6-layer MIMO performance, but functionally we defined 8-layer MIMO in Rel-15 without a worry in the world over missing performance requirements. It would be unfortunate to not allow proceeding with the discussion due to that. One possibility would be to take the question to RAN on a somewhat similar fashion as the BWP without restriction issue was raised to RAN. |
| vivo | N | First, we need to clarify which type of device is targeted. This discussion should happen in RAN4, RAN4 is correct place to discuss device types. If this proposal is for 8Rx UE, which is already supported in the spec we are open to discuss whether UE can report max rank=6.  |
| Huawei, HiSilicon | N | We have several questions over this proposal:* We are not clear on the benefits. For CSI reporting based transmission, 6 layers have limitations, e.g., no type-II high resolution codebook for 6-layer, coarser codebook compared with 4-layer. This can also be reflected in the simulation results that for SNR less than 30dB, there’s marginal difference between 4-layer & 6-layer. For reciprocity-based transmission, spec has supported UE reporting of 1t6r or 2t6r for antenna switching, thus in practice the 6-layer can be supported in practice.
* To enable practical use of 6-layer, the RAN4 requirement is needed. Therefore, there’s no rush to specify it now in RAN1 without RAN4 requirement. It can be considered in future releases including the RAN4 requirements.
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| QC2 |  | Regarding the comment on missing RAN4 requirement or RAN4 deprioritized defining 6Rx requirements in Rel-18, as far as we know, one of the arguments that opponents used in RAN4 to deprioritize 6Rx is 6L MIMO capability signaling is missing. Now, we want to add 6L MIMO capability signaling, then opponents are arguing RAN4 requirement is missing. It looks like we created a chiken-egg problem. To allow 6Rx UE in market for 5G eco-system, either RAN1 or RAN4 need take a step to break the chiken-egg loop. In our view, it is very reasonable that we define the capability signaling first, then ask RAN4 to follow-up to define performance requirement, because the effort to define the capability is very small. To VIVO: this proposal is mainly for 6Rx UE. If it helps to clarify things, we can even remove “An 8Rx UE can report a capability of two, four, six or eight layers of maximum number of DL MMO layers.” from note 2. To MediaTek: in Rel-15, we agreed extending from 4L MIMO to 8L MIMO has gain, right? Then why extend from 4L MIMO to 6L MIMO has no gain? In MediaTek’s view, what happens with 6L which steal the obvious spectrum efficiency gain? Can MediaTek please provide some nationale?To Huawei: Regarding your comment on CSI feedback caveat and required SNR for 6L, aren’t the same issues (even more severe) with 8L? Why did RAN1 specify 8L in Rel-15? |
| Moderator |  | According to the above comments, this proposal is supported by OPPO, CMCC, China Telecom, NTT DOCOMO, Lenovo, Qualcomm, Nokia, NSB (removing Note2/3), and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor.Therefore, this proposal is further discussed directly over RAN1 reflector toward the GTW on Thursday. As the first step, proponent is encouraged to address the concern from companies.Proposal is updated based on the comments from Nokia/NSB (which is necessary to meet the condition)**TEI proposal #2*** **Introduce a new candidate value, sixLayers, for the UE capability of supported maximal number of DL MIMO layers to support up to 6-layer DL MIMO transmission**
	+ **Prerequisite feature group is FG 2-1**
	+ **“Need for gNB to know whether the feature is supported by the UE” is “Yes”**
	+ **Reporting type is per FSPC**
	+ **“Mandatory/Optional” is Optional with capability signalling**
	+ **Note1: R15 NR has already supported the candidate values of twoLayers, fourLayers and eightLayers via the RRC parameter MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}. It’s up to RAN2 for the signaling design of the corresponding UE capability.**
	+ **Send an LS to RAN2 for necessary signalling design**
	+ **~~FFS on the following notes~~**
		- **~~Note2: A 6Rx UE can report a capability of two, four or six layers of maximum number of DL MMO layers. An 8Rx UE can report a capability of two, four, six or eight layers of maximum number of DL MMO layers.~~**
		- **~~Note3: Not to define RAN4 requirements for UE supporting up to 6-layer DL MIMO transmission, including core/performance in Rel-18.~~**
 |
|  |  | (No further input. Directly discuss over RAN1 reflector) |
| Moderator |  | No consensus was achieved in [112bis-e-R18-TEIs-01] |

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Based on the above contribution, following TEI proposal, which is the latest one in the last meeting, can be discussed in RAN1#113 meeting.

### **TEI proposal #1**

* **Introduce a new candidate value, sixLayers, for the UE capability of supported maximal number of DL MIMO layers to support up to 6-layer DL MIMO transmission**
	+ **Prerequisite feature group is FG 2-1**
	+ **“Need for gNB to know whether the feature is supported by the UE” is “Yes”**
	+ **Reporting type is per FSPC**
	+ **“Mandatory/Optional” is Optional with capability signalling**
	+ **Note: R15 NR has already supported the candidate values of twoLayers, fourLayers and eightLayers via the RRC parameter MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}. It’s up to RAN2 for the signaling design of the corresponding UE capability.**
	+ **Send an LS to RAN2 for necessary signalling design**

This proposal is already supported by OPPO, CMCC, China Telecom, NTT DOCOMO, Lenovo, China Unicom, Qualcomm.

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 repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI

Following proposal is made in the contribution.

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| [2] | **Background**In Rel-17 CE SI, most UL channels are identified as the coverage bottleneck channels in many scenarios, e.g., Rual 700MHz FDD NLOS O2I scenario [1]. Up to Rel-17, PUSCH repetition Type A is supported when transmitting PUSCH scheduled by a grant among the following cases. * DCI format 0\_1 or 0\_2 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1;
* RAR UL grant, i.e., Msg3 initial transmission;
* DCI format 0\_0 with CRC scrambled by TC-RNTI, i.e., Msg3 re-transmission.

In Rel-18, PRACH repetition [2] and repetition of PUCCH carrying Msg4 HARQ-ACK [3] will be further supported. PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI is one important channel left that does NOT support repetition transmission. In this contribution, the coverage performance of PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, e.g., Msg5 PUSCH, is evaluated. And potential issues and corresponding mechanisms to support Msg5 PUSCH repetition are also discussed. **Coverage analysis**As shown in Figure-1, after a UE performing 4-step RACH procedure, the network would schedule Msg5 PUSCH transmission to complete the RRC setup. Typically, the network performs the first RRC reconfiguration according to the UE capability information. Before the UE capability is reported, some functions that need to be determined based on the UE capability information cannot be configured. Therefore, before the first *RRCReconfiguration* message is received, DCI formats other than format 0\_0 cannot be used for UL scheduling. So, Msg5 PUSCH, which is scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, cannot be scheduled with repetition. ***Observation 1****: Msg5 PUSCH, which is scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, is the only uplink channel does not support repetition transmission after a UE performing 4-step RACH procedure in Rel-18.* Figure-1: Higher layer procedure for a UE accessing the networkIt is observed that Msg5 transmission is the coverage bottleneck according to the real filed test. The situation would get worse when repetition transmission of PRACH/Msg3/Msg4 HARQ-ACK is enabled. This is because more UEs would access to the network after the RACH procedure while congested during Msg5 transmission. ***Observation 2****:* *Msg5 PUSCH is the coverage bottleneck according to the real filed test.*Msg5 PUSCH is now one of the few UL channels does not support repetition transmission in Rel-18. However, it may have even worse coverage than some other UL channels (e.g., Msg3 PUSCH according to the evaluation below). Therefore, no support of Msg5 PUSCH repetition would jeopardize the commercialization of other Rel-17 and Rel-18 coverage related features, especially for repetition based features including the ones for NTN. ***Observation 3****:* *No support of Msg5 PUSCH repetition would jeopardize the commercialization of other Rel-17 and Rel-18 coverage* *enhancement related features in both TN and NTN scenarios.*To further evaluate the transmission performance of the Msg5 PUSCH, some link-level simulations are performed. Regarding the information carried by the Msg5 PUSCH, the packet size is assumed as 118 Bytes, which contains *RRCSetupComplete* (~102 Bytes), potential PHR and BSR (10 Bytes), and sub-layer (including, PDCP, RLC and MAC) header overhead (6 Bytes). In our evaluation, TDD frame structure ‘DDDSU DDSUU’ with 30kHz SCS is used in the simulation. The other detail simulation assumptions can be found in the Appendix. In the simulation, the Msg5 PUSCH transmission performances under different maximum transmission times are evaluated. For example, ‘Msg5 with max 2 (re-)transmissions’ represents that there are at most 2 transmissions for Msg5 PUSCH, including initial transmission and retransmission. The performance of Msg3 PUSCH transmissions with different repetition factors (i.e., 1, 2, 4 and 8) are taken as baseline. The simulation results are showed in Figure-2 and Table-1. Figure-2: Performance for Msg3 and Msg5 PUSCH transmissionTable-1: Performance for Msg3 and Msg5 at BLER = 0.1

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| --- | --- | --- |
| Simulation cases | Target SNR (dB) w/o power normalization | Target SNR (dB) w/ power normalization to one PRB |
| Msg3 without repetition | -7.31 | -4.3 |
| Msg3 with 2 repetitions | -11.27 | -8.26 |
| Msg3 with 4 repetitions | -13.67 | -10.66 |
| Msg3 with 8 repetitions | -15.91 | -12.9 |
| Msg5 with max 2 (re-)transmissions | -9.21 | 5.84 |
| Msg5 with max 4 (re-)transmissions | -10.25 | 4.8 |
| Msg5 with max 8 (re-)transmissions | -11.18 | 3.87 |

According to the above simulation results, significant performance gap can be observed between Msg5 PUSCH and Msg3 PUSCH, even though HARQ re-transmissions are enabled for Msg5 PUSCH while not for Msg3 PUSCH. It means that Msg5 PUSCH has more severe coverage issue than Msg3 PUSCH and therefore is the coverage bottleneck. ***Observation 4****: The performance gap between Msg5 PUSCH transmission and Msg3 PUSCH transmission is large, which is summarized in the following table.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Performance gap(dB) between Msg5 and Msg3 at BLER = 0.1*  | *Msg3 without Repetition* | *Msg3 with 2 Repetitions* | *Msg3 with 4 Repetitions* | *Msg3 with 8 Repetitions* |
| *Msg5 with max 2 (re-)transmissions* | *>10* | *>10* | *>15* | *>15* |
| *Msg5 with max 4 (re-)transmissions* | *9.1* | *>10.* | *>15* | *>15* |
| *Msg5 with max 8 (re-)transmissions* | *8.17* | *>10* | *>10* | *>15* |

During RAN1#112 meeting, RLC segmentation is proposed by some companies to improve Msg5 PUSCH coverage. However, the layer 2 header overhead increases significantly with the increase of the number of segmentations. For each segmented packet, an RLC header with 4 Bytes and a MAC header with 2 Bytes will be additionally added and a PDCP header with 2 Bytes is shared by all segmented packet. While for PUSCH repetition, there is always 6 Bytes layer header overhead for each repetition transmission. The payload size of Msg5 is much larger than Msg3. If segmentation is used, more than 10 segmentations are required to approach similar payload size as Msg3. Then, as given in Table-2, the ratio of layer 2 header overhead would reach 46.7% and 63.4% for 16 and 32 segmentations respectively, making it an unfeasible solution in reality. Table-2: Layer 2 header overhead for Msg5 PUSCH transmission w/ or w/o segmentation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number of segmented packets (N) | Size of data (excluding header overhead) | Layer 2 header overhead | Payload size of each packet after segmentation | Ratio of layer 2 header overhead |
| 1 (repetition or w/o segmentation) | 112 Bytes | 2 (PDCP header) + 2 (RLC header) + 2 (MAC header) = 6 Bytes | 118 Bytes | 5.1% |
| 2 | 112 Bytes | 2 (PDCP header) + 4\*N (RLC header) + 2\*N (MAC header) = 14 Bytes | 63 Bytes | 11.1% |
| 4 | 112 Bytes | 26 Bytes | 35 Bytes | 18.8% |
| 8 | 112 Bytes | 50 Bytes | 21 Bytes | 30.9% |
| 16 | 112 Bytes | 98 Bytes | 14 Bytes | 46.7% |
| 32 | 112 Bytes | 194 Bytes | 10 Bytes | 63.4% |

***Observation 5****: If segmentation is used, more than 10 segmentations are required to approach similar packet size as Msg3. The layer 2 header overhead increases significantly (e.g., 46.7% for 16 segmentations, 63.4% for 32 segmentations), making it an undesirable solution in reality.* In addition, similar to other PUSCH channels supporting repetition, using a larger TBS without segmentation can provide better performance in terms of large encoding gain and small high layer overhead. This is also the reason why TBoMS transmission is supported in Rel-18 for PUSCH scheduled by DCI format 0\_1/0\_2. ***Observation 6****: Similar to other PUSCH channels supporting repetition or TBoMS, PUSCH transmission with less segmentation can provide better performance in terms of large encoding gain and small high layer overhead.* Except for Msg5, similar coverage issue could be observed for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI even after UE capability reporting. Thus, we propose to support PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI. ***Proposal 1****: Support PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI.* **Proposed enhancement**Both Msg5 PUSCH and Msg3 retransmission are scheduled by DCI format 0\_0, and the only difference is the RNTIs used. That is, TC-RNTI is used to scramble CRC of the DCI format for Msg3 retransmission scheduling, while C-RNTI is used for Msg5 PUSCH. Therefore, from our perspective, similar repetition mechanism can be reused to support Msg5 PUSCH repetition, and the standardization effort would be limited. In this context, we can consider the following solution for support of PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI. * For the transmission schemes, reuse the same approach as Msg3 re-transmission which is scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, including repetition indication, RV determination, available slot determination and frequency hopping etc.
* During initial access, a UE can request repetition transmission for PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI via a higher layer signaling in Msg3 PUSCH, e.g., reserved LCID codepoints or reserved bit(R) in the MAC subheader.
* Alternatively, using separate PRACH resources for the request can also be considered, while this would result in further PRACH partition and therefore not preferred.
* Similar mechanism has been agreed/discussed in several Rel-18 topics,
* It has been agreed in RAN2 in RAN2#121 that the early indication for Rel-18 eRedCap is included in Msg3/MsgA PUSCH; More specifically, it is agreed as a RAN2 working assumption in RAN2#121bis-e to use LCID values to support Msg3 early identification for Rel-18 eRedCap UE.
* Regarding PUCCH repetition for Msg4 HARQ-ACK, the following working assumption of using a higher layer signaling in Msg3 PUSCH to carry the repetition request or capability report was achieved as discussed in Rel-18 NTN WI.

|  |
| --- |
| Working assumptionFor PUCCH repetition for Msg4 HARQ-ACK, support Option B as container of the repetition request or capability report indicated by UE.* Option B: Higher layer signaling in Msg3 PUSCH

Send an LS to RAN2 to ask the feasibility of Option B, and if feasible, to specify the details of Option B. |

***Proposal 2****: For support of PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, adopt the following solution.* * *For the transmission schemes, reuse the same approach as Msg3 re-transmission which is scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, including repetition indication, RV determination, available slot determination and frequency hopping etc.*
* *During initial access, a UE can request repetition transmission for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI via a higher layer signaling in Msg3 PUSCH.*
* *Send an LS to RAN2 ask the feasibility, and if feasible, to specify the details.*
* *Note: For early identification of Rel-18 eRedCap and PUCCH repetition for Msg4 HARQ-ACK in Rel-18 NTN, using higher layer signaling in Msg3 PUSCH is the current working assumption.*
 |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Company | Suppport (Y/N) | Comment |
| QC | N | We are still not convinced that this proposal is needed. From our observation in field, msg5 reception seems not an issue. |
| ZTE | Y | @QC, Msg3 is identified as bottleneck channel in some rural scenarios in Rel-17. And it’s clear that Msg5 has worse coverage than Msg3 as Msg5 has much larger payload size, therefore Msg5 could also have coverage issue. This issue may not be that severe in current deployment without implementing Rel-17/18 CE features. But as we commented before, we found the coverage issue of Msg5 during testing Msg3 repetition and found that the system performance is even worse after enabling Msg3 repetition because more UEs can access to the NW while congested during Msg5 transmission. We expect similar issue if enabling Rel-18 features like PRACH repetition and PUCCH repetition for Msg4 HARQ-ACK. We see it is promising to implement Rel-17/18 CE features in near future, e.g., for NTN scenarios or vertical scenarios. Thus, it is critical to make Msg5 repetition available together with other repetition-based features in Rel-18. Otherwise, it may jeopardize the implementation of other Rel-17/18 CE features.Regarding the comment for using re-transmission in the last meeting:Based on our evaluation, using re-transmission with a maximum 8 re-transmissions cannot compensate the performance gap between Msg3 and Msg5. The performance of Msg3 is better than Msg5, and Msg3 already supports repetition transmission. So, supporting Msg5 repetition is critical to reach the same coverage with Msg3. Regarding the comment for using segmentation in the last meeting:For a typical Msg5 payload, it requires more than 32 segmentations to reach a similar payload size of Msg3. This would cause huge layer 2 overhead (more than 60%) as analyzed in our tdoc. In addition, TBoMS is supported for coverage enhancement in Rel-17. The main motivation is that a larger TBS without segmentation can provide better performance in terms of large encoding gain and small high layer overhead. So, we don’t think segmentation can be helpful for coverage compared to repetition transmission. Regarding the comment for spec effort in the last meeting:Our proposal intends to reuse what we defined for Msg3 re-transmission (the only difference is the RNTI used), and spec impact for this would be minimized. Regarding early UE identification, a similar mechanism as defined for Rel-18 eRedCap can be reused here, i.e., indicating UE identification in Msg3 PUSCH. |
| MediaTek | N | After 2 Releases of discussion, this was not identified as a bottleneck. We have also not observed issues in the field here. Also it would seem to require a re-deisgn of initial access to allow the NW to be aware and configure such repetitions, which seems quite some effort. |
| Nokia, NSB |  | While we see that there maybe potential in the proposal, as we commented the last time, we still feel that this is more a work-item level proposal than a TEI item, and would suggest considering this in Rel-19. |
| vivo |  | First of all, pusch-RepetitionMultiSlots is a UE mandatory feature with capability signalling in Rel-15 and DCI 0\_1 is also mandatory in Rel-15, which means that Msg5 repetition is already possible to be scheduled by DCI 0\_1 with repetition.In addition, we have following comments:1. PUSCH scheduled by RAR in CFRA, MsgA (PRACH + PUSCH) in 2-step RACH are not supported with repetition either. 🡪 observation 1 is wrong.
2. Cell coverage is determined by the worst channel. Bottleneck channel is still PUSCH eMBB even after Rel-17/18 coverage enhancement.
3. Retransmission can be used for coverage extension of Msg5 though latency is a bit larger compared to repetition.

According to above, Msg5 repetition seems not necessary. In addition, this enhancement may require early UE feature indication which has large spec. impacts. |
| Huawei, HiSilicon | N | In our observation, the so called Msg5 reception seems not an issue in field. Additionally, since the first message after initial access is targeted in the proposal, a network may not be aware of the UE capability yet. An early identification for the new feature seems necessary and requires special RAN2 impacts which seems not a task involving only single WG. |
| Moderator |  | According to the above comments, this proposal is supported by ZTE, China Telecom, Sanechips, and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor.Therefore, this proposal is further discussed directly over RAN1 reflector toward the GTW on Thursday. As the first step, proponent is encouraged to address the concern from companies. |
|  |  | (No further input. Directly discuss over RAN1 reflector) |
| Moderator |  | No consensus was achieved in [112bis-e-R18-TEIs-01] |

 |

Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting. Red color shows the update from last RAN1 meeting.

### **TEI proposal #2**

* **Support PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI.**
	+ **For the transmission schemes, reuse the same approach as Msg3 re-transmission which is scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, including repetition indication, RV determination, available slot determination and frequency hopping etc.**
	+ **During initial access, a UE can request repetition transmission for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI via a higher layer signaling in Msg3 PUSCH.**
		- **Send an LS to RAN2 to ask the feasibility, and if feasible, to specify the details of the request.**
		- **Note: For early identification of Rel-18 eRedCap and PUCCH repetition for Msg4 HARQ-ACK in Rel-18 NTN, using higher layer signaling in Msg3 PUSCH is the current working assumption.**

This proposal is already supported by ZTE, China Telecom, 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. Enhanced PDCCH reception for mDCI based mTRP

Following proposal is made in the contribution.

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| [6] | Multi-DCI based multi-TRP is specified in Rel-16 with the following relevant features:* Two PDSCHs associated with different *coresetPoolIndex* values can be partially/fully overlapping in time in the same CC
	+ The max number of PDSCH per slot (in TDM manner) is defined per *coresetPoolIndex*, which can be indicated by UE capability.
* For PDCCH monitoring in multi-DCI based multi-TRP, the following are supported:
	+ The maximum number of CORESETs per BWP is increased to 5 CORESETs, with a maximum of 3 CORESETs per *coresetPoolIndex* value.
	+ The maximum number of BDs / CCEs is doubled subject to UE capability, with a limit per *coresetPoolIndex* value that is same as a single-TRP CC.

Furthermore, in Rel-18, it is agreed that two PUSCHs associated with different *coresetPoolIndex* values can be partially/fully overlapping in time in the same CC (for simultaneous transmission in MIMO AI).In order for the network to schedule overlapping PDSCHs / PUSCHs, the two TRPs need to transmit the two corresponding DCIs in any scheduling instance (e.g., in any slot or PDCCH monitoring occasion). As discussed above, the PDCCH monitoring capabilities (number of BDs / CCEs) are also enhanced accordingly. However, the following two issues make it practically infeasible for UE to receive two DCIs at the same time (issue 1 for FR2) or even in the same slot / PDCCH monitoring occasion (issue 2):* **Issue 1**: This issue is related to QCL-TypeD prioritization for overlapping CORESETs, which is specific to FR2. Based on the procedure defined in 38.213 Section 10.1, the UE selects one CORESET (based on a priority rule), and only that CORESET and other CORESETs with the same QCL-TypeD priorities are monitored when multiple CORESETs overlap in time.
	+ During the maintenance phase of Rel-16, extending this rule for multi-DCI based mTRP (to make it per TRP) was discussed. Such discussions were postponed with the understanding that Rel-17 can potentially address the issue. However, Rel-17 only enhanced this QCL-TypeD prioritization rule for the case of PDCCH repetition and for the case of SFN PDCCH, but it was not extended for the case of multi-DCI based multi-TRP.
* **Issue 2**: Even though the number of BDs / CCEs that the UE monitors is doubled (and number of CORESETs is increased to 5) in Rel-16, the capability to process DL DCIs or UL DCIs was not extended accordingly. That is, the UE can only monitor more PDCCH candidates, but cannot actually receive and process more DCIs.
	+ For basic PDCCH capability (FG 3-1), the UE can process one DL DCI and one UL DCI per slot for FDD, and one DL DCI and two UL DCIs per slot for TDD.
	+ For more advanced PDCCH monitoring capabilities such as FG 3-5a or FG 3-5b, the number of DL DCIs or UL DCIs that the UE can process is defined per PDCCH monitoring occasion or per PDCCH span. For these advanced PDCCH monitoring capabilities, it is possible to receive more than one DL DCI and more than one UL DCI per slot, but there is additional complexity associated with PDCCH monitoring as well.
	+ In either case, the max number of DL DCIs or UL DCIs is not extended accordingly for the case of multi-DCI based multi-TRP.
	+ Hence, in order to be able to receive DCIs from different TRPs in a slot in the case of multi-DCI based multi-TRP, the UE has to support one of these advanced UE capabilities, which is not reasonable. This can be a barrier for wide deployment of this feature. Effectively, the larger number of BDs / CCEs specified in Rel-16 for multi-DCI based multi-TRP cannot be utilized in practice to actually transmit more DL / UL DCIs from the two TRPs.

These two issues result in inefficient operation of multi-DCI based multi-TRP feature as they impose unnecessary restrictions on transmissions of DCIs from corresponding TRPs. Observation 1: Multi-DCI based multi-TRP operation based on existing specifications suffers from the following two issues:* **Issue 1: Existing QCL-TypeD prioritizations for overlapping CORESETs does not allow the UE to monitor PDCCHs with different beams from corresponding TRPs on the same / overlapping OFDM symbols.**
* **Issue 2: Even though the PDCCH monitoring capabilities (number of BDs / CCEs) are increased for multi-DCI based multi-TRP, the capability related to number of DL/UL DCIs that the UE can actually receive and process is not enhanced correspondingly.**

To address Issue 1, we propose to perform the legacy QCL-TypeD prioritization rules separately for *coresetPoolIndex* value 0 and for *coresetPoolIndex* value 1. An example of the change needed in 38.213 Section 10.1 is shown in the following TP:============TP for 38.213 Section 10.1 ====================================--Unchanged part omitted------------------------If a UE - is configured for single cell operation or for operation with carrier aggregation in a same frequency band, and- monitors PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORESETs that have been configured with same or different *qcl-Type* set to 'typeD' properties on active DL BWP(s) of one or more cellsthe UE monitors PDCCHs only in a CORESET, and in any other CORESET from the multiple CORESETs that have been configured with *qcl-Type* set to same 'typeD' properties as the CORESET, on the active DL BWP of a cell from the one or more cells - the CORESET corresponds to the CSS set with the lowest index in the cell with the lowest index containing CSS, if any; otherwise, to the USS set with the lowest index in the cell with lowest index- the lowest USS set index is determined over all USS sets with at least one PDCCH candidate in overlapping PDCCH monitoring occasionsIf a UE - is not provided *coresetPoolIndex* for first CORESETs, or is provided *coresetPoolIndex* with value 0 for first CORESETs, and - is provided *coresetPoolIndex* with value 1 for second CORESETs, and- is provided [*twoQCLTypeDforMulti-DCI*]the UE applies procedures described above independently across the first CORESETs and the second CORESETs.--Unchanged part omitted------------------------===============================================================To address issue 2, we propose to introduce a UE capability that can indicate the UE can process more DL / UL DCIs for a CC that is configured with two *coresetPoolIndex* values. Such capability may be separately indicated for DL DCI versus UL DCI. Also, this capability may explicitly indicate a number of DL/UL Dis that the UE can monitor, or can simply indicate that the number of DL/UL DCIs per *coresetPoolIndex* for the CC is the same as the number of DL/UL DCIs for a CC that is not associated with two *coresetPoolIndex* value (which is determined based on legacy UE capabilities). These details can be discussed as part of Rel-18 UE capability sessions. Proposal 1: For multi-DCI based multi-TRP operation, support the following:* **QCL-TypeD prioritization rules for overlapping CORESETs is performed per *coresetPoolIndex* value. The TP above can be used for this purpose.**
* **Introduce a UE capability that can indicate the UE can process more DL / UL DCIs for a CC that is configured with two *coresetPoolIndex* values.**
	+ **The details include whether separate FGs are needed for DL DCIs versus UL DCIs can be discussed in Rel-18 UE feature sessions.**
 |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Company | Suppport (Y/N) | Comment |
| QC | Y | In response to vivo’s comment from the previous meeting highlighted above: Decoding should be separate across different CORESETs, which is same as Rel-15. This proposal does not impact how UE decodes DCIs across different CORESETs.In response to MediaTek’s comment from the previous meeting highlighted above: This proposal does not impact any aspect of the Rel-18 MIMO scope. This proposal is related to Rel-16 multi-DCI based mTRP operation. In the existing specification, the larger number of BDs / CCEs specified in Rel-16 for multi-DCI based multi-TRP cannot be utilized in practice to actually transmit more DL / UL DCIs from the two TRPs. |
| CATT | Y | The flexibility of M-DCI can be improved by allowing the UE to monitor PDCCHs with different beams from corresponding TRPs on the overlapped OFDM symbol(s). |
| Samsung |  | Regarding QCL-TypeD prioritization rule extension, we understand the issue and support. However, we still don’t understand why we need such additional UE capability since FG 3-5a or 3-5b were already defined even from Rel-15. Since multi-DCI based multi-TRP is also advanced functionality which could process two independent PDCCHs, PDSCHs, and/or PUSCHs from UE side, we don’t see any problem for using FG 3-5a or 3-5b. |
| ZTE | Y |  |
| MediaTek | N | We question the real value of this proposal compared to the flexibility already in the specifications today, so we do not support its inclusion. In response to Qualcomm response, thanks for clarifying. But we wonder how critical this is if not important enough to be covered in the MIMO WI scope. |
| Nokia, NSB | Y | We generally support increasing the BD/CCE/DCI budget, where possible. |
| Huawei, HiSilicon |  | With different scheduling delay, PDCCH occasions not overlapping in time domain can also schedule PDSCH/PUSCH overlapping in time domain, it this further complexity critical for mTRP mDCI operation? |
| QC | (providing response to comments) | **@Samsung**: For issue 2 (UE capability), we see two problems with reusing FG 3-5a or 3-5b:* The complexity of these two FGs is in another dimension orthogonal to the complexity of multi-DCI based multi-TRP. A UE that supports FG 3-5a or 3-5b needs to monitor back-to-back PDCCH within a slot in multiple monitoring occasions. This should not be a pre-requisite for a UE that supports the additional complexity of multi-DCI based mTRP (e.g., twice the number of BDs/CCEs) for it to be able to receive two DL/UL DCIs in a same monitoring occasion. In other words, if we solely rely on FG 3-5a or 3-5b for Issue 2, the UE needs to handle these two different complexities (in different dimensions) at the same time, which is not necessary for this purpose.
* These two FGs cannot support 2 DL DCIs and 2 UL DCIs in a monitoring occasion. For FG 3-5a, network can send 1 DL DCI + 1 UL DCI per monitoring occasion. For FG 3-5b, network can send 1 DL DCI + 2 UL DCIs or 2 DL DCIs + 1 UL DCI for TDD, and 1 DL DCI + 1 UL DCI for FDD per PDCCH span.

**@MediaTek**: We are not sure why you keep referring to MIMO WI scope. To clarify, the proposal was not discussed (was not on the table) during Rel-18 WI scope discussions because it was not proposed by any company (including us). There were some related discussions during Rel-16 maitenence, but w/o enough time or enough attention to the practical implications of not allowing for this functionality for multi-DCI based mTRP operation at that time. If you are generally questioning why now and why not in previous releases, I guess that can be said for any TEI proposal. **@Huawei, HiSilicon**: With normal PDCCH monitoring capability (FG 3-1), only one DL DCI or one UL DCI can be received per slot. Hence, overlapping PDSCHs/PUSCHs scheduling cannot be maintained across multiple slots, which is detrimental to the intention of multi-DCI based mTRP that is Tput enhacements. This is in addition to the network not being able to utilize the increased number of BDs/CCEs at the UE side.  |
| Moderator |  | According to the above comments, this proposal is supported by Qualcomm, CATT, ZTE, Nokia, NSB, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.Companies are encouraged to check the reply comments from proponent (Qualcomm) and to provide further comments, if any.Note that if this proposal does not meet the above condition by the 1st checkpoint (April 21), no further discussion is expected in this RAN1 meeting. |
| Moderator |  | This proposal could not meet the above condition by the 1st checkpoint (April 21), and hence, no further discussion is expected in this RAN1 meeting. |
|  |  | (No more discussion in this meeting) |

 |

Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting.

### **TEI proposal #3**

* **For multi-DCI based multi-TRP operation, support the following:**
	+ **QCL-TypeD prioritization rules for overlapping CORESETs is performed per coresetPoolIndex value.**
		- **Adopt following TP in Clause 10.1 in TS 38.213.**

|  |
| --- |
| --Unchanged part omitted------------------------If a UE - is configured for single cell operation or for operation with carrier aggregation in a same frequency band, and- monitors PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORESETs that have been configured with same or different *qcl-Type* set to 'typeD' properties on active DL BWP(s) of one or more cellsthe UE monitors PDCCHs only in a CORESET, and in any other CORESET from the multiple CORESETs that have been configured with *qcl-Type* set to same 'typeD' properties as the CORESET, on the active DL BWP of a cell from the one or more cells - the CORESET corresponds to the CSS set with the lowest index in the cell with the lowest index containing CSS, if any; otherwise, to the USS set with the lowest index in the cell with lowest index- the lowest USS set index is determined over all USS sets with at least one PDCCH candidate in overlapping PDCCH monitoring occasionsIf a UE - is not provided *coresetPoolIndex* for first CORESETs, or is provided *coresetPoolIndex* with value 0 for first CORESETs, and - is provided *coresetPoolIndex* with value 1 for second CORESETs, and- is provided [*twoQCLTypeDforMulti-DCI*]the UE applies procedures described above independently across the first CORESETs and the second CORESETs.--Unchanged part omitted------------------------ |

* + **Introduce a UE capability that can indicate the UE can process more DL / UL DCIs for a CC that is configured with two coresetPoolIndex values.**
		- **The details include whether separate FGs are needed for DL DCIs versus UL DCIs can be discussed in Rel-18 UE feature sessions.**

This proposal is already supported by Qualcomm.

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. Enhancement for scheduling request

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [6] | In Rel-17, when PDCCH skipping is configured for a UE, it is allowed that an SR transmission from the UE during a PDCCH skip duration can override the previous PDCCH skipping indication and the UE resumes PDCCH monitoring. The underlying principle of this behavior is that, when an SR is pending at the UE during a PDCCH skip duration, the network can realize it only after receiving an SR transmission from the UE. By terminating PDCCH skipping after the SR transmission, the UE and network do not need to wait until the end of the indicated PDCCH skip duration and, thus, a latency benefit is achieved.In addition to PDCCH skipping, search space set group (SSSG) switching, which is another UE power saving feature for licensed band, has been introduced in Rel-17. For example, when a UE is configured with two SSSGs, the first SSSG may be configured with frequent PDCCH monitoring, while the second SSSG may be configured with sparse PDCCH monitoring. In a heavy traffic situation, the UE may be indicated to monitor PDCCH according to the first SSSG. Otherwise, for UE power saving, the UE may be indicated to monitor PDCCH according to the second SSSG. If an SR is pending while the UE is monitoring PDCCH according to the first (i.e., dense) SSSG, the UE would receive a PDCCH scheduling an UL transmission quite soon after the SR transmission. However, if the UE is monitoring PDCCH according to the second (i.e., sparse) SSSG, the next PDCCH monitoring occasion would be quite far apart from the SR occasion, and the latency of the first PUSCH transmission after the SR may increase. Furthermore, after the UE transmits a BSR on the first PUSCH, it will expect additional UL grants to clear out the buffer, if the first UL grant is not large enough. Thus, unless the UE is indicated 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 feature of SR overriding (SRO) for PDCCH skipping should be extended for SSSG switching. That is, in order not to delay the UL transmission, it should be allowed that an SR transmission overrides SSSG switching, as well as PDCCH skipping.To show the impact of SRO to the latency, we conducted system-level performance evaluation. We assumed three different PDCCH monitoring adaptation schemes: 1) Rel-17 PDCCH skipping, 2) Rel-17 SSSG switching, and 3) Rel-17 SSSG switching with SRO. Note that, for 1), SRO is already supported, while, for 2), SRO is not supported. The PDCCH monitoring adaptation schemes were assumed to be triggered by the last scheduling DCIs before the DL buffer is flushed. For each scheme, we tried different configurations as described in Table 1 to show the trade-off between the power saving gain and the latency. For the traffic model, we assumed an interactive web-browsing traffic model, which consists of both DL and UL traffics.In Figure 4‑1, the relationship between the power saving gain over the baseline and the latency is shown for the three PDCCH monitoring adaptation schemes. In Figure 4‑1 (a), it is observed that, at the same power saving gain, SRO significantly improves the UL latency of SSSG switching. Also, with SRO, SSSG switching achieves the same power saving gain vs. latency trade-off as PDCCH skipping. Interestingly, in Figure 4‑1 (b), it is observed that SRO can also improve the DL latency of SSSG switching. Since the assumed web-browsing traffic model is interactive, an UL transmission may trigger a follow-on DL transmission and vice versa. Thus, SSSG switching by SRO primes the network for the subsequent DL transmissions and reduces the DL latency. Table 1: Configurations of PDCCH monitoring adaptation schemes.

|  |  |  |
| --- | --- | --- |
| Power saving | PDCCH skipping | SSSG switching (both with and w/o SRO) |
| Baseline | PDCCH monitoring in every slot (No skipping/SSSG switching) |
| Scheme 1 | PDCCH skipping for 5 ms | Switching to SSSG with 5 ms PDCCH monitoring periodicity |
| Scheme 2 | PDCCH skipping for 10 ms  | Switching to SSSG with 10 ms PDCCH monitoring periodicity  |
| Scheme 3 | PDCCH skipping for 20 ms  | Switching to SSSG with 20 ms PDCCH monitoring periodicity  |
| Scheme 4 | PDCCH skipping for 30 ms  | Switching to SSSG with 30 ms PDCCH monitoring periodicity  |

|  |  |
| --- | --- |
| (a) | (b) |

Figure 4‑1: Power saving gain vs. latency: (a) uplink latency, (b) downlink latency.**Proposal 3: If a UE is indicated 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** $P\_{switch}$ **symbols after the last symbol of a PUCCH carrying an SR.** |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Company | Suppport (Y/N) | Comment |
| QC | Y |  |
| CATT | N | There is no benefit shown in this proposal.  |
| Samsung | [N] | For the first bullet, we think that this can be avoided by gNB implementation since similar mechanism is already supported by PDCCH skipping indication. Thus, it is questionable on how much gain can be further achieved on top of PDCCH skipping feature.  |
| ZTE | Y to second bullet | We support the second bullet of proposal #7. We identify the necessity of introducing time-domain offset for PUCCH-SR transmission. In addition, the benefits of updating the time/frequency resources of PUCCH by the spatial relation/TCI Activation/Deactivation MAC-CE can be foreseen.For the first bullet, we don’t support it, since we think proper PDCCH monitoring periodicity can be configured, in that respect, the capacity benefits from SSSG switching after transmission of PUCCH carrying SR, is not clear. |
| MediaTek | N for 1st bullet  | For the first bullet, the interaction between PDCCH skipping and pending SR has been enhanced to reduce SR latency in RAN1 #112 (under agenda 8.7). It is questionable how much gain can be further achieved.For the second bullet, the proposal seems to avoid re-configuraiton of SR resources when the beam direction is changed by MAC-CE and SR resources need to be re-aligned; we are open to further discuss the details. Yet, we share a similar concern with Huawei whether the scope of this proposal can fit into TEI.  |
| Huawei, HiSilicon | N | For the first bullet of the proposal, it is not necessary to introduce this optimition. It was already supported in Rel-17 UE power saving to configure multiple PDCCH skipping duration lengths, which can be dynamically indicated by gNB for PDCCH skipping. If the latency of uplink scheduling matters, gNB shall configure at least one proper PDCCH skipping duration length. Meanwhile, it was already supported by Rel-17 that the PDCCH skipping shall be cancelled when a positive SR is transmitted and is pending. This could already cover the most cases, and we didn’t see the need to further optimize other corner cases where SR cannot be transmitted but BSR can be transmitted.For the second bullet, we have similar concerns. It was already supported in Rel-17 that three SSSGs can be configured. At least one of them can be configured with a proper PDCCH monitoring periodicity which is smaller than the required latency of uplink service, if gNB thinks the latency would be important for the uplink scheduling of this UE.For the third bullet, we are open to discuss the issue. But we don’t think it is proper to discuss it as a TEI issue as it involves big spec impact of RAN 1 (UE behavior description), RAN 2 (time/frequency/code domain offset configuration, offset indication signling, e.g., MAC-CE, DCI), RAN 4 (e.g., new requirement). Suggest to discuss in Rel-19. |
| Ericsson | Y for 1st bullet | We support the 1st bullet –it improves SR latency performance for case with SSSG switching (like the improvements for case with PDCCH skipping in Rel-17). A gNB can configure UE with even-sparser SSSG (increased UE power savings) without compromising SR latency performance. |
| Moderator |  | According to the above comments, this proposal is supported by Qualcomm, ZTE (2nd bullet), Ericsson (1st bullet) and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.Proponents are encouraged to address the concern from companies not answered yet.Note that if this proposal does not meet the above condition by the 1st checkpoint (April 21), no further discussion is expected in this RAN1 meeting. |
| QC2 | Y | For the first bullet, as pointed out by some companies above, a similar mechanism is currently supported for PDCCH skipping, and the benefit is the reduced SR latency. Thus, to enjoy the same benefit with SSSG switching, which is another Rel-17 PDCCH monitoring adaptation scheme, the same mechanism should be supported.Although there was a comment that the SR latency issue could be avoided by gNB configuration, it should be noted that the same would hold for PDCCH skipping; that is, a proper configuration of PDCCH skipping duration can avoid the SR latency issue, but the SR overriding PDCCH skipping is supported to provide additional latency benefit. Likewise, for SSSG switching, if the feature of SR overriding SSSG switching is supported, the gNB can configure UE with even sparser SSSGs to enhance UE power saving, without compromising SR latency as Ericsson commented above. |
| Moderator |  | This proposal could not meet the above condition by the 1st checkpoint (April 21), and hence, no further discussion is expected in this RAN1 meeting. |
|  |  | (No more discussion in this meeting) |

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Based on the above contribution, following TEI proposal (i.e. 1st bullet in RAN1#112bis-e) can be discussed in RAN1#113 meeting.

### **TEI proposal #4**

* **If a UE is indicated 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** $P\_{switch}$ **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.

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| Company | Suppport (Y/N) | Comment |
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* 1. UE reporting of power offset for SRS antenna switching

Following proposal is made in the contribution.

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| [6] | Release 17 introduced SRS antenna switching for 6Rx and 8Rx devices, namely {1T8R, 2T8R, 4T8R, 1T6R and 2T6R} to enable DL CSI acquisition across all Rx antennas. However, antenna switching for 6/8Rx devices comes at the cost of extra RF switching circuitry that introduces insertion loss. For some UE implementation, the insertion loss may be large which causes big mismatch between the actual DL channel and the one estimated by the gNB from UL sounding. This results into different Tx power between antenna ports or equivalent power offset between SRS antenna ports. gNB is unaware of the power offset between the SRS ports which will impact channel reciprocity reducing the quality of DL-CSI and DL beamforming by the gNB. RAN4 specification allows for some relaxation of SRS transmit power for any ports other than first port and is given by a parameter, ∆TRxSRS, as shown in the text below from 38.101-1 version 17.8.0.

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| **6.2.4 Configured transmitted power**The UE is allowed to set its configured maximum output power PCMAX,f,c for carrier f of serving cell c in each slot. The configured maximum output power PCMAX,f,c is set within the following bounds:PCMAX\_L,f,c ≤ PCMAX,f,c ≤ PCMAX\_H,f,c with PCMAX\_L,f,c = MIN {PEMAX,c– ∆TC,c, (PPowerClass – ΔPPowerClass) – MAX(MAX(MPRc+∆MPRc, A-MPRc)+ ΔTIB,c + ∆TC,c +∆TRxSRS, P-MPRc) }PCMAX\_H,f,c = MIN {PEMAX,c, PPowerClass – ΔPPowerClass }**…**∆TRxSRS is applied during SRS transmission occasions with usage in SRS-ResourceSet set as ‘antennaSwitching’ when1. 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'
2. 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'
3. UE transmits SRS from the second SRS port pair on the second SRS resource in every configured SRS resource set consisting of two SRS ports when the SRS-TxSwitch capability is indicated as ' t2r4' or ' t1r4- t2r4', or 't1r1-t1r2-t2r2-t2r4' or 't1r1-t1r2-t2r2-t1r4-t2r4', or
4. UE transmits SRS to a DL-only carrier

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. For other SRS transmissions ∆TRxSRS is zero; |

Considering 1T4R UE architecture as a baseline for extending to 8Rx antennas, an extra RF switching circuitry is needed to route the Tx path to the extra Rx antennas. An example of such architecture is shown in the Figure ‑1 below. It is important to note that there will be X1 to X2 dB extra insertion loss (i.e. power offset) for antenna ports 4-7 as compared to the first 4 antenna ports. Figure 5‑1 Example of 8Rx UE RF architecture with single Tx chain*To overcome this mismatch, the UE can report to the network the power offset between the antenna ports which can help the network to compensate the UL/DL channel mismatch*. To evaluate the effectiveness of such reporting, a link-level evaluation was done for an 8Rx UE with 1T8R SRS antenna switching using CDL-C 300ns, 3km/hr and 20MHz DL/UL BW. The results are shown in Figure ‑2 in which we compare three different schemes: legacy 4Rx with 1T4R, 8Rx UE with 1T4R and 8Rx with 1T8R for both scenarios of power offset compensation enabled and disabled at the gNB. The power offset across the extra four antenna ports is assumed to be [ 1 1 2 2] dB. For the case of 1T8R with gNB reporting of power offset, the throughput performance is close to the ideal scenario of no power offset across the antenna ports.Figure 5‑2: Power offset reporting and compensationObservation 2: UE reporting of power offset can help the gNB to compensate of the power offset between the UL and DL channels and improve the DL throughput.RAN1 received an LS from RAN4 on the issue of UE SRS IL imbalance. The LS clarified that the insertion loss (IL) for the diversity branch might be different from the main branch. They provided the following example for better explanation of the UE RF switching for 1T4R and 1T8R.Figure 5‑3 . Example of possible RF architecture between ‘t1r4’ (left) and ‘t1r8’ (right) AS-SRS capable UERAN4 thinks it is necessary to address such IL imbalance issue as it leads to inaccurate channel estimation at receiver, which could lead to incorrect PMI selection that would degrade overall system performance. The LS listed possible solutions and asked RAN1 to evaluate possible solution. *The UE reporting of the actual IL imbalance for each diversity branch was highlighted in the LS and listed as the first solution for handling this issue.* Observation 3: RAN4 identified UE static reporting the actual IL imbalance for each diversity as the first solution for handling SRS IL imbalances across the diversity antennas. Proposal 4: For SRS antenna switching, Support UE capability of reporting of relative power offset of SRS antenna ports with respect to the first SRS port.  |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

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| Company | Suppport (Y/N) | Comment |
| DOCOMO |  | Now RAN4 asks RAN1 to discuss the exact same issue in R1-2302267. We suggest having the discussion in a single place to avoid duplicated discussions, i.e., under AI5. |
| Moderator |  | As announced by Chair, this discussion is put on hold until the discussions in [112bis-e-LS-04] is finalized.R1-2302267     LS on the UE SRS IL imbalance issue    RAN4, HuaweiRAN1 is requested study UE SRS IL imbalance issue. To be handled in agenda item 5.[112bis-e-LS-04] Email discussion on UE SRS IL imbalance issue by April 21 – Zhening (Huawei).Relevant discussions under 9.16 to be put on hold until the discussions in [112bis-e-LS-04] is finalized. |
| Moderator |  | RAN1 will continue discussion on the issue in [112bis-e-LS-04] in RAN1#113 |

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Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting.

### **TEI proposal #5**

* **For SRS antenna switching, support UE capability of reporting of relative power offset of SRS antenna ports with respect to the first SRS port**

This proposal is already supported by Qualcomm.

As announced by RAN1 chair, the issue in [112bis-e-LS-04] will be discussed under AI 5 in this RAN1 meeting. Therefore, similar to the last RAN1 meeting, TEI proposal #5 is put on hold until the discussion under AI 5 is finalized.

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| **Rel-18 NR\_ENDC\_RF\_FR1**R1-2304402 Discussion on RAN4 LS on the UE SRS IL imbalance issue ZTER1-2304643 Discussion on the UE SRS IL imbalance issue Huawei, HiSiliconR1-2305399 Discussion on RAN4 LS on the UE SRS IL imbalance issue Nokia, Nokia Shanghai BellR1-2305410 Discussion on SRS insertion loss issue OPPOR1-2305489 Discussion on RAN4 LS on the UE SRS IL imbalance issue SamsungR1-2305646 Evaluation of SRS antenna switching with insertion loss MediaTek Inc.R1-2305838 Discussion the UE SRS IL imbalance issue vivoR1-2305947 Draft reply LS on the UE SRS IL imbalance issue Huawei, HiSiliconR1-2305948 Draft reply LS on the UE SRS IL imbalance issue QualcommR1-2305911 Discussion on RAN4 LS on the UE SRS IL imbalance issue EricssonR1-2305912 Draft reply LS on RAN4 LS on the UE SRS IL imbalance issue EricssonContinuation of discussions from RAN1#112bis-e on incoming RAN4 LS in R1-2302267. Also consider R1-2304433 in 9.15. To be moderated by Zhening (Huawei) |

* 1. RAT-independent Positioning Enhancements

Following proposal is made in the contribution.

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| [6] |  LPP protocol (TS 37.355) enables Control plane based positioning across multiple technologies, as shown in the following table:

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|  | LPP Supported Positioning Methods |
| Method | UE-based | UE-assisted |
| LTE/NB-IoT | OTDOA | No | Yes |
| E-CID | No | Yes |
| RAT-Independent | A-GNSS | Yes | Yes |
| Sensor | Yes | Yes |
| WLAN | Yes | Yes |
| Bluetooth | No | Yes |
| TBS | Yes | Yes |
| NR | DL-TDOA | Yes | Yes |
| DL-AoD | Yes | Yes |
| Multi-RTT | No | Yes |
| NR E-CID  | No | Yes |
| UL-TDOA(1) | No(2) | No(2) |
| UL-AoA(1) | No(2) | No(2) |
|  | NOTE 1: Only LPP Capability TransferNOTE 2: NW-based method |

With regards to RAT-independent technologies, beyond GNSS, specification enhancements for the remaining technologies has been rather limited. Such signaling enhancements (in RAN2) can be done without the need of significant time and effort. Such enhancements will help expand the role of the multi-technology 3GPP-based positioning protocol and increase its value in the overall positioning ecosystem.

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| **Potential RAT-independent Enhancement** | **Motivation** |
| **UWB Ranging** | A high-bandwidth (>=500 MHz) technology that can support secure and accurate ranging capability which has received a lot of product and ecosystem attention lately. UWB Technology is not included in LPP |
| **BT 5.1** | Bluetooth positioning in LPP is based on Bluetooth 4.2. Enhancements based on Bluetooth 5.1 (e.g. AoA/AoD positioning) could be introduced, along with UE-based Positioning |
| **WiFi 802.11az FTM** | WiFi RTT has been added in an earlier release (Rel-13). Enhancements needed to pick up the required changes for devices supporting the latest IEEE 802.11az FTM. |

Proposal 5: Send an LS to RAN2 to add the necessary signalling enhancements for the following RAT-independent Positioning Enhancements: * Introduction of UWB Ranging/Positioning,
* update of BT positioning with Angular measurements and UE-based BT Positioning
* **Updates on the WLAN Positioning for devices supporting IEEE 802.11az FTM.**
 |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Company | Suppport (Y/N) | Comment |
| DOCOMO |  | Same as last RAN1 meeting, we think this proposal can be discussed directly in RAN2. |
| QC | Y |  |
| CATT | N | The proposed potential RAT-independent enhancements (UWB, Bluetoorth, WiFi RTT) mainly impact RAN2’s work, but not RAN1. The proposal should be discussed in RAN2. |
| Samsung | N | Agree with DOCOMO’s comment |
| Ericsson |  | We think the proposals have value, but should be discussed by RAN2, where there is specification impact.  |
| MediaTek | N | We do not consider this a critical issue. The scope of Positioning enhancements is already very large for Rel-18, and we already agreed one Positioning TEI last meeting on top of that. We have a concern to up-scope Positioning effort now further.  |
| vivo | N | we are not sure it should be discussed in RAN1 if only signaling enhance,  |
| Huawei, HiSilicon | N | It should not be RAN1 to discuss this or trigger RAN2 to specify this. |
| Moderator |  | According to the above comments, this proposal is supported by Qualcomm, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.Proponents are encouraged to address the concern from companies not answered yet.Note that if this proposal does not meet the above condition by the 1st checkpoint (April 21), no further discussion is expected in this RAN1 meeting. |
| Moderator |  | This proposal could not meet the above condition by the 1st checkpoint (April 21), and hence, no further discussion is expected in this RAN1 meeting. |
|  |  | (No more discussion in this meeting) |

 |

Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting.

### **TEI proposal #6**

* **Send an LS to RAN2 to add the necessary signalling enhancements for the following RAT-independent Positioning Enhancements:**
	+ **Introduction of UWB Ranging/Positioning,**
	+ **update of BT positioning with Angular measurements and UE-based BT Positioning**
	+ **Updates on the WLAN Positioning for devices supporting IEEE 802.11az FTM.**

This proposal is already supported by Qualcomm.

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. Enhancement for HARQ multiplexing on PUSCH

Following proposal is made in the contribution.

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| [3] | In Rel-15 and Rel-16, to maintain the single carrier metric of uplink transmission, UCI (except SR) from PUCCH is multiplexed on a PUSCH within the same PUCCH group, when they are overlapped in time and have same priority level. To guarantee UE and gNB have the same understanding of HARQ bits number on the PUSCH, total DAI mechanism is applied and a restriction on PDSCH scheduling is introduced, which is described in the TS 38.213 Clause 9 and the restriction is copied as below:*“A UE does not expect to detect a DCI format scheduling a PDSCH reception or having associated HARQ-ACK information report without scheduling a PDSCH reception, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.”*In RAN1 #112bis-e, whether/how to relax the restriction for PUSCH repetitions are discussed and majority companies think such a restriction is too limited to gNB scheduling and are willing to remove this restriction. In this contribution, the impact of PDSCH scheduling restriction is analyzed based on the PUSCH repetition case and analysis of impact on HARQ codebook generation is provided.**Scheduling restriction on PDSCH**In contribution [R1-2110856], the scheduling restriction on PDSCH is explained and can be interpreted as two ways:* Interpretation 1: After UL DCI, gNB cannot schedule a PUCCH transmission to carry HARQ information in the slot of PUSCH transmission scheduled by the UL DCI, unless the PUSCH and PUCCH transmissions are not overlapped in time.
* Interpretation 2: After UL DCI, gNB may not schedule PDSCH until all the PUSCH transmissions scheduled by the UL DCI are finished.

Following Interpretation 1, to avoid overlapping between PUCCH and PUSCH, when gNB schedules a DL data transmission after the UL grant, gNB has to indicate a PUCCH reporting corresponding HARQ information transmitted after PUSCH transmission, which results in quite large HARQ latency. Considering the case of PUSCH with repetition in TDD system, the latency could become huge and beyond the largest k1 value (i.e. 15) configured for eMBB service. Take Figure 1 as an example, a DL domain frame is configured as DDDSU. In slot 0 of frame N, UL DCI triggers PUSCH transmitted 4 times repeatedly and each repetition occupies 14 symbols. Although PDSCH is scheduled in slot 1 of frame N, the corresponding HARQ will be reported until slot 4 of frame N+2, 22 slots between the PDSCH reception and PUCCH transmission. It should be noted, number of repetitions can be configured as 8, and for the coverage extension scenario, the number could be as large as 32. ***Observation 1: If PUSCH repetition is configured, the timing restriction on scheduling PDSCH after UL grant introduces large delay for HARQ feedback.***C:\Users\y00415751\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\7E9E5B9.tmpFigure 1. PDSCH scheduling restriction results in large HARQ feedback delayAs interpreted in the second way, to have a short HARQ latency and smaller value of k1, gNB may postpone PDSCH scheduling after PUSCH repetitions finishing. This will cause no PDSCH can be scheduled during the period of PUSCH repetitions which will decrease the spectrum efficiency dramatically. Use the same UL\_DL configuration and repetition times as above example, once gNB triggers a PUSCH transmission with repetition in slot 0, Frame N, it may wait until slot 0, Frame N+2 to schedule a new PDSCH expecting a quick HARQ feedback. Details are illustrated in Figure 2. C:\Users\y00415751\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\896AA6CE.tmpFigure 2. PDSCH scheduling restriction results in PDSCH blockage***Observation 2: If PUSCH repetition is configured, the timing restriction on scheduling PDSCH after UL grant causes PDSCH blockage for small k1 values.*****Solutions to reduce the impact**Based on the analysis in section 2.1, whether to relax the scheduling restriction was comprehensively discussed in the last meeting, and a nearly stable proposal is proposed as below. The majority think it is necessary to remove the restriction, but not totally aligned on the applicable scenarios and need more time to check the impact on HARQ codebook generation.

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| **TEI proposal #10 (Ⅳ)**The restriction on scheduling PDSCH after UL grant ~~should be~~ is removed for the case of PUSCH with repetitions* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition other than the first repetition scheduled by the DCI format can be introduced in Rel-18.
* Note: When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition case, UE generates Type-1/2/3 HARQ-ACK CB according to the existing specification.
* Note: Above proposal applies to type HARQ-ACK 1/2/3 CB. ~~FFS: type-21 HARQ-ACK CB~~
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* FFS: cases of PUSCH without repetitions and the first PUSCH repetition
* This feature is subject to UE capability.
* FFS: Additional UE capability to support the following functions
	+ HARQ-ACK codebook size change.
	+ PUCCH resource change
 |

**Applicable scenarios**According to the analysis in Section 2.1, the restriction brings large HARQ feedback delay and PDSCH blockage due to multiple PUSCH repetitions. The impact become more severe when a greater number of repetitions is configured/scheduled. For the case of PUSCH without repetition, the impact still exists but not as much serious as the repetition case. Thus, RAN1 can focus repetition case at beginning and extend to single PUSCH transmission case if needed. For PUSCH repetition scenario, all repetitions can be treated together and remove the restriction for all of them.**Impact on Type-1 HARQ codebook generation**The generation of Type-1 HARQ codebook multiplexed on PUSCH is reusing the codebook generation procedure on PUCCH, which is specified in the clause 9.1.2.2 of TS 38.213 (also cited in Appendix with yellow highlighted). For the Type-1 HARQ codebook generation on PUCCH, two steps can be summarized.**Step 1:** UE determines a set of $M\_{A,c}$ occasions for candidate PDSCH receptions based:1. on a set of slot timing values$K\_{1}$
2. on a set of row indexes $R$ of TDRA table
3. on the ratio $2^{μ\_{DL}-μ\_{UL}}$ between the downlink SCS configuration $μ\_{DL}$ and the uplink SCS configuration $μ\_{UL}$
4. on tdd configuration
5. on CA slot offset

**Step 2:** UE generates HARQ codebook based on determined $M\_{A,c}$ occasions.1. In each of occasion, UE generates one or more HARQ bits for each TB (depends on TB-based or CBG-based HARQ feedback)

It can be justified, for step 1, all the parameters to determine the set of PDSCH monitoring occasion are not associated with the scheduling restriction of PDSCH, neither impacted by the time order of UL grant and DL grant. The determined PDSCH occasion can locate at either before or after the UL grant, shown in Figure 3.C:\Users\y00415751\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\3839506E.tmpFigure 3. Determination of PDSCH occasionsOn the second the step 2, UE would generate HARQ bits for each determined PDSCH occasion, and based on the spec below, HARQ-ACK information corresponding to PDSCH reception scheduled after UL grant should be set to NACK. This is because following the scheduling restriction of PDSCH, no PDSCH would be scheduled after UL grant, but semi-static codebook requires constant codebook size, NACK is used to fill the HARQ codebook. Specifically, in Figure 3, UE will report NACK in PDSCH occasion\_3.

|  |
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| ***TS38.213, Clause 9.1.2.2****A UE sets to NACK value in the HARQ-ACK codebook any HARQ-ACK information corresponding to PDSCH reception or SPS PDSCH release or TCI state update that the UE detects in a PDCCH monitoring occasion that starts after a PDCCH monitoring occasion where the UE detects a DCI format scheduling the PUSCH transmission.* |

After the scheduling restriction is removed, slightly update on the spec is necessary, where actual ACK or NACK value should be set corresponding to the PDSCH(s) scheduled after UL grant, i.e. shown in Figure 3, the actual ACK/NACK value is reported in PDSCH occasion\_3.***Observation 3: For Type-1 HARQ codebook multiplexing on PUSCH, determining a set of PDSCH monitoring occasion is not associated with the scheduling restriction of PDSCH and current spec cannot support to report actual ACK/NACK value corresponding to the PDSCH(s) scheduled after UL grant.***In addition, the procedure to set the DAI value in UL grant still keep the same after the scheduling restriction is relaxed. No matter the PDSCH is scheduled before or after UL DCI format, corresponding HARQ would be multiplexed on the PUSCH, when the total DAI is set as $V\_{T-DAI}^{UL}=1$ to enable multiplexing.**Impact on Type-2 HARQ codebook generation**The optimization of restriction relaxes the scheduling of PDSCH later than UL DCI and makes it possible to piggyback the associated HARQ information on the scheduled PUSCH. However, for Type-2 HARQ codebook, the current spec only considers the HARQ bits for the PDSCH scheduled before UL DCI format and the total DAI in the UL DCI format cannot reflect the number of scheduled PDSCH(s) after the UL grant. Further enhancements on total DAI mechanism taking the DL scheduling after the UL grant into account should be investigated. A simple and straight way is making the total DAI in UL DCI format to cover both the number of PDCCHs sent before the UL grant and the ones will be delivered after the UL grant. This kind of overbooking can be done by UE implementation, which an upper bound of HARQ bits is set, as shown in Figure 4. Figure 4. Total DAI in UL DCI cover all past and future DL grantsBased on above spirit to cover the HARQ feedback before and after UL grant, the impact to have the larger DAI value is investigated. The procedure of multiplexing Type-2 HARQ codebook can be explained as below.1. According to spec copied in the Appendix and highlighted in blue, when a UE multiplexes HARQ-ACK codebook in a PUSCH that scheduled by a DCI format that includes a DAI filed, the UE generates HARQ-ACK codebook following pseudo-code in section 9.1.3.1 of TS38.213 with modification of one parameter $V\_{temp2}$.
2. Based on section 9.1.3.1, UE determines the PDCCH monitoring occasions based on the k1 and k2 in every cell.
3. UE generates HARQ information bit traversing all the PDCCH monitoring occasions corresponding to the same PUCCH resource.
4. UE set $V\_{temp2}=V\_{T-DAI}^{UL}$ which is equal to the total DAI value in UL DCI format to generate HARQ codebook on PUSCH.

It can be observed, Type-2 HARQ codebook is generated without touching the timing order of UL and DL grant. Even the total DAI is set as a larger value by gNB implementation without considering the restriction, the Type-2 codebook generation is kept the same and the whole procedure of multiplexing Type-2 codebook on PUSCH is still not changed.***Observation 4: When the PDSCH scheduling restriction is removed and a lager total DAI value is indicated by gNB implementation, the Type-2 HARQ codebook generation is not changed and neither the procedure of Type-2 HARQ codebook multiplexing on PUSCH.*****Impact on Type-3 HARQ codebook generation**One shot HARQ feedback is introduced by NR-U feature and tend to report all the remaining HARQ information in one PUCCH resource once triggered. According to the section 9.1.4 of TS38.213, the Type-3 HARQ codebook is generated to go through every CBG/TB, HARQ process and cell. When PUCCH and PUSCH are overlapped, the Type-3 codebook can be multiplexed on the PUSCH. Therefore, no matter Type-3 codebook is triggered before or after UL grant, it does impact how Type-3 codebook generated.***Observation 5: The timing to trigger Type-3 HARQ codebook generation, i.e. before or after UL grant does not impact how Type-3 codebook generated.*****UE capability and RRC parameter**From UE Side, a new UE capability can be introduced to support the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the UL DCI format, in Rel-18. To align the understanding between gNB and UE and avoid unnecessary ambiguity due to false alarm, RRC parameter(s) are needed as well to configure the function. When UE reports a capability to support the function, gNB can configure it and schedule HARQ-ACK information multiplexed on the PUSCH scheduled previously. Otherwise, the scheduling restriction is maintained and there is no change to current specifications. Therefore, based on the analysis above, the following is proposed.***Proposal:*** ***The restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions**** ***UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.***
* ***UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.***
* ***This feature is subject to UE capability.***
* ***RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition are introduced in Rel-18.***
* ***Note: the number of PUSCH repetitions can be scheduled/configured by gNB.***
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This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

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| Company | Suppport (Y/N) | Comment |
| DOCOMO | Y | We support to remove the scheduling restriction since especially when PUSCH repetition is used, the issue of delaying PUCCH timing is critical for DL data latency.Regarding the proposal details, as commented at the last meeting, spec-wise description should be used. The current proposal seems to be a kind of gNB behavior. Whether each DAI value is larger than the actual number of scheduled PDSCHs or not is not considered at UE side. Rather, from UE side, what should be clarified is whether still UL DAI is used or DAI in the last DL assignment after UL grant is used, to generate HARQ-ACK CB. We think that the intention is still to use the UL DAI value for HARQ-ACK CB generation, so the second sub-bullet should be updated as follows.* + **When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition case,**
		- **UE generates HARQ-ACK CB as if any scheduled PDSCH after UL grant RX is scheduled before UL grant RX, and thus the UL DAI value is used for the HARQ-ACK CB generation**
 |
| QC |  | Question: if this restriction is removed, why not remove it even for PUSCH without repetitions? Not saying we support or not support extend this proposal to PUSCH without repetitions, but we are curious why only fix this for PUSCH with repetitions. Also, a comment to the second sub-bullet: there seems no spec impact here. The Pseudo-code to construct HARQ-ACK codebook does not need any change. It is up to gNB to indicate whatever value in the UL total DAI, while UE just simply run current pseudo code following that DAI. Can proponents of this proposal confirm this is the correct understanding? |
| CATT | Y | After further checking, we support to release the restriction on scheduling PDSCH after UL grant for the case of PUSCH with repetition. And we think this proposal is also meaningful for the case of AP-CSI scheduling, as if the value of K2 is large during the AP-CSI scheduling, the value of K1 of PDSCH scheduling after UL grant might be increased as well. Hence, it’s better to introduce the release of restriction on scheduling PDSCH after UL grant for the case of PUSCH withouth repetions as well. we suggest update the proposal as following: * **The restriction on scheduling PDSCH after UL grant should be removed for the case of PUSCH with/without repetitions**
	+ **An RRC parameter to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the DCI format can be introduced in Rel-18.**

**When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition/without case, the UL total DAI can be indicated with a large DAI value to count all HARQ bits corresponding to the PDSCHs scheduled before and after the UL grant to generate a HARQ codebook.** |
| Samsung |  | It is understood that PDSCH scheduling limitation is the main issue that the proposal is trying to resolve. There are alternatives in the current specification as follows. 1. Simultaneous PUCCH and PUSCH: it can be extended to same priority or same band. [HW, HiSi]: Simultaneous PUCCH and PUSCH transmission in same band may increase PAPR issue and impact on the UE transmission power. 2. PUCCH cell switching[HW, HiSi]: Not sure whether this is always feasible, and how it resolves the issue, could you explain more a little bit?3. HARQ disabling feature by HARQ process (NTN) and by DCI (Multicast): for multicast DCI, it can be extended to unicast DCI. [HW, HiSi]: Disable the HARQ will decrease reliability dramatically, it needs to introduce enhancement to overveome the performance loss.Regarding specification impact, we would like to understand whether thr proposal is just feasibly by simplying removing the restriction in RAN1 specification on top of introducing related RRC parameters/UE capabilities.  |
| ZTE |  | We’d like to clarify the scope/understanding of the proposal first: * The scheduling restriction exists for both Type 1 and Type 2 HARQ-ACK codebook, while the proposal seems only to address Type 2 HARQ-ACK codebook (as it is using wording like ‘larger DAI’), right?
* Is the proposal only for the repetitions other than the first repetition?
* According to current spec, all PUSCH repetitions should satisfy the UCI multiplexing timeline in Clause 9.2.5 of 38.213, i.e., the timeline depends on the first symbol of all PUSCH repetitions. With the proposal, whether does it allow the scheduling of PDSCH#4~5 in Figure 1 below? If allowed, does that mean the UCI multiplexing timeline should be changed to per repetition basis?
* Our understanding is it’s up to gNB about how to set the UL total DAI value, while UE’s behavior for determining the HARQ-ACK codebook size in each repetition needs clarification. Take Figure 1 as an example, gNB may indicate UL total DAI=1, which may have two different UE behaviors in such case: 1) UE multiplexes 1 bit in PUSCH repetition#1, and 5 bits (with one padding NACK bit) for PUSCH repetition#2. This causes different HARQ-ACK codebook size among different repetitions, which is different compared to legacy. 2) UE multiplexes 1 bit for both two repetitions, meaning no enhancement in this case. Which is the proposed UE behavior?
	+ In case gNB indicates UL total DAI=4，UE may multiplex 4 bits for both repetitions. But it would cause problems if the DCI of PDSCH#1 is missed, as the UE would not multiplex any UCI in PUSCH in case of no PDSCH detection and UL total DAI=4. Then what’s the understanding here, and how to address the missing DCI issue?

Figure 1 |
| Nokia, NSB | Y | Agree with DOCOMO edits.We would be happy to eliminate the restriction also for non-repetition cases. |
| vivo |  | We understand the scheduling restriction issue and would be open to discuss proper solution with less specification/implementation impacts. Regarding the proposal, as discussed during last RAN1 meeting, it should be clarified the exact meaning of “**for the case of PUSCH with repetitions**” for the case of Rel-17 PUSCH repetition with dynamic indicated repeition number, i.e. whether the PUSCH repetition is based on RRC configuration or DCI indication.  |
| Huawei, HiSilicon | Y | The RRC parameter is introduced to enable the function of PDSCH scheduling relax, and align the understanding between UE and gNB. Only when such a function is configured, UE will consider the PDSCH scheduling after the UL grant. The second bullet is to clarify how to assign the DAI to cover the potential DL scheduling after the UL grant. The spec wise change from DCM is also a good way for move forward.On PUSH without repetitionWe propose the relax for PUSCH with repetition since in the repetiton case, the impact is more severe, but we are also fine to extend to the case of PUSCH without repetition.On Spec impactWe think the only changes on the spec are to include the RRC parameter and potential UE feature. The pricinple to construct HARQ codebook will not be changed.@Samsung, please find our replies inline. |
| MediaTek |  | We are open to further discuss the details. It is understandable the restriction causes more problem when a PUSCH with large number of repetitions is applied, hence it seems reasonable to discuss this enhancement to PUSCH with repetitions only. |
| Samsung2 |  | @Huawei, HiSiliconThanks for the follow-up. Regarding specification impact, if there is no specification impact especially for TS 38.213, we wonder why such restriction (i.e., DL scheduling restriction) had to be made at Rel-15 stage. This is because the restriction seems not to provide any benefits. It would be appreciated if you share the background for our better understanding.  |
| Moderator |  | According to the above comments, this proposal is supported by Huawei, HiSilicon, Ericsson, China Unicom, DOCOMO, Nokia, NSB, and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor.Therefore, this proposal is further discussed directly over RAN1 reflector toward the GTW on Thursday. As the first step, proponent is encouraged to address the concern from companies and update the proposal, if necessary. |
|  |  | (No further input. Directly discuss over RAN1 reflector) |
| Moderator |  | No consensus was achieved in [112bis-e-R18-TEIs-01] |

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Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting. Red color shows the update from last RAN1 meeting.

### **TEI proposal #7**

* **The restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions**
	+ **UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.**
	+ **UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.**
	+ **This feature is subject to UE capability.**
	+ **RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition are introduced in Rel-18.**
	+ **Note: the number of PUSCH repetitions can be scheduled/configured by gNB.**

This proposal is already supported by Huawei, HiSilicon, Ericsson, 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 |
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* 1. Pathloss RS for Type 1 CG-PUSCH

Following proposal is made in the contribution.

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| [4] | In RAN1#99, the following agreements were archived on the update of pathloss reference for PUSCH via MAC-CE.***Agreement (RRC impact)****On power control for PUSCH, PUCCH, and SRS, the total number of maximum configurable pathloss RSs, in including those supported in Rel-15, by RRC is 64** *Note: Such pathloss reference signals are for configuration purpose only, and UE is still only required to track up to 4 pathloss RSs for any PUSCH, PUCCH, and SRS transmissions.*
	+ *“Up to 4 pathloss RSs” applies the total number of pathloss RSs for PUSCH, PUCCH, and SRS*

***Agreement (RRC impact)****For the feature of MAC CE based pathloss RS updates for PUSCH/SRS in Rel-16,** *Introduce one new RRC parameter to enable the feature of MAC CE based pathloss RS updates for PUSCH/SRS in Rel-16, i.e.,*
	+ *enablePLRSupdateForPUSCHSRS*

***Agreement****When enablePLRSupdateForPUSCHSRS is configured, if a grant-based or grant-free PUSCH transmission is scheduled/activated by DCI format 0\_1 that does not include a SRI field, the RS resource index qd corresponding to the PUSCH-PathlossReferenceRS-Id mapped with sri-PUSCH-PowerControlId = 0 is used for path-loss measurement of PUSCH transmission. In this case, UE expects to be configured with sri-PUSCH-PowerControl*While in this contribution, we give our views on the update of pathloss reference signal for Type 1 CG-PUSCH in Rel-16. According to the agreement listed above, we can see that the pathloss reference signal for Type 2 CG-PUSCH and dynamic-grant PUSCH can be updated by the SRI field in DCI. However, for Type 1 CG-PUSCH, the spatial relation based on *srs-ResourceIndicator* configured in *rrc-ConfiguredUplinkGrant* can be updated by MAC CE, but the corresponding pathloss reference signal cannot be updated, because of

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| 7.1.1 UE behaviour……- For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*, * a RS resource index  is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*

 …… |

which the *pathlossReferenceIndex* configured in *rrc-ConfiguredUplinkGrant* has to be used, as seen in the text in 38.213. In this case the pathloss reference signal will not match with the spatial relation indicated by the *srs-ResourceIndicator.*Compared to type 2 CG PUSCH, the advantage of Type 1 CG PUSCH is to reduce the latency and improve the reliability by not needing to wait for or decode the DCI, which is important for URLLC service.In the unified TCI state, it was agreed to follow unified TCI state for both Type 1 and Type 2 CG PUSCH, which means it is beneficial to update the pathloss reference signal and spatial relation of Type 1 CG PUSCH simultaneously. **With respect to the comments raised in the last meeting, we would like to provide some clarifications.**First it is about the use case for Type 1 CG PUSCH, and why not to use Type 2 CG PUSCH if pathloss reference signal need to be updated by MAC CE?**Clarification:** as for the use case of Type 1 and Type 2 CG PUSCH, there were a lot of discussion during Rel-15 when to introduce both Type 1 and Type 2 CG PUSCH. We think it is unnecessary to repeat it here. And the motivation of this TEI proposal is to enhance the Type 1 CG PUSCH which has been supported already. Second it is about the corresponding UE capability and RRC parameter to enable/disable this new behavior.**Clarification:** in order to support this new UE behavior, we agree that corresponding new UE capability and RRC parameter to enable/disable this new UE behavior may be needed to differentiate from the legacy UE behavior on Type 2 CG PUSCH and dynamic grant PUSCH. And we can add a note into the proposal and the detail can be further discussed in future meetings.Hence, we propose the following text proposal with a note.

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| 7.1.1 UE behaviour……**<Unchanged parts are omitted>**- For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*, * if the UE is provided *enablePL-RS-UpdateForPUSCH-SRS,* the UE determines a RS resource index  from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the *sri-PUSCH-PowerControlId* indicated by the *srs-ResourceIndicator* value included in *rrc-ConfiguredUplinkGrant*
* if the UE is not provided *enablePL-RS-UpdateForPUSCH-SRS,* a RS resource index  is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*
* ……

**<Unchanged parts are omitted>** |

Note: UE capability and RRC configuration will be discussed in future meetings. |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112bis-e meeting is shown below [7].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | In Rel.16, to update PL-RS by MAC CE, overlapped two features were supported.* UE feature 1) explicit PL-RS update by MAC CE
* UE feature 2) default PL-RS/spatial relation

If we use UE feature 2), PL-RS of Type1 CG-PUSCH follows to PL-RS of SRS with usage CB/NCB, by the following text. If PL-RS of SRS is updated by MAC CE (e.g. by default PL-RS/spatial relation to the SRS), PL-RS of Type 1 CG-PUSCH can be updated by MAC CE.Hence, we think the proposal is not needed, because the existing spec. can update PL-RS for Type1 CG-PUSCH by MAC CE by using the UE feature 2).Note that in our understanding, “the PUSCH transmission is not scheduled by DCI format 0\_0” includes Type 1 CG-PUSCH.

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| 7.1.1 UE behaviour (in TS 38.213)[…]- If the PUSCH transmission is not scheduled by DCI format 0\_0, and if the UE is provided *enableDefaultBeamPL-ForSRS* and is not provided *PUSCH-PathlossReferenceRS* and *PUSCH-PathlossReferenceRS-r16,* the UE uses the same RS resource index $q\_{d}$ as for an SRS resource set with an SRS resource associated with the PUSCH transmission |

 |
| QC | N | This one seems not a critical issue* First, the proposal is to update the PL RS when spatial relation is updated for the SRI associated with the Type 1 CG. Our view is that this may not solve the issue completely. Because precoding, rank, MCS may all need to change if the beam changes. However, they are only updated by RRC. Dynamically changing 1 or 2 parameters may not solve the issue. Dynamically changing all parameters will have no difference from Type 2 CG.

Second, we think RRC updating PL RS is not too slow compared with actual MAC-CE latency. Indeed, RRC command latency is around 15 ms, higher than MAC-CE’s 3 ms. But up to 5 PL RS samples are needed anyway after MAC-CE command based on RAN4 requirement. This is a bigger part compared with command latency, e.g. 5 SSB samples are typically 100 ms.   |
| CATT | Y | For Type 1 CG-PUSCH, it’s reasonable to address the issue with mismatched pathloss reference signal and spatial relation indicated by *srs-ResourceIndicator.* |
| Samsung | N | Motivation is not clear to us. If the fast update for the pathloss reference signaling is main intention, type 2 CG-PUSCH can be used instead of type 1 CG-PUSCH.  |
| Xiaomi | Y | @DOCOMO, as we discussed before, in my understanding, the text you pasted here is not to cover type I CG PUSCH. ‘the PUSCH transmission is not scheduled by DCI format 0\_0’ in the text equals to ‘the PUSCH transmission is scheduled by DCI format 0\_1 or DCI format 0\_2’. You can refer to the TP agreed in R1-2007092 (pasted below for reference).

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| 7.1.1 UE behavior\*\*\* Unchanged text is omitted \*\*\*- If the PUSCH transmission is scheduled by a DCI format 0\_0, and if the UE is provided a spatial setting by PUCCH-SpatialRelationInfo for a PUCCH resource with a lowest index for active UL BWP $b$ of each carrier $f$ and serving cell $c$, as described in Clause 9.2.2, the UE uses the same RS resource index $q\_{d}$ as for a PUCCH transmission in the PUCCH resource with the lowest index- If the PUSCH transmission is scheduled by a DCI format 0\_1 or a DCI format 0\_2, and if the UE is provided *enableDefaultBeamPlForSRS* and is not provided *PUSCH-PathlossReferenceRS* and *PUSCH-PathlossReferenceRS-r16,* the UE uses the same RS resource index $q\_{d}$ as for a SRS resource set with an SRS resource associated with the PUSCH transmission- If - the PUSCH transmission is scheduled by a DCI format 0\_0 and the UE is not provided a spatial setting for a PUCCH transmission, or - the PUSCH transmission is scheduled by a DCI format 0\_1 or a DCI format 0\_2 that does not include an SRI field, or - *SRI-PUSCH-PowerControl* is not provided to the UE,  the UE determines a RS resource index $q\_{d}$ with a respective *PUSCH-PathlossReferenceRS-Id* value being equal to zero where the RS resource is either on serving cell$c$ or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*\*\*\* Unchanged text is omitted \*\*\* |

And can also refer to 38213\_CR0137\_(Rel-16)\_ R1-2007459 (RP-201809) submitted to RAN-89, the reason for CR of this part “-  If the PUSCH transmission is not scheduled by DCI format 0\_0, and if the UE is provided *enableDefaultBeamPL-ForSRS-r16* and is not provided *PUSCH-PathlossReferenceRS* and *PUSCH-PathlossReferenceRS-r16,* the UE uses the same RS resource index $q\_{d}$ as for a SRS resource set with an SRS resource associated with the PUSCH transmission.” is“2. Enable use of DCI format 0\_2 for scheduling of codebook based or non-codebook based PUSCH in Clause 7.1.1 ([102-e-NR-eMIMO-01])”.In addition, I had confirmed it with the FL of this issue at that time and he also confirmed that the text you pasted here not cover the Type I CG PUSCH. @QC yes, we agree with you that this may not solve the issue completely. But the PL RS can be updated with little spec effort since if the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, it means the UE support to the UE feature of MAC CE based pathloss RS updates for PUSCH/SRS, which is not restricted for PUSCH scheduled by DCI only. In this case, UE can update the PL RS for type I CG PUSCH as well as PUSCH scheduled by DCI. And as discussed in unified TCI state, the PL RS was supported to be associated or included in TCI state, and type I CG PUSCH was supported to apply the indicated joint/UL TCI states with both spatial relation info and PL RS. But the precoding, rank, MCS will be not changed. So it is useful to update the spatial relation info and PL RS without changing precoding, rank, MCS.In addition, if PL RS for type I CG PUSCH can’t be updated by MAC CE, there will be up to 3 PL RSs can be updated by MAC CE since UE can only support to maintain up to 4 PL RSs simulteously, which reduces the NW flexibility.@CATT yes, we share same view as CATT@Samsung, the PL RS can be updated with little spec effort since NW has updated the PL RS and UE has capability to update the PL RS, why not to update it for Type I CG PUSCH? It will be not even worse. And in unified TCI state, both Type I and Type II CG PUSCH can apply unified TCI state to update the spational relation ifo and PL RS. |
| ZTE | Y |  |
| Huawei, HiSilicon | Y | The motivation is reasonable. The solution seems simple and helpful to resolve this identified issue.  |
| Moderator |  | According to the above comments, this proposal is supported by Xiaomi, China Unicom, OPPO, ZTE, CATT and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor.Therefore, this proposal is further discussed directly over RAN1 reflector toward the GTW on Thursday. As the first step, proponent is encouraged to address the concern from companies and update the proposal, if necessary. |
|  |  | (No further input. Directly discuss over RAN1 reflector) |
| Moderator |  | No consensus was achieved in [112bis-e-R18-TEIs-01] |

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Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting.

### **TEI proposal #8**

* **Rel-18 TEI proposal on pathloss RS for Type 1 CG-PUSCH is agreed. Relevant TP for clause 7.1.1 in TS 38.213 is endorsed**
	+ **FFS:** **UE capability and RRC configuration**

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| 7.1.1 UE behaviour……**<Unchanged parts are omitted>**- For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*, * if the UE is provided *enablePL-RS-UpdateForPUSCH-SRS,* the UE determines a RS resource index *qd* from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the *sri-PUSCH-PowerControlId* indicated by the *srs-ResourceIndicator* value included in *rrc-ConfiguredUplinkGrant*
* if the UE is not provided *enablePL-RS-UpdateForPUSCH-SRS,* a RS resource index *qd* is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell *c* or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*
* ……

**<Unchanged parts are omitted>** |

This proposal is already supported by Xiaomi, CATT, China Unicom, Huawei, HiSilicon, OPPO, ZTE.

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. Extended CP support for NR MBS

Following proposal is made in the contribution.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [1], [10] | For the MBS feature frozen in Rel-17 and the enhanced MBS in the on-gong Rel-18 work item, the frame work is based on the supported numerologies and the CP types (normal, extended) as defined in Table 4.2-1 in TS 38.211. Therefore, although the SFN transmission scheme for MBS broadcast and multicast can be supported, while the reachable coverage is limited by the CP length. This paper provides the motivation and the feasibility of promoting a Rel-18 TEI on supporting ECP for the 15kHz and 30kHz subcarrier spacing. For MBS broadcast and multicast, on one hand, a group of UEs are expected to receive the same contents but the UE may not be located in vicinity, e.g., some UEs are in cell center but other UEs are at cell edge, the larger the CP the larger the cell coverage. On the other hand, the UEs located at the cell edge can benefit from SFN transmission scheme in terms of improving the received SNR. However, the specification only allows normal CP for the 15kHz and 30kHz subcarrier spacing so far, which unnecessarily imposes the limits to the deployments of MBS with low spectral efficiency. Support of Extended CP has been motivated and discussed as in [RWS-210446] and [RWS-210330] when scoping Rel-18 but was precluded in the end due to leveraging several aspects including available TU and the proposed enhancements scope. ***Observation 1: The specification allowing only normal CP for 15kHz and 30kHz subcarrier spacing unnecessarily imposes the limits to the deployments of MBS***. ***Observation 2: Extended CP can help improve the special efficiency for MBS transmission***. For supporting the extended CP for the 15kHz and 30kHz subcarrier spacing, the specification impact is mainly in RAN1 and the change is minor. For example, all the changes envisioned are as follows:***Changes to TS38.211***The changes needed to TS38.211 are to the following tables as highlighted in red fonts:**Table 4.2-1: Supported transmission numerologies.**

|  |  |  |
| --- | --- | --- |
|  |  | Cyclic prefix |
| 0 | 15 | Normal, Extended |
| 1 | 30 | Normal, Extended |
| 2 | 60 | Normal, Extended |
| 3 | 120 | Normal |
| 4 | 240 | Normal |
| 5 | 480 | Normal |
| 6 | 960 | Normal |

**Table 4.3.2-2: Number of OFDM symbols per slot, slots per frame, and slots per subframe for extended cyclic prefix**.

|  |  |  |  |
| --- | --- | --- | --- |
| $$μ$$ | $$N\_{symb}^{slot}$$ | $$N\_{slot}^{frame,μ}$$ | $$N\_{slot}^{subframe,μ}$$ |
| 0 | 12 | 10 | 1 |
| 1 | 12 | 20 | 2 |
| 2 | 12 | 40 | 4 |

***Changes to TS38.213***The change needed to TS38.213 for determining the slot format is as follows as in red fonts:

|  |
| --- |
| *If a BWP in the serving cell is configured with* $μ=0, 1, or 2$ *and with extended CP, the UE expects* $μ\_{SFI}=0$*,* $μ\_{SFI}=1$*, or* $μ\_{SFI}=2$*. A format for a slot with extended CP is determined from a format for a slot with normal CP. A UE determines an extended CP symbol to be a downlink/uplink/flexible symbol if the overlapping normal CP symbols that are downlink/uplink/flexible symbols, respectively. A UE determines an extended CP symbol to be a flexible symbol if one of the overlapping normal CP symbols is flexible. A UE determines an extended CP symbol to be a flexible symbol if the pair of the overlapping normal CP symbols includes a downlink and an uplink symbol.**A reference SCS configuration* $μ\_{SFI}$*, or* $μ\_{SFI,DL}$*, or* $μ\_{SFI,UL}$*, or* $μ\_{SFI,SUL}$ *is either 0, or 1, or 2 for FR1 and is either 2 or 3 for FR2.*  |

The reason for the little specification impact to RAN1 is because all other parts of the specifications are already written to support extended CP for 60 kHz SCS in a way that is transparent to SCS.***Necessary signalling support from RAN2***Once RAN1 decides to adopt such a TEI, RAN2 can directly incorporate the necessary signalling support for the configuration of the CFR via a CR. ***Observation 3: The specification impact to RAN1 is minor including, i.e., changes to TS 38.211 clause 4.2 Table 4.2-1 and clause 4.3.2 Table 4.3.2-2, and TS 38.213 clause 11.1.1 for slot format determination.******Observation 4: RAN2 can directly incorporate the necessary signalling for the configuration of normal or extended CP for the CFR via a CR.***Overall, the support of extended CP for the 15kHz and 30kHz subcarrier spacing as a Rel-18 TEI is feasible based on the above analysis. ***Proposal: Specify the support of extended CP for the 15kHz and 30kHz subcarrier spacing*** ***by scaling based on eCP for 60 kHz SCS for MBS broadcast and multicast transmission as a Rel-18 TEI.*** |

Based on the above contribution, following TEI proposal can be discussed in RAN1#113 meeting.

### **TEI proposal #9**

* **Support extended CP for the 15kHz and 30kHz subcarrier spacing by scaling based on extended CP for 60 kHz SCS for MBS broadcast and multicast transmission**

This proposal is already supported by CBN, China Telecom, China Unicom, CATT, Huawei, HiSilicon, ZTE, Sanechips.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
|  |  |  |
|  |  |  |
|  |  |  |

1. Conclusion

To be updated

Reference

[1] R1-2305917 Rel-18 TEI proposal on eCP support for NR MBS CBN

[2] R1-2304602 On PUSCH repetition type A scheduled by DCI format 0-0 with CRC scrambled by C-RNTI ZTE, China Telecom, Sanechips

[3] R1-2304675 Rel-18 TEI proposal on HARQ multiplexing on PUSCH Huawei, HiSilicon, Ericsson, China Unicom

[4] R1-2304888 Rel-18 TEI on pathloss RS for Type 1 CG PUSCH xiaomi

[5] R1-2305408 TEI on the introduction of a UE capability with up to 6-layer DL MIMO OPPO

[6] R1-2305366 Rel-18 RAN1 TEI proposals Qualcomm Incorporated

[7] R1-2304223 Summary #3 on Rel-18 TEIs Moderator (NTT DOCOMO, INC.)

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

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

[10] R1-2305964 Rel-18 TEI proposal on eCP support for NR MBS CBN, China Telecom, China Unicom, CATT, Huawei, HiSilicon, ZTE, Sanechips

Appendix: TEI guidance in [9]

**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.