3GPP TSG RAN WG1 #109-e R1-22xxxxx

**e-Meeting, May 9th – 20th, 2022**

**Agenda item: 8.8**

**Source: Moderator (China Telecom)**

**Title: Summary of preparation phase for Rel-17 NR coverage enhancements**

**Document for: Discussion and Decision**

# Introduction

This contribution is a summary of the discussion to identify maintenance issues for Rel-17 NR coverage enhancements in RAN1#109-e.

# Discussion

## AI 8.8.1

#### Enhancements on PUSCH repetition type A

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| **Issues** | **Related contributions** | **Initial assessment** |
| **Issue#1**: Frequency hopping for PUSCH scheduled by RAR UL grant or DCI format 0\_0 | R1-2203095, R1-2203191, R1-2203439, R1-2203610, R1-2203994, R1-2204212, R1-2204278, R1-2204664, R1-2204871 | **[Medium Priority]** Suggest to be discussed in RAN1#109-e.  This issue has been discussed for a couple of meetings without achieving consensus on any particular TP. Recommend firstly checking if FL’s proposed conclusion from the last meeting is acceptable to everyone. |
| **Issue#2**: DL throughput degradation for PUSCH repetitions due to limited range of RRC *dL-DataToUL-ACK* and UCI multiplexing restriction | R1-2203095 | [Suggest **NOT** to be discussed in RAN1#109-e.]  The issue is valid. Companies are invited their views on whether this issue should be discussed in RAN1#109-e or not. |
| **Issue#3**: Available slot counting for Inter-cell multi-TRPs | R1-2203191, R1-2203521, R1-2203869, R1-2204089, R1-2204278, R1-2204527, R1-2204548, R1-2204664, R1-2204775, R1-2204871 | **[High Priority]** Suggest to be discussed in RAN1#109-e.  This discussion has been deferred, and now is the time to re-open since there was some related progress in MIMO session in the last meeting. |
| **Issue#4**: SSB for Available slot counting in CA | R1-2203521 | Suggest **NOT** to be discussed in RAN1#109-e.  The current spec seems clear enough. |
| **Issue#5**: Restriction on K2 offset for DG-PUSCH with K>1 and Out-of-order handling when AvailableSlotCounting is enabled | R1-2203610, R1-2203994, R1-2204657, R1-2204664 | **[High Priority]** Suggest to be discussed in RAN1#109-e.  At least, it is important to confirm the common understanding on this issue in order to avoid different assumptions between UE and gNB. |
| **Issue#6**: Editorial change on TB repetition across N\*K slots | R1-2203791 | Suggest **NOT** to be discussed in RAN1#109-e.  The current spec seems clear enough. |
| **Issue#7**: Editorial correction on available slot counting for RedCap HD UE | R1-2204664, R1-2204775, R1-2204871, R1-2204990 | **[Low Priority]** Suggest to be discussed in RAN1#109-e. This correction does not require much discussion/effort. |

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| **Company** | **Views** |
| Huawei, HiSilicon | Regarding issue#2, it is surely in scope because the Rel-17 feature PUSCH repetition with up to 32 repetitions in current spec has severe degradation of DL throughput which is unacceptable to practical network. For example, as shown in figure 2 of R1-2203095, **11 DL slots** cannot be scheduled if the UE is scheduled for PUSCH repetitions with **only** **6 available UL slots** (equivalently scheduled 22 physical slots). The larger repetition number, the more degradation of DL throughput. It is a severe issue to Rel-17 PUSCH repetition feature. Therefore, a discussion is necessary. Since larger range of RRC *dL-DataToUL-ACK* is not a complete solution, nor the only potential solution, we suggest to rename the issue as “DL throughput degradation for PUSCH repetitions due to limited range of RRC *dL-DataToUL-ACK* and UCI multiplexing restriction”  Additionally, since TBoMS relies on slot counting based on available slots, the same issue also impacts on TBoMS severely. We suggest to discuss it for PUSCH repetition first, then determine whether it can fully be reused to TBoMS or any additional impact is necessary. |
| FL(Sharp) | @Huawei: Thanks for the explanation. The issue you raised seems valid. So, I updated the initial assessment on Issue#2, accordingly. At the same time, I’m still wondering if the extension of *dL-DataToUL-ACK* can mitigate DL throughput degradation, because the number for DL HARQ processes is anyway limited. Let’s see other’s views. |
| ZTE | Except for the recommended issues, we are also open to discuss Issue#2 to address the practical deployment issue, and Issue#4 for better clarity for CA case. |
| InterDigital | OK to discuss Issue#2. Fine with proposal. |
| Nokia/NSB | The initial assessment looks good to us. We are also fine to discuss Issue#2. |
| Qualcomm | We are okay with the initial assessment. On Issue #2, we think it is out of scope of coverage enhancement. The scheduling restriction and allied topics were discussed extensively during R17-TEI and yet there was no consensus or urgent need identified to address any of them. We would prefer to focus on the core issues during maintenance phase. Encourage proponents to bring it up for R18 TEI if there is significant interest and to have a broader discussion. |
| Intel | It is not clear to us whether Issue#2 is relevant to the discussion for increase of the maximum number of repetitions for PUSCH repetition type A. Our understanding is that PUCCH can still be scheduled in the slot where PUSCH repetition type A is scheduled, i.e., HARQ-ACK can be multiplexed on PUSCH.  We are fine with FL’s suggestions on other issues. |
| Spreadtrum | We support the initial assessment. |
| CATT | Fine with the initial assessment. |
| CMCC | Thanks for FL’s update about Issue #2. We support to discuss this issue in this meeting.  From our understanding, if the additional repetition numbers are enhanced but with the price that the DL slots cannot be used, this feature will be in a lower priority to be introduced.  In the 7D1S2U TDD configuration, if 32 physical slot repetitions are configured, actual 8 PUSCH repetitions will happen, which also equal to 8 available slot repetitions. Without any additional solution, there are 19 DL slots cannot be used during the PUSCH repetitions. if only extend the *dL-DataToUL-ACK* 1from 15 to 31, there are still 16 DL slots cannot be used. But if both *dL-DataToUL-ACK* and HARQ process number are enhanced, only 7 DL slots cannot be used. Though 7 DL slots is still a big number which is close to half a fame in 30kHz SCS, it is much better than 19 DL slots. |
| WILUS | We are fine with the FL’s initial assessment. |
| NTT DOCOMO | We support the initial assessment. |

#### TB processing over multi-slot PUSCH

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| **Issues** | **Related contributions** | **Initial assessment** |
| **Issue #1**: Removing the condition that AvailableSlotCounting is enabled for TBoMS | R1-2203191, R1-2203610, R1-2203791, R1-2204871, R1-2203095, R1-2204775 | **[High priority]** Suggest to be discussed in RAN1#109-e.  In Rel-17, the number of slots for TBoMS is always counted based on the available slots without any dependency on a RRC parameter. TP may be needed for capturing this correctly. |
| **Issue #2**: MAC layer may not generate MAC PDU for CG PUSCH with TBoMS when there is overlapping with DG PUSCH. | R1-2203191 | Suggest **NOT** to be discussed in RAN1#109-e.  The agreements in RAN1 are clear. This should be part of normative works in RAN2. |
| **Issue #3**: Multiplexing of HARQ-ACK on TBoMS following UL T-DAI in case without overlapping PUCCH since DL DCI is missed. | R1-2203191 | **[Low priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue #4:** Support of Rel-17 coverage enhancement techniques in unlicensed band. | R1-2203837, R1-2203869 | Suggest **NOT** to be discussed in RAN1#109-e.  Whether CovEnh techniques are applicable for unlisenced band or not should not be discussed in the maintenance of CovEnh itself. In addition, TBoMS is a PUSCH transmission with a single TB and single HARQ process number, the use of this NR-U feature for TBoMS seems to be irrelevant. |
| **Issue #5**: TP for available slot determination for TBoMS in CG-PUSCH | R1-2204664, R1-2204775 | **[High priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue #6**: Out-of-order handling for TBoMS | R1-2204775 | Suggest **NOT** to be discussed in RAN1#109-e.  The same issue, if any, seems to exist in Rel-15/16 as well. Therefore, it should be discussed in Rel-15/16 maintenance. Rel-17 can simply follow the existing handling. |
| **Issue #7:** CSI report on TBoMS | R1-2204775 | **[High priority]** Suggest to be discussed in RAN1#109-e. |

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| **Company** | **Views** |
| ZTE | For Issue#2, we don’t think previous RAN1 agreement/conclusion is clear enough for collision handling between DG PUSCH and CG TBoMS. Take the following two collision cases for example, it is much appreciated if FL or any other companies could share your views on the expected UE behavior.    Figure 1 Overlapping between DG PUSCH and CG TBoMS  From our understanding, RAN1 needs to first clarify the intended behavior for such collision and then inform RAN2 if any RAN2 impact is identified. |
| InterDigital | Fine with proposal.  @ZTE: Agree with moderator that this is RAN2 issue. RAN2 can discuss it without receiving LS from RAN1. |
| FL (Nokia) | @ZTE: Thank you for bringing up the scenario! From FL perspective, the following RAN1 agreement should be enough to clarify the behavior from RAN1 perspective. RAN2 should consider this in their normative work and ask RAN1 if further clarification is needed. I would like to encourage companies to provide your views on Issue#2 raised by ZTE.  Agreement (RAN1#106-e)  The UE determines whether or not to drop a slot determined as available for TBoMS transmission according to Rel-15/16 PUSCH dropping rules, where the dropped slot is still counted in the N allocated slots for the single TBoMS transmission.  FFS: Rel-17 PUSCH dropping rules are also applied if introduced in other WI(s) |
| Qualcomm | We are okay with the FL assessment.  @ZTE: Treat collisions on a slot-by-slot basis (same as legacy spec). Treat CG-PUSCH TBOMS transmission in a slot no different from a repetition of a regular PUSCH Rep Type A and apply the existing rules. This is our interpretation of the agreements we made. |
| Intel | For Issue#2, we share similar view as FL and other companies that the collision handling issue is clear in RAN1 based on the previous agreements. If needed, RAN2 can discuss this issue, but not RAN1.  For Issue#3, similar issue is currently under the discussion in Rel-16 CR for HARQ-ACK multiplexing on PUSCH in case of missing DL DCI. Suggest to wait for the progress before we discuss this issue for TBoMS.  For Issue#6, it would be good to reconsider for discussions. This is similar to what was discussed in Rel-17 NR extension to 71GHz WI. Scheduling restriction for same ending symbol for two scheduling PDCCH needs to be considered for out of order handling. |
| Spreadtrum | We generally agree with the FL’s assessment. In addition, Issue #3 is more related with the CR discussion in 7.1. We prefer to postpone it. Although, it already had some agreements, but there are still some open issues.  According to Issue#2, we share the same view that it should be discussed in RAN2. |
| CATT | Generally fine.  For Issue#3, it is noticed that a related discussion is still ongoing for PUSCH repetition in 7.1 CR (See ‘HARQ-ACK multiplexing on PUSCH without PUCCH’ of RAN1#109-e\_NR\_CRs\_7.1\_summary). We suggest applying the solution in 7.1 into TBoMS once clear consensus is achieved, but not to have duplicated discussion. |
| NTT DOCOMO | We generally support the initial assessment.  For issue#3, we prefer to defer the discussion until the mechanism for PUSCH repetition is complete. |
| ZTE2 | @FL @Qualcomm, Thanks a lot for the reply. The issue is we are not sure which Rel-15/16 rules should be reused for the concerned case. Based on the reply from Qualcomm, it seems the collision rules for PUSCH repetition type A should be reused here. If so, it means we need threat each slot of the TBoMS as a grant, similar to the repetition case as specified in TS 38321 below. This certainly has RAN2 impact. More specifically, MAC PDU can be generated in every grant/slot within a bundle for TBoMS. For case 1 in above Figure 1, a UE would not generate a MAC PDU due to collision while generate MAC PDU in the second slot. Then, we are not sure whether this is RAN1 wants and how should RAN1 determines the started coding bit for the second slot?  Another interpretation could be we can reuse the rules for a single PUSCH transmission with a single RV. Then, a UE may not generate any PDU as long as there is collision in one of the slot. In our view, this may don’t have any RAN1 or RAN2 impact.  Anyway, we are open for reusing any legacy rules here while we believe we need to be clear on what legacy rules we are reusing. Again, shouldn’t it better for RAN1 to first clarify the intended behavior as there could be interpretation without RAN2 impact?   |  | | --- | | *If REPETITION\_NUMBER > 1, after the first transmission within a bundle, at most REPETITION\_NUMBER – 1 HARQ retransmissions follow within the bundle. For both dynamic grant and configured uplink grant, and uplink grant received in a MAC RAR bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle, HARQ retransmissions are triggered without waiting for feedback from previous transmission according to REPETITION\_NUMBER for a dynamic grant or configured uplink grant or uplink grant received in a MAC RAR unless they are terminated as specified in clause 6.1 of TS 38.214 [7]. Each transmission within a bundle is a separate uplink grant delivered to the HARQ entity.* | |

#### Type A PUSCH repetitions for Msg3

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| **Issues** | **Related contributions** | **Initial assessment** |
| **Issue#1**: Handling of the working assumption on CFRA PUSCH repetition | R1-2203610, R1-2203791, R1-2204089, R1-2204278, R1-2204349, R1-2204775, R1-2204871 | **[High Priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue#2**: TP for Msg3 PUSCH repetition in section 8.3 of TS38.213 | R1-2203791 | Suggest **NOT** to be discussed in RAN1#109-e.  The current specification texts are technically correct, and the proposed TP is not essential. |
| **Issue#3**: Collision handling between SSB and Msg3 PUSCH transmission for HD-FDD UE | R1-2204278 | Suggest **NOT** to be discussed in RAN1#109-e.  RAN1 has agreed to reuse the decision from RedCap WI, i.e., SSB is prioritized in case of the collision. No specification impact is expected. |
| **Issue#4**: Available slot counting for Msg3 repetition with K=1 | R1-2204990 | [Suggest **NOT** to be discussed in RAN1#109-e.]  Companies are invited to provide views on this issue. |

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| **Company** | **Views** |
| InterDigital | Fine with proposal. |
| Nokia/NSB | We are fine with the initial assessment. |
| Qualcomm | Issue #4 will be good to be discussed and I hope we can reconsider.  Right now, when a UE sends RACH without requesting any repetitions, its not clear to the gNB if this is a R17 UE or a R15/R16 UE. The spec however requires available slot counting to be applied even when K=1. There seem to be no accommodation for legacy UE behaviour. Even if this UE is capable of available slot counting, before UE is in RRC connected state, gNB does not know about this. So, UE behavior is ambiguous to the gNB. |
| Intel | We are fine with FL’s suggestions |
| CATT | We are generally fine with the assessment. For Issue#4, we are OK to consider and prefer to align Msg3 with other PUSCH regarding available slot counting restriction (i.e. K>1). |
| NTT DOCOMO | We support the initial assessment. |
| FL(ZTE) | Thanks Qualcomm for the clarification. I agree that if a UE doesn’t request repetition, it may have potential ambiguity. But it seems questionable why gNB would schedule a Msg3 on an unavailable slot in case of K=1 . In addition, the proposed TP also changes the behavior in case a UE requests Msg3 with repetition.  Anyway, let’s hear companies’ views on this. |

## AI 8.8.2

#### Joint channel estimation for PUSCH

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| **Issues** | **Related contributions** | **Initial assessment** |
| **Issue#1**: Group common TPC commands handling for DMRS bundling for PUSCH and PUCCH. | R1-2203192, R1-2203611, R1-2204350, R1-2204991, R1-2203652, R1-2204090, R1-2204213, R1-2204279, R1-2204513, R1-2204872, R1-2203096, R1-2203309, R1-2203402, R1-2203440, R1-2203522, R1-2203870, R1-2204776 | **[High priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue#2**: Clarification on UE behavior of restarting DMRS bundling with respect to multiple semi-static and dynamic events within one nominal TDW. | R1-2203611, R1-2203652, R1-2204090, R1-2204279, R1-2204872, R1-2203402, R1-2203522 | **[High priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue#3**: Clarification on the description of maximum duration in RAN1 and RAN2 specifications. | R1-2203611 | **[Low priority]** Suggest to discuss related issue only in RAN1 specifications in RAN1#109-e. |
| **Issue#4**: Clarification on candidate values for maximum duration. | R1-2203611, R1-2203612 | Suggest to be discussed in UE feature session AI 8.16.8. |
| **Issue#5**: Clarification on DMRS bundling in unlicensed band. | R1-2203870 | Suggest to be discussed in UE feature session AI 8.2.5. |
| **Issue#6**: Clarification on the interpretation of for DG-PUSCH repetitions for accumulated TPC command and clarification on the timeline for absolute TPC mode. | R1-2204513 | Suggest **NOT** to be discussed in RAN1#109-e.  This issue was extensively discussed in Rel-15 maintenance in RAN1 #108-e, no consensus has been reached and no further discussion is expected. |
| **Issue#7**: Clarification on UE behaviour about performing the same precoder of precoding cycling within an actual TDW. | R1-2203402 | Suggest **NOT** to be discussed in RAN1#109-e.  This issues was proposed and discussed during the past meetings, it seems to be a common understanding that precoder cannot be changed within one actual TDW. |
| **Issue#8**: Other minor clarification/correction issues.  **Issue#8-1**: Editorial issue on “power control parameters” in TS 38.214.  **Issue#8-2**: Alignment on RRC parameter ‘[maxDMRS-BundlingDuration]’ in TS 38.214 with RAN2 spec. | R1-2203096, R1-2203192 | **[Low priority]** Suggest to be discussed in RAN1#109-e. |

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| **Company** | **Views** |
| InterDigital | Suggest to not discuss #8-1 since specification is already clear. #8-2 seems dependent on the outcome of issue #1. |
| Nokia/NSB | We are fine with the initial assessment. |
| Intel | We are fine with FL’s suggestions |
| Spreadtrum | We are fine with the assessment. |
| CATT | We are fine with the assessment. |
| NTT DOCOMO | We support the initial assessment. |

#### PUCCH enhancements

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| **Issues** | **Related contributions** | **Initial assessment** |
| **Issue#1**: Correction/Clarification on frequency hopping for DMRS bundling for PUCCH and PUSCH. | R1-2204991, R1-2204872, R1-2203096, R1-2203522, R1-2204776, R1-2203440, R1-2203193 | **[High priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue#2**: Clarification on inter-slot frequency hopping for Msg3 when DMRS bundling is enabled. | R1-2204513 | **[Low priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue#3**: Clarification on Rel-17 inter-slot frequency hopping when frequency hopping interval is configured but DMRS bundling is not enabled. | R1-2204872, R1-2204873 | **[Low priority]** Suggest to be discussed in RAN1#109-e. |
| **Issue#4**: Clarification on the interrelationship between the length of hopping interval and that of nominal TDW. | R1-2204549 | Suggest **NOT** to be discussed in RAN1#109-e.  Based on the agreement in RAN1 #107, the hopping interval and nominal TDW are separately configured, while the nominal TDW was determined followed by the determination of hopping interval. It seems this issue is clear. |
| **Issue#5**: Clarification on dynamic PUCCH repetition factor indication for HARQ-ACK of first SPS PDSCH associated with the activation DCI and SPS release DCI. | R1-2203309, R1-2204957, R1-2203193 | **[Medium priority]** Suggest to be discussed in RAN1#109-e. |

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| **Company** | **Views** |
| InterDigital | Fine with proposal. |
| Nokia/NSB | We are fine with the initial assessment. |
| Intel | We are fine with FL’s suggestions |
| Spreadtrum | We are fine with the assessment. |
| CATT | Fine with the assessment. |
| WILUS | We are fine with the FL’s initial assessment in principle. We want to make our understanding clear about FL’s initial assessment on Issue#4. A gNB may always configure nominal TDW length not smaller than hopping interval? |
| NTT DOCOMO | We support the initial assessment. |

# Conclusion

# References

1. R1-2203095 Discussion on PUSCH enhancements Huawei, HiSilicon
2. R1-2203191 Discussion on remaining issues for PUSCH enhancements ZTE
3. R1-2203439 Remaining issues on PUSCH enhancements in Rel-17 CATT
4. R1-2203521 Remaining issues on PUSCH enhancements vivo
5. R1-2203610 Remaining issues on PUSCH coverage enhancements Nokia, Nokia Shanghai Bell
6. R1-2203791 Maintenance on PUSCH enhancements xiaomi
7. R1-2203837 Remaining issues on TB processing over multi-slot PUSCH Langbo
8. R1-2203869 PUSCH enhancements Samsung
9. R1-2203994 Enhancements on PUSCH repetition type A OPPO
10. R1-2204089 Remaining issues on PUSCH enhancements InterDigital, Inc.
11. R1-2204212 Remaining issues on PUSCH repetition type A enhancement Apple
12. R1-2204278 Discussion on the remaining issues of CE PUSCH enhancement CMCC
13. R1-2204349 Remaining issues on PUSCH enhancements for coverage enhancement NTT DOCOMO, INC.
14. R1-2204527 Remaining details on PUSCH enhancements LG Electronics
15. R1-2204548 Remaining issues on enhancements for PUSCH repetition Type A WILUS Inc.
16. R1-2204657 Discussion on remaining issues on PUSCH repetition Type A enhancements Panasonic
17. R1-2204664 PUSCH enhancements for Rel-17 CovEnh Sharp
18. R1-2204726 Discussion on PUSCH enhancements MediaTek Inc.
19. R1-2204728 Discussion on Joint channel estimation over multi-slot MediaTek Inc.
20. R1-2204775 Remaining issues on PUSCH enhancements Intel Corporation
21. R1-2204871 Maintenance for PUSCH Repetition and TBoMS Ericsson
22. R1-2204990 PUSCH Enhancements Qualcomm Incorporated
23. R1-2203096 Discussion on joint channel estimation for PUSCH and PUCCH Huawei, HiSilicon
24. R1-2203192 Discussion on remaining issues for joint channel estimation ZTE
25. R1-2203309 Discussion on joint channel estimation for PUSCH&PUCCH Spreadtrum Communications
26. R1-2203402 Discussion on joint channel estimation for PUSCH and PUCCH Panasonic
27. R1-2203440 Remaining issues on joint channel estimation in Rel-17 CATT
28. R1-2203522 Remaining issues on joint channel estimation vivo
29. R1-2203611 Remaining issues on joint channel estimation for PUSCH and PUCCH Nokia, Nokia Shanghai Bell
30. R1-2203652 Remaining issues on joint channel estimation for PUSCH and PUCCH China Telecom
31. R1-2203870 Joint channel estimation for PUSCH and PUCCH Samsung
32. R1-2204090 Joint channel estimation for PUSCH and PUCCH InterDigital, Inc.
33. R1-2204213 Remaining issues on cross-slot channel estimation for PUSCH Apple
34. R1-2204279 Discussion on the remaining issues of joint channel estimation for PUSCH and PUCCH CMCC
35. R1-2204350 Remaining issues on joint channel estimation for PUSCH and PUCCH for coverage enhancement NTT DOCOMO, INC.
36. R1-2204455 Discussion on joint channel estimation for PUSCH&PUCCH Spreadtrum Communications
37. R1-2204513 Joint channel estimation for PUSCH and PUCCH Sharp
38. R1-2204549 Remaining issues on Joint channel estimation for PUCCH and PUSCH WILUS Inc.
39. R1-2204776 Remaining issues on joint channel estimation for PUSCH and PUCCH Intel Corporation
40. R1-2204872 Maintenance of Joint Channel Estimation for PUSCH and PUCCH Ericsson
41. R1-2204991 Joint channel estimation for PUSCH and PUCCH Qualcomm Incorporated
42. R1-2203193 Discussion on remaining issues for coverage enhancements for PUCCH ZTE
43. R1-2203612 Draft LS on description of RRC parameters for nominal time domain window length for PUSCH and PUCCH DMRS bundling Nokia, Nokia Shanghai Bell
44. R1-2203792 Other considerations for TB processing over multi-slot PUSCH xiaomi
45. R1-2204873 Rel-17 Multi-Slot Frequency Hopping and Further Enhancements Ericsson
46. R1-2204902 Further consideration on PUSCH coverage enhancment Huawei, HiSilicon
47. R1-2204957 Remaining issues for PUCCH coverage enhancements InterDigital, Inc.