**3GPP TSG-RAN WG4 Meeting # 109 (Draft)** **R4-2318214**

**Chicago, USA, November 13 – November 17, 2023**

**Agenda item:** 8.14.7

**Source:** Moderator (Nokia, Nokia Shanghai Bell)

**Title:** Topic summary for [109][322] NR\_FR1\_lessthan\_5MHz\_BW\_demod

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

RAN4#109 is the second meeting to discuss the demodulation performance requirements for Rel-18 **NR\_FR1\_lessthan\_5MHz\_BW WI**.

The WI description can be found in [RP-230186](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_99/Docs/RP-230186.zip).

This summary provides the overview and captures the open issues based on the TDoc submitted to RAN4#109 meeting into the following AIs**:**

* 8.14.6 Demodulation performance requirements
  + 8.14.6.1 UE demodulation performance and CSI requirements
  + 8.14.6.2 BS demodulation performance requirements

The previous agreements and open issues are captured in the following WFs:

* [R4-2316924](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_108bis/Docs/R4-2316924.zip), WF on NR\_FR1\_lessthan\_5MHz\_BW\_demod, Nokia. Nokia Shanghai Bell, RAN4#108bis, Xiamen, China, October 09 – October 13, 2023.

# Topic #1: UE Demod

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2318680](file:///C:\..\:w:\r\sites\c5g\5gradio\_layouts\15\Doc.aspx?sourcedoc=%7B4424D6FD-8277-4602-B292-FF6E54AE211D%7D&file=R4-2318680%20UE%20demodulation%20performance%20and%20CSI%20requirements%20for%20NR%20support%20for%20dedicated%20spectrum%20less%20than%205MHz%20for%20FR1.docx&action=default&mobileredirect=true) | Apple | **UE demodulation performance and CSI requirements for NR support for dedicated spectrum less than 5MHz for FR1**  **Proposal 1**: Via applicability rules, only define 3MHz requirements for UEs that specifically support only 3MHz operation. Other UEs supporting both 3MHz and >5MHz CBW should only be tested using legacy PDSCH requirements.  Observation 1: 4Rx is not mandatory for the frequency bands considered in this R18 work item.  **Proposal 2**: Define 3MHz requirements using only 2Rx, since 4Rx is not mandatory for the frequency bands considered in this WI.  **Proposal 3**: Explore the feasibility of defining PDSCH requirements in HST for the single-tap propagation conditions in B.3.1, including MCS values and parameters such as Dmin, Ds, and f\_d.  Observation 2: For the frequency bands in consideration in this work item, HST-972 seems too high of a doppler spread when considering a maximum speed of 500 km/h.  **Proposal 4**: For PDSCH requirements for the single-tap propagation HST consider instead to use HST-750, or even define a new scenario with a lower doppler spread.  **Proposal 5**: Do not introduce new requirements for punctured PDCCH with focus on CORESET#0 puncturing since this is not a testable scenario.  **Proposal 6:** Via applicability rules, determine that only UEs only supporting less than 5MHz operation should be subject to new PDCCH requirements.  **Proposal 7**: RAN4 to define non-punctured PDCCH demodulation requirements with 15PRBs, 3MHz CBW, for UE supporting only NR\_FR1\_lessthan\_5MHz\_BW: 12 PRB CORESET + 2 symbols, AL2, DCI 1\_0 (35 bits for 15 PRBs) as proposed during RAN4#108bis.  **Proposal 8**: Do not consider 1x4 antenna configuration scenario for PBCH since this is not a mandatory scenario. Frequency bands considered in this WI only require mandatory support of 2Rx.  **Proposal 9**: Do not define additional PBCH requirements under the HST scenario, since this is not a bottleneck situation for the UE or for the network.  **Proposal 10**: For operation in less than 5MHz, do not define additional CSI reporting requirements for legacy UEs. Only define requirements, via applicability rules, if UE supports only less then 5MHz CBW |
| [R4-2318788](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2318788%20-%20On%20Lessthan5MHz%20UE%20demod%20perf%20and%20CSI%20requirements.docx) | Nokia, Nokia Shanghai Bell | **On Lessthan5MHz UE demod perf and CSI requirements**  **General Aspects**  Common HST propagation conditions and parameters  Observation 1: SFN transmission scheme is not beneficial because the contribution of the far most cells in the joint transmission will not be significant.  **Proposal 1**: For HST propagation conditions use single-tap propagation based on B.3.1  Observation 2: To reduce simulation time, lower value of Ds can possible be used the assumption that doppler is not changing much for high values of Ds, hence existing value for Ds=300m can be used.  **Proposal 2**: For HST propagation conditions use Ds=300m.  Observation 3: The maximum doppler when v=500km/h and fcc = 900MHz (n100) is fd = 417Hz.  **Proposal 3**: Introduce requirements for HST with fd = 417Hz to cover 900MHz band (n100)  **Proposal 4**: Introduce requirements for HST with Dmin = 2m.  Applicability of requirements  Observation 4: Both creating requirements applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW or making the new requirements applicable to specific bands (i.e., not band-agnostic) can work.  **PDSCH**  Observation 5: With 3MHz CBW, the UE performance numbers will be very sensitive to the edge effect of the implementation, in particular the channel smoothening and filter implementation. Hence, UEs supporting <5Mhz are expected to have potentially different implementations that privilege edge-PRB performance in any edge vs. non-edge trade-offs when compared to existing UEs. Thus, new requirements are needed to test UE performance with 3MHz CBW.  Observation 6: The frequency band n100 only support 3 and 5MHz CBW (see [R4-2304575]). It is expected that there will be UEs in deployment, which support only band n100, hence requirements with 5MHz and/or 3MHz CBW, SCS 15kHz is needed.  **Proposal 5**: Introduce a new set of requirements for PDSCH for UE supporting only less than 5MHz with 3MHz CBW. Existing RedCap requirements can be used as reference/starting point.  SDR Requirements  Observation 7: As requirements already exists for SDR, including 3MHz into existing requirement definition can be done by extending the existing table to include 3MHz CBW.  **Proposal 6**: Extend the existing SDR requirements section to include 3MHz CBW.  PDSCH parameters for further evaluation (non-HST scenario)  Observation 8: Our simulation results show significant difference between 10MHz CBW and 3MHz CBW which also depend on threshold and SNR measurement choices within the baseband algorithm, hence we see PDSCH requirements as relevant to be defined for both 2Rx and 4Rx. Existing RedCap requirements can be used as starting point with 3MHz CBW.  **Proposal 7**: Define non-HST PDSCH requirements based on existing RedCap PDSCH, using 15 PRB, as follows:    PDSCH requirements in HST scenario  Observation 9: It is likely that UEs with <5MHz CBW support only will be seen in actual deployment, hence requirements for HST scenario(s) are relevant and requested by rail operators. Using existing HST tests from TS38.101-4 as reference is a good starting point.  **Proposal 8**: Define PDSCH requirements for HST scenario based on tests 1-6 from TS38.101-4 tables 5.2.2.1.1-3 and 5.2.2.3.1-3 as reference with the following parameters: Dmin=2m, Ds=300m, fd=471Hz, *v*=500km/h.  **PDCCH**  Non punctured PDCCH  Observation 10: To ensure UEs supporting only <5MHz CBW are tested, PDCCH requirements need to be defined for 3MHz CBW.  **Proposal 9**: RAN4 shall define (non-punctured) PDCCH demodulation requirements with 15PRBs, 3MHz CBW, for UE supporting NR\_FR1\_lessthan\_5MHz\_BW with the following configuration: 12 PRB CORESET, 2 symbols, AL2, DCI 1\_0 (35 bits for 15 PRBs). Further discuss if additionally, to introduce PDCCH requirements for 5MHz CBW.  Punctured PDCCH  Observation 11: We found no limitations in RAN1 specifications which prohibits CORESET#0 to be used in USS in addition to CSS, rather it is specifically listed as one option.  Observation 12: When the UE receives DCI on CORESET#0 in USS, the UE reports ACK/NACK, e.g., for PDSCH scheduling DCI with CRC scrambled with C-RNTI in USS.  Observation 13: There will not be a change in the DCI 1\_0 size, when configured for USS with C-RNTI compared to CSS with SI-RNTI.  **Proposal 10**: Define requirements with punctured CORESET#0 mapped to USS. Use the following configuration “with 3 symbols AL 8 PDCCH with 3 MHz CBW, interleaved”.  Propagation conditions  **Proposal 11**: Consider TDLA30-10 for 1Tx, TDLC300-100 for 2Tx when defining non-HST PDCCH requirements.  **Proposal 12**: Use single-tap propagation conditions for 500km/h HST PDCCH requirement definition.  **PBCH**  PBCH parameters  **Proposal 13**: Define PBCH requirements for both 1Tx2Rx and 1Tx4Rx antenna configurations using the following configurations:  Whether to consider HST conditions for PBCH  Observation 14: Our simulation results show 1.9dB to 3.6dB difference in performance between non-HST and HST cases when using 417Hz max doppler (900MHz).  **Proposal 14**: Define PBCH requirements for HST conditions. Use the following configurations as starting point:    **CSI Reporting**  **Proposal 15**: Define CSI requirements for CBW=3MHz and SCS=15kHz: PMI, CQI and RI. Further discuss if applicability rules can be introduced.  **Proposal 16**: For CQI requirements use existing RedCap requirements as starting point.  **Proposal 17**: For PMI requirements use existing requirements for “Single PMI with 4Tx TypeI-SinglePanel Codebook” as starting point.  **Proposal 18**: For RI requirements use existing requirements for 2Rx and 4Rx as starting point. FSS to down select after initial simulation results are available. |
| [R4-2318789](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2318789%20-%20On%20Lessthan5MHz%20UE%20demod%20perf%20and%20CSI%20requirements%20-%20Simulations.docx) | Nokia, Nokia Shanghai Bell | **On Lessthan5MHz UE demod perf and CSI requirements – Simulations**  This contribution contains Nokia’s initial simulation results for the <5MHz WID. |
| [R4-2319419](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2319419%20Discussion%20on%20UE%20demodulation%20requirements%20for%20dedicated%20spectrum%20less%20than%205MHz.docx) | Samsung Shenzhen | **Discussion on UE demodulation requirements for dedicated spectrum less than 5MHz**  **Proposal 1**: Apply single-tap HST for HST propagation conditions and parameters  **Proposal 2**: Introduce new applicability table for the UE supporting new sync raster (specific bands)  **Proposal 3**: Introduce PDSCH requirements for 3MHz channel bandwidth  **Proposal 4**: Introduce HST single tap propagation condition for PDSCH requirements  Observation1: CORESET#0 can be configured both CSS and USS  **Proposal 5**: Introduce PDCCH requirements with punctured PRB  **Proposal 6**: Not to introduce HST scenario for PDCCH requirements  **Proposal 7**: Not to introduce HST scenario for PBCH requirements  **Proposal 8**: Introduce CSI reporting requirements |
| [R4-2319541](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2319541%20Discussion%20on%20UE%20demodulation%20performance%20and%20CSI%20requirements%20for%20less%20than%205MHz%20%20.docx) | ZTE Corporation | **Discussion on NR support for dedicated spectrum less than 5MHz for FR1 demodulation performance requirements**  **Proposal 1**. Only Considering 2Rx for PBCH demodulation requirements.  Observation 1. In our simulation results, no significant performance difference between 15PRB and legacy RedCap 52PRB.  **Proposal 2**. If RAN4 defines PDSCH requirements for 3MHz, propose to introduce limited test cases.  **Proposal 3**. For HST scenario, propose to consider DPS propagation conditions for less than 5MHz.  **Proposal 4**. For non-punctured PDCCH requirements, propose to don’t define requirements for less than 5MHz.  **Proposal 5**. For punctured PDCCH requirement, if If RAN4 can resolve the test ability issue for PDCCH in CORESET#0, RAN4 should consider define PDCCH requirements.  **Proposal 6**. For CSI requirements, propose to don’t define requirements in less than 5MHz. |
| [R4-2319542](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2319542%20Simulation%20results%20for%20UE%20demodulation%20performance%20and%20CSI%20requirements%20for%20less%20than%205MHz.docx) | ZTE Corporation | **Simulation results for UE demodulation performance and CSI requirements for less than 5MHz**  This contribution contains initial simulation results for the <5MHz WID [1]. The results are provided to aid in determining where new requirements can/should be introduced. |
| [R4-2319746](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2319746%20LT5MHz%20UE%20demod.docx) | Ericsson | **Discussion on UE demodulation and CSI reporting requirements for NR less than 5MHz**  **Proposal 1**: Define PDSCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW by reusing TS 38.101-4 5.2.2.1.17.   * FDD, SCS=15kHz, 15PRB * QPSK, 1/3, TDLB100-400, Rank 1, * 16QAM, 0.48, TDLC300-100, Rank 1 * 64QAM, 0.5, TDLA30-10, Rank 2 * 256QAM, 0.82, TDLA30-10, Rank 1   **Proposal 2**: Revisit PDCCH AL configuration to fit to 3MHz CBW for PDSCH demodulation requirements with 3MHz CBW. Possible PDCCH configuration is to set AL2 without puncturing.  **Proposal 3**: Define UE demodulation and CSI requirements for 2Rx only.  **Proposal 4**: Apply SDR tests for 3MHz CBW. Update TS 38.101-4 Tables 5.5A-1 and 5.5A-4 to support 3MHz CBW.  **Proposal 5:** Define PDSCH demodulation requirements with HST-DPS propagation condition by reusing TS 38.101-4 5.2.2.1.10 with the following modification.   * CBW=3MHz (15PRB) * Reuse the same Dmin, Ds, and f\_d values as specified in TS38.101-4 Table B.3.3-1   Observation 1: CORESET#0 can be used for PDCCH transmitted in UE-specific search space.  **Proposal 6:** Define punctured PDCCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   * 15PRBs, 3 symbols, non-interleaved, AL4, DCI 1\_0 (35 bits for 15 PRBs), TDLC300-100, 2Tx, 2Rx * Use CCEs #4, #5, #6, and #7 to transmit PDCCH with DCI 1\_0.   **Proposal 7:** Define non-punctured PDCCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   * 15PRBs, 2 symbols, interleaved, AL2, DCI 1\_0 (35 bits for 15 PRBs), TDLA30-10, 1Tx, 2Rx.   Observation 2: Degradation due to the puncturing is about 4.0dB.  **Proposal 8:** Define CQI definition test under static channel condition with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   * 15PRBs, CQI Table 2, 2Tx Rank 2, 2Rx, 2 SNR test points. * Reuse the same metric as Rel-15 CQI definition test in static condition.   **Proposal 9:** Define CQI reporting test under fading channel condition with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   * 15PRBs, CQI Table 2, 2Tx Rank 1, TDLA30-5, 2Rx, 2 SNR test points. * Reuse the same metric as Rel-15 CQI reporting test in fading condition.   **Proposal 10:** Define PMI reporting test with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   * 15PRB, Single PMI, Type I, MCS13 (16QAM, 0.48), Rank 1, 4 CSI-RS ports, 4Tx XPOL, TDLA30-5, 2Rx. * Reuse the same metric as Rel-15 4TX PMI reporting requirements.   **Proposal 11:** Define RI reporting test with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   * 15PRBs, CQI Table 2, SNR=[0dB], 2Tx, low antenna correlation, TDLA30-5, 2Rx, fixed RI=2 vs. follow RI * 15PRBs, CQI Table 2, SNR=20dB, 2Tx, low antenna correlation, TDLA30-5, 2Rx, fixed RI=1 vs. follow RI * 15PRBs, CQI Table 2, SNR=20dB, 2Tx, high antenna correlation, TDLA30-5, 2Rx, fixed RI=1 vs. follow RI * Reuse the same metric as Rel-15 RI reporting requirements.   **Proposal 12:** Revisit PDCCH AL configuration to fit to 3MHz when RAN4 define CSI reporting requirements with 3MHz CBW. Possible configuration is to set AL2 without puncturing. If necessary, set higher SNR test points especially for RI/CQI tests to ensure low PDCCH BLER.  **Proposal 13:** Create the UE demodulation requirement applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   |  |  |  |  | | --- | --- | --- | --- | |  |  | **Applicable tests** | | |  | **Test type** | **Type 1: Only supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 5MHz or less** | **Type 2: Supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 10MHz or more** | | FR1 FDD | PDSCH | New tests (15PRB) | Existing PDSCH tests (10MHz) | | 2Rx | PDCCH | New tests (15PRB) | Existing PDCCH tests (10MHz)  punctured PDCCH tests (15PRB) | |  | PBCH | New tests (12PRB) | Existing PBCH tests (10MHz)  Punctured PBCH tests (12PRB) | |  | SDR | Existing SDR tests | Existing SDR tests |     **Proposal 14:** Create the CSI reporting requirement applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.   |  |  |  |  | | --- | --- | --- | --- | |  |  | **Applicable tests** | | |  | Test type | **Case 1: Only supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 5MHz or less** | **Case 2: Supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 10MHz or more** | | FR1 FDD | CQI | New tests (15PRB) | Existing CQI tests (10MHz) | | 2Rx | PMI | New tests (15PRB) | Existing PMI tests (10MHz) | |  | RI | New tests (15PRB) | Existing RI tests (10MHz) | |
| [R4-2320197](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2320197%20Discussions%20on%20UE%20performance%20requirements%20for%20FR1%20spectrum%20less%20than%205MHz.docx) | Huawei,HiSilicon | **Discussions on UE demodulation and CSI requirements for dedicated sprectrum less than 5MHz for FR1**  **Proposal 1**: RAN4 to define new performance requirements only for 3MHz  **Proposal 2**: RAN4 focus on demodulation requirements and deprioritize the CSI requirements  **Proposal 3**: RAN4 only define PDSCH requirements with HST channel and define PDCCH and PBCH requirements with TDL channel.  **Proposal 4**: Define the applicability rules as follows:   * Requirements with 3MHz are only applicable to UE supporting 3MHz bandwidth. * If a UE passes the cases with 10MHz/15kHz SCS, test cases with 3MHz can be skipped   **Proposal 5**: Cover both 2Rx and 4Rx for requirements definition  **Proposal 6**: RAN4 define non-punctured PDCCH requirements, don’t define the PDCCH requirements with CORESET#0  **Proposal 7**: For non-punctured PDCCH requirements, use following parameters and requirements:   * For 2Rx test:   + Test parameters: Reuse Table 5.3.2.1-1   + Requirements: Reuse Test 1, 2 and 3 in Table 5.3.2.1.1-1 and Test1 in Table 5.3.2.1.2-1 * For 4Rx test:   + Test parameters: Reuse Table 5.3.3.1-1   + Requirements: Reuse Test 1, 2 and 3 in Table 5.3.3.1.1-1 and Test1 in Table 5.3.3.1.2-1   **Proposal 8**: Use DPS for PDSCH requirements definition.  **Proposal 9**: Use band n100 (919.4MHz-925MHz) for max Doppler derivation, which is about 400MHz. |
| [R4-2320198](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2320198%20Simulation%20results%20for%20PBCH%20requirements%20with%203MHz%20bandwidth.docx) | Huawei,HiSilicon | **Simulation results for PBCH requirements with 3MHz bandwidth**  RAN4 agreed to define PBCH requirements with puncturing the RBs outside the 3MHz. In this contribution we provide our simulation results. |
| [R4-2320704](https://nokia.sharepoint.com/sites/c5g/5gradio/RAN4%205G%20Documents/RAN4%20109%20Chicago/Rel_18/NR_FR1_lessthan5MHz_BW/Demod/All%20papers/R4-2320704%20Discussion%20on%20UE%20demodulation%20requirements%20for%20less%20than%205MHz%20BW.docx) | MediaTek inc. | **Discussion on UE demodulation requirements for less than 5MHz BW**  ***Proposal 1*:** For non-HST scenario, define PDSCH demodulation requirements with 15PRBs for UE supporting less than 5MHz. RAN4 can reuse minimum performance for RedCap in 5.2.2.1.17 and only consider 2Rx as below.  Table 1: Minimum performance for Rank 1 in less than 5MHz   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Test num. | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Correlation matrix and antenna configuration | Reference from TS38.101-4 | | 1-1 | 3 / 15 | QPSK, 0.30 | TDLB100-400 | 2x2, ULA Low | Test 1-1 in Table 5.2.2.1.17-3 | | 1-2 | 3 / 15 | 16QAM, 0.48 | TDLC300-100 | 2x2, ULA Low | Test 1-2 in Table 5.2.2.1.17-3 | | 1-3 | 3 / 15 | 256QAM, 0.82 | TDLA30-10 | 2x2, ULA Low | Test 1-3 in Table 5.2.2.1.17-3 |   Table 2: Minimum performance for Rank 2 in less than 5MHz   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Test num. | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Correlation matrix and antenna configuration | Reference from TS38.101-4 | | 2-1 | 3 / 15 | 64QAM, 0.50 | TDLA30-10 | 2x2, ULA Low | Test 2-1 in Table 5.2.2.1.17-4 |   ***Proposal 2*:** Update TS 38.101-4 Tables 5.5A-1 and 5.5A-4 to support less than 5MHz:   * Add “2/AL2 for 15 kHz / 3 MHz” in the field of “Number of PDCCH candidates and aggregation levels” in Tables 5.5A-1 * Add number of PRBs for 15 kHz / 3 MHz as 15 in Tables 5.5A-4   ***Proposal 3***: For UE supporting less than 5MHz, do not define PDCCH demodulation requirements for punctured case.  ***Proposal 4***: For UE supporting less than 5MHz, define (non-punctured) PDCCH demodulation requirements with 15PRBs, 3MHz CBW:  Table 3: Minimum performance for PDCCH in less than 5MH    ***Proposal 5***: Consider only 2Rx case for PBCH requirements in less 5MHz.  ***Proposal 6***: Define CQI definition test under static channel condition with 15PRBs for UE supporting less than 5MHz   * Use Table 6.2.2.1.1.1-1 as a starting point * 15PRBs, CQI Table 2, 2T2R, Rank 2, 2 SNR test points * Reuse the same metric as Rel-15 CQI definition test in static condition   ***Proposal 7***: Define CQI reporting test under fading channel condition with 15PRBs for UE supporting less than 5MHz   * Use Table 6.2.2.1.2.1-1 as a starting point * 15PRBs, CQI Table 2, 2T2R, Rank 1, TDLA30-5, 2 SNR test points * Reuse the same metric as Rel-15 CQI reporting test in fading condition   ***Proposal 8***: Define PMI reporting test with 15PRBs for UE supporting less than 5MHz   * Use Table 6.3.2.1.1-1 as a starting point * 15PRB, Single PMI, TypeI-SinglePanel, MCS13 (16QAM, 0.48), Rank 1, 4 CSI-RS ports, High XP 4 x 2, TDLA30-5 * Reuse the same metric as Rel-15 4Tx PMI reporting requirements   ***Proposal 9***: Define RI reporting test with 15PRBs for UE supporting less than 5MHz   * Use Table 6.4.2.1-1 Test 1 as a starting point * 15PRBs, CQI Table 2, SNR=0dB, ULA Low 2x2, TDLA30-5, fixed RI=2 vs. follow RI * Reuse the same metric as Rel-15 RI reporting requirements   ***Proposal 10***: Follow RAN4 legacy rule by using requirements applicability table for UE supporting less than 5MHz.  Table 4: Requirements applicability for optional UE features (PDSCH and PDCCH)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | UE feature/capability | Test type | | Test list | Applicability notes | | TBD (UE capability related to less than 5MHz) | FR1 FDD | PDSCH | TBD |  | | FR1 FDD | PDCCH | TBD |  |   Table 5: Requirements applicability for optional UE features (CSI)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | UE feature/capability | Test type | | Test list | Applicability notes | | TBD (UE capability related to less than 5MHz) | FR1 FDD | CQI | TBD |  | | FR1 FDD | PMI | TBD |  | | FR1 FDD | RI | TBD |  |   ***Proposal 11***: Introduce requirements’ applicability tables for PDSCH, PDCCH (non-punctured), CQI, RI and PMI requirements to indicate which test case can be skipped when UE supports both less and larger than 5MHz.  Table 6: Applicability of requirements for less than 5MHz (PDSCH)   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | If UE has passed | | | UE can skip | | | Applicability notes | | Test type | | Test list | Test type | | Test list |  | | FR1 FDD | PDSCH | Test 1-1 in Table 5.2.2.1.1-3 | FR1 FDD | PDSCH | Test 1-1 in Table 1 |  | | FR1 FDD | PDSCH | Test 1-2 in Table 5.2.2.1.1-3 | FR1 FDD | PDSCH | Test 1-2 in Table 1 |  | | FR1 FDD | PDSCH | Test 1-3 in Table 5.2.2.1.1-3 | FR1 FDD | PDSCH | Test 1-3 in Table 1 |  | | FR1 FDD | PDSCH | Test 2-1 in Table 5.2.2.1.1-4 | FR1 FDD | PDSCH | Test 2-1 in Table 2 |  |   Table 6: Applicability of requirements for less than 5MHz (PDCCH)   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | If UE has passed | | | UE can skip | | | Applicability notes | | Test type | | Test list | Test type | | Test list |  | | FR1 FDD | PDCCH | Test 1 in Table 5.3.2.1.1-1 | FR1 FDD | PDCCH | Test 1 in Table 3 |  |   Table 6: Applicability of requirements for less than 5MHz (CQI, PMI, RI)   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | If UE has passed | | | UE can skip | | | Applicability notes | | Test type | | Test list | Test type | | Test list |  | | FR1 FDD | CQI | Tests in Table 6.2.2.1.1.1-1 | FR1 FDD | CQI | Test in Proposal 6 |  | | FR1 FDD | CQI | Tests in Table 6.2.2.1.2.1-1 | FR1 FDD | CQI | Test in Proposal 7 |  | | FR1 FDD | PMI | Tests in Table 6.3.2.1.1-1 | FR1 FDD | PMI | Test in Proposal 8 |  | | FR1 FDD | RI | Test 1 in Table 6.4.2.1-1 | FR1 FDD | RI | Test in Proposal 9 |  | |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: General

*Sub-topic description:*

In this sub-topic the proposals related to the General aspects of UE Demodulation requirements for less than 5MHz CBW are presented.

#### Issue 1-1-1: Channel BW for performance requirements

* Proposals and Observations:
  + Option 1 [Huawei, Apple]: RAN4 to define new performance requirements only for 3MHz
  + Other options are not precluded
* Recommended WF
  + Further discuss whether such a general proposal can be agreed, or 5MHz CBW shall be still considered?

#### Issue 1-1-2: Number of RX antenna in UE Demodulation requirements

* Background
  + At RAN4#108bis requirements with 2RX were generally supported by all the companies, but 4RX was left FFS.
* Proposals and Observations:
  + Observation 1 (Apple): 4Rx is not mandatory for the frequency bands considered in this R18 work item.
  + **Proposal** **1** (Apple): Define 3MHz requirements using only 2Rx, since 4Rx is not mandatory for the frequency bands considered in this WI.
  + **Proposal 3** (Ericsson): Define UE demodulation and CSI requirements for 2Rx only.
  + **Proposal 5** (Huawei): Cover both 2Rx and 4Rx for requirements definition
* Candidate options / tentative agreements:
  + *Tentative agreement*: Define UE Demodulation performance and CSI reporting UE requirements in 3MHz CBW for 2Rx.
  + Option 1 [Apple, Ericsson]: Define 3MHz requirements using only 2Rx
  + Option 2 [Huawei, Nokia]: Cover both 2Rx and 4Rx for requirements definition.
* Recommended WF
  + Discussion candidate options during the meeting.

#### Issue 1-1-3: HST propagation conditions

* Background
  + Options from RAN4#108bis:

Further discuss which HST propagation conditions (500 km/h) and parameters to use:

* Option 1: Single-tap propagation conditions ( based on B.3.1)
  + Ds = [300] m, Dmin = [2] m, f\_d =[972] Hz
* Option 2: HST DPS propogation conditions (based on B.3.3.)
  + Ds = [700] m, Dmin = [150] m, f\_d = [TBA]
* Proposals and Observations:
  + **Proposal 3** (Apple): Explore the feasibility of defining PDSCH requirements in HST for the single-tap propagation conditions in B.3.1, including MCS values and parameters such as Dmin, Ds, and f\_d.
  + Observation 2 (Apple): For the frequency bands in consideration in this work item, HST-972 seems too high of a doppler spread when considering a maximum speed of 500 km/h.
  + **Proposal 4** (Apple): For PDSCH requirements for the single-tap propagation HST consider instead to use HST-750, or even define a new scenario with a lower doppler spread.
  + Observation 1 (Nokia): SFN transmission scheme is not beneficial because the contribution of the far most cells in the joint transmission will not be significant.
  + **Proposal 1** (Nokia): For HST propagation conditions use single-tap propagation based on B.3.1
  + Observation 2 (Nokia): To reduce simulation time, lower value of Ds can possible be used the assumption that doppler is not changing much for high values of Ds, hence existing value for Ds=300m can be used.
  + **Proposal 2** (Nokia): For HST propagation conditions use Ds=300m.
  + Observation 3 (Nokia): The maximum doppler when v=500km/h and fcc = 900MHz (n100) is fd = 417Hz.
  + **Proposal 3** (Nokia): Introduce requirements for HST with fd = 417Hz to cover 900MHz band (n100)
  + **Proposal 4** (Nokia): Introduce requirements for HST with Dmin = 2m.
  + **Proposal 1** (Samsung): Apply single-tap HST for HST propagation conditions and parameters
  + Proposal 3 (ZTE): For HST scenario, propose to consider DPS propagation conditions for less than 5MHz.
  + **Proposal 8** (Huawei): Use DPS for PDSCH requirements definition.
  + **Proposal 9** (Huawei): Use band n100 (919.4MHz-925MHz) for max Doppler derivation, which is about 400Hz.
* Candidate options / tentative agreements:
  + Option 1: Single-tap propagation conditions (B3.1 model), Ds = 300 m, Dmin = 2 m
    - Option 1-a: f\_d = 972 Hz
    - Option 1-b: f\_d = 750 Hz or less
    - Option 1-c: f\_d = 417 Hz
  + Option 2: DPS propagation conditions (B3.3 model)
    - Option 2-a: Ds = 700 m, Dmin = 150 m, f\_d = 870 Hz
    - Option 2-b: Ds = 700 m, Dmin = 150 m, f\_d = [400] Hz
    - Option 2-c: Ds = 300 m, Dmin = 2 m, f\_d = 417 Hz
* Recommended WF
  + Further discuss the options during the meeting

#### Issue 1-1-4: Applicability rules

* Background

WF from RAN4#108bis:

|  |
| --- |
| **Issue 1-5-2: Applicability of requirements**  **Way forward:**  FFS, how to introduce applicability rules for UE Demodulation and CSI reporting requirements in less than 5 MHz channel BW:   * Option 1: Create requirements’ applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW. * Option 2: The new requirements are only applicable to the specific bands for this WI, instead of being band-agnostic. * Other options are not precluded. |

* Proposals and Observations:
  + **Proposal 1** (Apple): Via applicability rules, only define 3MHz requirements for UEs that specifically support only 3MHz operation. Other UEs supporting both 3MHz and >5MHz CBW should only be tested using legacy PDSCH requirements.
  + Observation 4 (Nokia): Both creating requirements applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW or making the new requirements applicable to specific bands (i.e., not band-agnostic) can work.
  + **Proposal 2** (Samsung): Introduce new applicability table for the UE supporting new sync raster (specific bands)
  + **Proposal 13** (Ericsson)**:** Create the UE demodulation requirement applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Applicable tests** | |
|  | **Test type** | **Type 1: Only supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 5MHz or less** | **Type 2: Supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 10MHz or more** |
| FR1 FDD | PDSCH | New tests (15PRB) | Existing PDSCH tests (10MHz) |
| 2Rx | PDCCH | New tests (15PRB) | Existing PDCCH tests (10MHz)  punctured PDCCH tests (15PRB) |
|  | PBCH | New tests (12PRB) | Existing PBCH tests (10MHz)  Punctured PBCH tests (12PRB) |
|  | SDR | Existing SDR tests | Existing SDR tests |

* + **Proposal 14** (Ericsson)**:** Create the CSI reporting requirement applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Applicable tests** | |
|  | Test type | **Case 1: Only supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 5MHz or less** | **Case 2: Supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 10MHz or more** |
| FR1 FDD | CQI | New tests (15PRB) | Existing CQI tests (10MHz) |
| 2Rx | PMI | New tests (15PRB) | Existing PMI tests (10MHz) |
|  | RI | New tests (15PRB) | Existing RI tests (10MHz) |

* + **Proposal 10** (MediaTek): Follow RAN4 legacy rule by using requirements applicability table for UE supporting less than 5MHz.

Table 4: Requirements applicability for optional UE features (PDSCH and PDCCH)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE feature/capability | Test type | | Test list | Applicability notes |
| TBD (UE capability related to less than 5MHz) | FR1 FDD | PDSCH | TBD |  |
| FR1 FDD | PDCCH | TBD |  |

Table 5: Requirements applicability for optional UE features (CSI)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE feature/capability | Test type | | Test list | Applicability notes |
| TBD (UE capability related to less than 5MHz) | FR1 FDD | CQI | TBD |  |
| FR1 FDD | PMI | TBD |  |
| FR1 FDD | RI | TBD |  |

* + **Proposal 4** (Huawei)**:** Define the applicability rules as follows:
    - Requirements with 3MHz are only applicable to UE supporting 3MHz bandwidth.
    - If a UE passes the cases with 10MHz/15kHz SCS, test cases with 3MHz can be skipped
  + **Proposal 11** (MediaTek): Introduce requirements’ applicability tables for PDSCH, PDCCH (non-punctured), CQI, RI and PMI requirements to indicate which test case can be skipped when UE supports both less and larger than 5MHz.

Table 6: Applicability of requirements for less than 5MHz (PDSCH)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| If UE has passed | | | UE can skip | | | Applicability notes |
| Test type | | Test list | Test type | | Test list |  |
| FR1 FDD | PDSCH | Test 1-1 in Table 5.2.2.1.1-3 | FR1 FDD | PDSCH | Test 1-1 in Table 1 |  |
| FR1 FDD | PDSCH | Test 1-2 in Table 5.2.2.1.1-3 | FR1 FDD | PDSCH | Test 1-2 in Table 1 |  |
| FR1 FDD | PDSCH | Test 1-3 in Table 5.2.2.1.1-3 | FR1 FDD | PDSCH | Test 1-3 in Table 1 |  |
| FR1 FDD | PDSCH | Test 2-1 in Table 5.2.2.1.1-4 | FR1 FDD | PDSCH | Test 2-1 in Table 2 |  |

Table 6: Applicability of requirements for less than 5MHz (PDCCH)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| If UE has passed | | | UE can skip | | | Applicability notes |
| Test type | | Test list | Test type | | Test list |  |
| FR1 FDD | PDCCH | Test 1 in Table 5.3.2.1.1-1 | FR1 FDD | PDCCH | Test 1 in Table 3 |  |

Table 6: Applicability of requirements for less than 5MHz (CQI, PMI, RI)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| If UE has passed | | | UE can skip | | | Applicability notes |
| Test type | | Test list | Test type | | Test list |  |
| FR1 FDD | CQI | Tests in Table 6.2.2.1.1.1-1 | FR1 FDD | CQI | Test in Proposal 6 |  |
| FR1 FDD | CQI | Tests in Table 6.2.2.1.2.1-1 | FR1 FDD | CQI | Test in Proposal 7 |  |
| FR1 FDD | PMI | Tests in Table 6.3.2.1.1-1 | FR1 FDD | PMI | Test in Proposal 8 |  |
| FR1 FDD | RI | Test 1 in Table 6.4.2.1-1 | FR1 FDD | RI | Test in Proposal 9 |  |

* Candidate options / tentative agreements:
  + Option 1 [Apple, Huawei]:
    - Via applicability rules, only define 3MHz requirements for UEs that specifically support only 3MHz operation.
    - Other UEs supporting both 3MHz and >5MHz CBW should only be tested using legacy PDSCH requirements, e.g., if a UE passes the cases with 10MHz/15kHz SCS, test cases with 3MHz can be skipped.
  + Option 2 [Ericsson]: Create the UE demodulation and CSI reporting requirement applicability table for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.
    - Case 1: Only supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 5MHz or less.
    - Case 2: Supporting FDD band(s) supporting 3MHz CBW and whose maximum channel bandwidth is 10MHz or more.
  + Option 3 [MediaTek]:
    - Follow RAN4 legacy rule by using requirements applicability table for UE supporting less than 5MHz.
    - Introduce requirements’ applicability tables for PDSCH, PDCCH (non-punctured), CQI, RI and PMI requirements to indicate which test case can be skipped when UE supports both less and larger than 5MHz.
* Recommended WF
  + [Moderator]: Options 2 and Option3 seems to be very close, however, the representation of applicability rules is a bit different.
  + Further clarify the understanding of applicability rules by the companies during the meeting.
  + Discussion can wait before the set of needed requirements for less that 5MHz CBW is fully clarified.

### Sub-topic 1-2: PDSCH requirements

*Sub-topic description:*

In this sub-topic the proposals related to the PDSCH requirements for less than 5Mhz CBW are summarized.

#### Issue 1-2-1: Scope of PDSCH requirements

* Background

WF from RAN4#108bis:

|  |
| --- |
| **Issue 1-1-1: Introduction of new requirements**  **Way forward**  FFS, whether new PDSCH demodulation performance requirements needs to be introduced:   * FFS, whether to introduce a set of requirements for PDSCH for UE supporting only less than 5 MHz:   + Consider minimum requirements for RedCap (5.2.2.1.17) as a reference   + Further evaluate a need for optional features and excluding advance features which is out of scope of the RAN1 WI   + FFS, a need for SDR requirements * FFS, a need to introduce the limited set or no new requirements for PDSCH for UE supporting multiple CBWs (i.e., less than and more than 5 MHz) |

* Proposals and Observations:
  + Observation 5 (Nokia): With 3MHz CBW, the UE performance numbers will be very sensitive to the edge effect of the implementation, in particular the channel smoothening and filter implementation. Hence, UEs supporting <5Mhz are expected to have potentially different implementations that privilege edge-PRB performance in any edge vs. non-edge trade-offs when compared to existing UEs. Thus, new requirements are needed to test UE performance with 3MHz CBW.
  + Observation 6 (Nokia): The frequency band n100 only support 3 and 5MHz CBW (see [R4-2304575]). It is expected that there will be UEs in deployment, which support only band n100, hence requirements with 5MHz and/or 3MHz CBW, SCS 15kHz is needed.
  + **Proposal 5** (Nokia): Introduce a new set of requirements for PDSCH for UE supporting only less than 5MHz with 3MHz CBW. Existing RedCap requirements can be used as reference/starting point.
  + **Proposal 3** (Samsung): Introduce PDSCH requirements for 3MHz channel bandwidth
  + Observation 1 (ZTE): In our simulation results, no significant performance difference between 15PRB and legacy RedCap 52PRB.
  + **Proposal 2** (ZTE): If RAN4 defines PDSCH requirements for 3MHz, propose to introduce limited test cases.
  + **Proposal 3** (Huawei): RAN4 only define PDSCH requirements with HST channel and define PDCCH and PBCH requirements with TDL channel.
* Candidate options / tentative agreements:
  + *Tentative agreement*: Introduce PDSCH requirements with HST channel for 3MHZ CBW.
  + Option 1: Introduce a new set of requirements for PDSCH for 3MHz CBW in non-HST conditions:
    - Option 1-a: Use RedCap requirements parameters as a reference/starting point
    - Option 1-b: Introduce limited set of requirements for PDSCH for 3MHz CBW
  + Option 2 [Huawei]: Only define PDSCH requirements with HST channel.
* Recommended WF
  + Agree to introduce PDSCH requirements with HST channel for 3MHz CBW
  + Further discuss the set of necessary requirements in non-HST conditions.

#### Issue 1-2-2: PDSCH requirements in non-HST conditions

* Background

Agreement from RAN4#108bis:

|  |
| --- |
| **Issue 1-1-3: PDSCH parameters for further evaluation (non-HST scenario)**  **Agreement:**   * Consider the following parameters for further evaluation of PDSCH performance in less than 5MHz:   + Duplex: FDD, CBW: 3MHz, SCS: 15kHz, Number of PRBs: 15   + Parameters from RedCap PDSCH minimum requirements (5.2.2.1.17) can be used for reference     - Use 2 RX as a starting point, FFS 4 RX |

* Proposals and Observations:
  + Observation 8 (Nokia): Our simulation results show significant difference between 10MHz CBW and 3MHz CBW which also depend on threshold and SNR measurement choices within the baseband algorithm, hence we see PDSCH requirements as relevant to be defined for both 2Rx and 4Rx. Existing RedCap requirements can be used as starting point with 3MHz CBW.
  + **Proposal 7** (Nokia): Define non-HST PDSCH requirements based on existing RedCap PDSCH, using 15 PRB, as follows:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test num. | Reference channel | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Correlation matrix and antenna configuration | Reference value | |
|  |  |  |  |  |  | Fraction of maximum throughput (%) | SNR (dB) |
| 1-1 | R.PDSCH.1-1.1 FDD | 3 / 15 | QPSK, 0.30 | TDLB100-400 | 2x2, ULA Low | 70 | TBD |
| 2x4, ULA Low | 70 | TBD |
| 1-2 | R.PDSCH.1-2.1 FDD | 3 / 15 | 16QAM, 0.48 | TDLC300-100 | 2x2, ULA Low | 70 | TBD |
| 2x4, ULA Low | 70 | TBA |
| 1-3 | R.PDSCH.1-4.1 FDD | 3 / 15 | 256QAM, 0.82 | TDLA30-10 | 2x2, ULA Low | 70 | TBD |
| 2x4, ULA Low | 70 | TBA |
| 2-1 | R.PDSCH.1-3.1 FDD | 3 / 15 | 64QAM, 0.50 | TDLA30-10 | 2x2, ULA Low | 70 | TBD |
| 2x4, ULA Low | 70 | TBD |

* + **Proposal 1** (Ericsson): Define PDSCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW by reusing TS 38.101-4 5.2.2.1.17.
    - FDD, SCS=15kHz, 15PRB
    - QPSK, 1/3, TDLB100-400, Rank 1,
    - 16QAM, 0.48, TDLC300-100, Rank 1
    - 64QAM, 0.5, TDLA30-10, Rank 2
    - 256QAM, 0.82, TDLA30-10, Rank 1
  + **Proposal 1** (MediaTek)**:** For non-HST scenario, define PDSCH demodulation requirements with 15PRBs for UE supporting less than 5MHz. RAN4 can reuse minimum performance for RedCap in 5.2.2.1.17 and only consider 2Rx as below.
* Table 1: Minimum performance for Rank 1 in less than 5MHz

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test num. | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Correlation matrix and antenna configuration | Reference from TS38.101-4 |
| 1-1 | 3 / 15 | QPSK, 0.30 | TDLB100-400 | 2x2, ULA Low | Test 1-1 in Table 5.2.2.1.17-3 |
| 1-2 | 3 / 15 | 16QAM, 0.48 | TDLC300-100 | 2x2, ULA Low | Test 1-2 in Table 5.2.2.1.17-3 |
| 1-3 | 3 / 15 | 256QAM, 0.82 | TDLA30-10 | 2x2, ULA Low | Test 1-3 in Table 5.2.2.1.17-3 |

* Table 2: Minimum performance for Rank 2 in less than 5MHz

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test num. | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Correlation matrix and antenna configuration | Reference from TS38.101-4 |
| 2-1 | 3 / 15 | 64QAM, 0.50 | TDLA30-10 | 2x2, ULA Low | Test 2-1 in Table 5.2.2.1.17-4 |

* Tentative agreement:
  + Define non-HST PDSCH requirements for 3MHz CBW:
    - Duplex: FDD, CBW: 3MHz, SCS: 15kHz, Number of PRBs: 15

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Reference channel | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Rank | Correlation matrix and antenna configuration | Reference value | |
|  |  |  |  |  |  | Fraction of maximum throughput (%) | SNR (dB) |
| R.PDSCH.1-1.1 FDD | 3 / 15 | QPSK, 0.30 | TDLB100-400 | Rank 1 | 2x2, ULA Low | 70 | TBD |
| FFS [2x4, ULA Low] | 70 | TBD |
| R.PDSCH.1-2.1 FDD | 3 / 15 | 16QAM, 0.48 | TDLC300-100 | Rank 1 | 2x2, ULA Low | 70 | TBD |
| FFS [2x4, ULA Low] | 70 | TBA |
| R.PDSCH.1-4.1 FDD | 3 / 15 | 256QAM, 0.82 | TDLA30-10 | Rank 1 | 2x2, ULA Low | 70 | TBD |
| FFS [2x4, ULA Low] | 70 | TBA |
| R.PDSCH.1-3.1 FDD | 3 / 15 | 64QAM, 0.50 | TDLA30-10 | Rank 2 | 2x2, ULA Low | 70 | TBD |
| FFS [2x4, ULA Low] | 70 | TBD |

* Recommended WF
  + Agree on tentative agreement taking into account the outcomes of Issue -1-1-2 (Number of RX antenna) and Issue 1-2-1 (Scope of PDSCH requirements).

#### Issue 1-2-3: Parameters of PDSCH requirement in HST deployments

* Proposals and Observations:
  + **Proposal 3** (Apple): Explore the feasibility of defining PDSCH requirements in HST for the single-tap propagation conditions in B.3.1, including MCS values and parameters such as Dmin, Ds, and f\_d.
  + Observation 2 (Apple): For the frequency bands in consideration in this work item, HST-972 seems too high of a doppler spread when considering a maximum speed of 500 km/h.
  + **Proposal 4** (Apple): For PDSCH requirements for the single-tap propagation HST consider instead to use HST-750, or even define a new scenario with a lower doppler spread.
  + Observation 9 (Nokia): It is likely that UEs with <5MHz CBW support only will be seen in actual deployment, hence requirements for HST scenario(s) are relevant and requested by rail operators. Using existing HST tests from TS38.101-4 as reference is a good starting point.
  + **Proposal 8** (Nokia): Define PDSCH requirements for HST scenario based on tests 1-6 from TS38.101-4 tables 5.2.2.1.1-3 and 5.2.2.3.1-3 as reference with the following parameters: Dmin=2m, Ds=300m, fd=471Hz, *v*=500km/h.
  + **Proposal 4** (Samsung): Introduce HST single tap propagation condition for PDSCH requirements
  + **Proposal 5** (Ericsson)**:** Define PDSCH demodulation requirements with HST-DPS propagation condition by reusing TS 38.101-4 5.2.2.1.10 with the following modification.
    - CBW=3MHz (15PRB)
    - Reuse the same Dmin, Ds, and f\_d values as specified in TS38.101-4 Table B.3.3-1
  + **Proposal 8** (Huawei): Use DPS for PDSCH requirements definition.
* Candidate options:
  + *Tentative agreement*: Define requirements with the following parameters.
    - Duplex: FDD, CBW: 3MHz, SCS: 15kHz, Number of PRBs: 15
  + Option 1 [Nokia]: Define PDSCH requirements for HST scenario based on tests 1-6 from TS38.101-4 tables 5.2.2.1.1-3 and 5.2.2.3.1-3 as reference.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Reference channel | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Correlation matrix and antenna configuration | Reference value | |
|  |  |  |  |  | Fraction of maximum throughput (%) | SNR (dB) |
| R.PDSCH.1-8.2 FDD | 10 / 15 | 64QAM, 0.43 | [HST-417] | 1x2 | 70 | TBA |
| R.PDSCH.1-8.2 FDD | 10 / 15 | 64QAM, 0.43 | [HST-417] | 1x4 | 70 | TBA |

* + Option 2 [Ericsson]: Define PDSCH demodulation requirements with HST-DPS propagation condition by reusing TS 38.101-4 5.2.2.1.10

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Reference channel | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition | Number of active PDSCH TCI states | Correlation matrix and antenna configuration | Reference value | |
| Fraction of maximum throughput (%) | SNR (dB) |
| R.PDSCH.1-8.4 FDD | 10 / 15 | 64QAM, 0.43 | HST-DPS | 1 | 2x2 | 70 | TBA |
| R.PDSCH.1-8.4 FDD | 10 / 15 | 64QAM, 0.43 | HST-DPS | 2 | 2x2 | 70 | TBA |

* + Other options are not precluded.
* Recommended WF
  + Discuss propagation HST Propagation conditions in General sub-topic.
  + Follow HST conditions agreed in in the Issue 1-2-3 (HST propagation conditions).

#### Issue 1-2-4: SDR requirements

* Proposals and Observations:
  + Observation 7 (Nokia): As requirements already exists for SDR, including 3MHz into existing requirement definition can be done by extending the existing table to include 3MHz CBW.
  + **Proposal 6** (Nokia): Extend the existing SDR requirements section to include 3MHz CBW.
  + **Proposal 4** (Ericsson): Apply SDR tests for 3MHz CBW. Update TS 38.101-4 Tables 5.5A-1 and 5.5A-4 to support 3MHz CBW.
  + **Proposal 2** (MediaTek): Update TS 38.101-4 Tables 5.5A-1 and 5.5A-4 to support less than 5MHz:
    - Add “2/AL2 for 15 kHz / 3 MHz” in the field of “Number of PDCCH candidates and aggregation levels” in Tables 5.5A-1
    - Add number of PRBs for 15 kHz / 3 MHz as 15 in Tables 5.5A-4
* Candidate options / tentative agreements:
  + Apply SDR tests for 3MHz CBW. Update TS 38.101-4 Tables 5.5A-1 and 5.5A-4 to support 3MHz CBW
* Recommended WF
  + Discuss whether tentative agreement is ageable during the meeting.
  + Further check the PDCCH configuration.

#### Issue 1-2-5: PDCCH AL for PDSCH requirements (test setup)

* Proposals and Observations:
  + **Proposal 2** (Ericsson): Revisit PDCCH AL configuration to fit to 3MHz CBW for PDSCH demodulation requirements with 3MHz CBW. Possible PDCCH configuration is to set AL2 without puncturing.
* Recommended WF
  + Further check and discuss the proposals during the meeting.

### Sub-topic 1-3: PDCCH requirements

*Sub-topic description:*

In this sub-topic the proposals related to the PDCCH requirements for less than 5Mhz CBW are summarised.

A general WF for PDCCH requirements from RAN4#108bis:

|  |
| --- |
| **Issue 1-2-1: Introduction of new requirements**  **Way forward:**  FFS, whether new PDCCH demodulation performance requirements needs to be introduced in less than 5 MHz CBW:   * Consider only 15KHz SCS, FDD, 2Rx, FFS for 4Rx * Option1: Don’t define PDCCH requirements for channel bandwidth less than 5MHz * Non punctured PDCCH:   + Option 2: Define (non-punctured) PDCCH demodulation requirements with 15PRBs, 3MHz CBW, for UE supporting NR\_FR1\_lessthan\_5MHz\_BW:     - 12 PRB CORESET     - 2 symbols, AL2, DCI 1\_0 (35 bits for 15 PRBs)   + Option 3: Define (non-punctured) PDCCH demodulation requirements with 24 PRB PDCCH, for 5 MHz CBW with AL 4. * Punctured PDCCH:   + FFS, how to address the testability issue, i.e., no ACK/NACK for the SIB1 scheduled by PDCCH in CORESET#0.   + Option 4: If the testability issue can be resolved than consider PDCCH demodulation requirements with punctured PDCCH for CORESET#0 (FFS, testing punctured PDCCH mapped to USS in CORESET#0)     - * with 3 symbols AL 8 PDCCH with 3 MHz CBW, interleaved       * Other options are not precluded |

#### Issue 1-3-1: Requirements for non-punctured PDCCH

* Proposals and Observations:
  + **Proposal 6** (Apple)**:** Via applicability rules, determine that only UEs only supporting less than 5MHz operation should be subject to new PDCCH requirements.
  + **Proposal 7** (Apple): RAN4 to define non-punctured PDCCH demodulation requirements with 15PRBs, 3MHz CBW, for UE supporting only NR\_FR1\_lessthan\_5MHz\_BW: 12 PRB CORESET + 2 symbols, AL2, DCI 1\_0 (35 bits for 15 PRBs) as proposed during RAN4#108bis.
  + Observation 10 (Nokia): To ensure UEs supporting only <5MHz CBW are tested, PDCCH requirements need to be defined for 3MHz CBW.
  + **Proposal 9** (Nokia): RAN4 shall define (non-punctured) PDCCH demodulation requirements with 15PRBs, 3MHz CBW, for UE supporting NR\_FR1\_lessthan\_5MHz\_BW with the following configuration: 12 PRB CORESET, 2 symbols, AL2, DCI 1\_0 (35 bits for 15 PRBs). Further discuss if additionally, to introduce PDCCH requirements for 5MHz CBW.
  + **Proposal 11** (Nokia): Consider TDLA30-10 for 1Tx, TDLC300-100 for 2Tx when defining non-HST PDCCH requirements.
  + **Proposal 4** (ZTE): For non-punctured PDCCH requirements, propose to don’t define requirements for less than 5MHz.
  + **Proposal 7** (Ericsson)**:** Define non-punctured PDCCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.
    - 15PRBs, 2 symbols, interleaved, AL2, DCI 1\_0 (35 bits for 15 PRBs), TDLA30-10, 1Tx, 2Rx.
  + Observation 2 (Ericsson): Degradation due to the puncturing is about 4.0dB.
  + **Proposal 6** (Huawei): RAN4 define non-punctured PDCCH requirements, don’t define the PDCCH requirements with CORESET#0
  + **Proposal 7** (Huawei): For non-punctured PDCCH requirements, use following parameters and requirements:
    - For 2Rx test:
      * Test parameters: Reuse Table 5.3.2.1-1
      * Requirements: Reuse Test 1, 2 and 3 in Table 5.3.2.1.1-1 and Test1 in Table 5.3.2.1.2-1
    - For 4Rx test:
      * Test parameters: Reuse Table 5.3.3.1-1
      * Requirements: Reuse Test 1, 2 and 3 in Table 5.3.3.1.1-1 and Test1 in Table 5.3.3.1.2-1
  + **Proposal 4** (MediaTek): For UE supporting less than 5MHz, define (non-punctured) PDCCH demodulation requirements with 15PRBs, 3MHz CBW:
* Table 3: Minimum performance for PDCCH in less than 5MH

****

* Candidate options / tentative agreements:
  + Option 1 [Apple, Nokia, Ericsson, Huawei, MediaTek]: RAN4 to define non-punctured PDCCH demodulation requirements with 15PRBs, 3MHz CBW, for UE supporting only NR\_FR1\_lessthan\_5MHz\_BW:
    - Option 1-a [Nokia]: Reference from TS 38.1-1-4: 2Rx: Test 1 in Table 5.3.2.1.1-1, Test 1 in Table 5.3.2.1.2. 4Rx: Test 1 in Table 5.3.3.1.1-1 and Test 1 in Table 5.3.3.1.2-1.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bandwidth (MHz)** | **CORESET RB** | **CORESET duration** | **Aggregation level** | **Reference Channel** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | |
| **Pm-dsg (%)** | **SNR (dB)** |
| 3 | 12 | 2 | 2 | TBA [DCI 1\_0, 35 bits] | TDLA30-10 | 1x2 Low | 1 | TBA |
| 3 | 12 | 2 | 2 | TBA [DCI 1\_0, 35 bits] | TDLC300-100 | 2x2 Low | 1 | TBA |
| 3 | 12 | 2 | 2 | TBA [DCI 1\_0, 35 bits] | TDLA30-10 | 1x4 Low | 1 | TBA |
| 3 | 12 | 2 | 2 | TBA [DCI 1\_0, 35 bits] | TDLC300-100 | 2x4 Low | 1 | TBA |

* + - Option 1-b [Ericsson, MediaTek]: 15PRBs, 2 symbols, AL2, DCI 1\_0 (35 bits for 15 PRBs), TDLA30-10, 1Tx, 2Rx.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bandwidth (MHz)** | **CORESET RB** | **CORESET duration** | **Aggregation level** | **Reference Channel** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | |
| **Pm-dsg (%)** | **SNR (dB)** |
| 3 | 12 | 2 | 2 | TBA [DCI 1\_0, 35 bits] | TDLA30-10 | 1x2 Low | 1 | TBA |

* + - Option 1-c [Huawei]:
      * For 2Rx test:
        + Test parameters: Reuse Table 5.3.2.1-1
        + Requirements: Reuse Test 1, 2 and 3 in Table 5.3.2.1.1-1 and Test1 in Table 5.3.2.1.2-1
      * For 4Rx test:
        + Test parameters: Reuse Table 5.3.3.1-1
        + Requirements: Reuse Test 1, 2 and 3 in Table 5.3.3.1.1-1 and Test1 in Table 5.3.3.1.2-1
  + Option 2 [ZTE]: For non-punctured PDCCH requirements, propose to don’t define requirements for less than 5MHz.
* Recommended WF
  + Discuss whether Option 1 is agreeable and further discuss parameters in sub-options.
  + FFS for interleaved vs non-interleaved PDCCH.
  + FFS whether PDCCH requirements for 5MHz CBW should be considered. For UE supporting 5MHz CBW and less.

#### Issue 1-3-2: Requirements for punctured PDCCH

* Proposals and Observations:
  + **Proposal 5** (Apple): Do not introduce new requirements for punctured PDCCH with focus on CORESET#0 puncturing since this is not a testable scenario.
  + Observation 11 (Nokia): We found no limitations in RAN1 specifications which prohibits CORESET#0 to be used in USS in addition to CSS, rather it is specifically listed as one option.
  + Observation 12 (Nokia): When the UE receives DCI on CORESET#0 in USS, the UE reports ACK/NACK, e.g., for PDSCH scheduling DCI with CRC scrambled with C-RNTI in USS.
  + Observation 13 (Nokia): There will not be a change in the DCI 1\_0 size, when configured for USS with C-RNTI compared to CSS with SI-RNTI.
  + **Proposal 10** (Nokia): Define requirements with punctured CORESET#0 mapped to USS. Use the following configuration “with 3 symbols AL 8 PDCCH with 3 MHz CBW, interleaved”.
  + Observation1 (Samsung): CORESET#0 can be configured both CSS and USS
  + **Proposal 5** (Samsung): Introduce PDCCH requirements with punctured PRB
  + Proposal 5 (ZTE). For punctured PDCCH requirement, if If RAN4 can resolve the test ability issue for PDCCH in CORESET#0, RAN4 should consider define PDCCH requirements.
  + Observation 1 (Ericsson): CORESET#0 can be used for PDCCH transmitted in UE-specific search space.
  + **Proposal 6** (Ericsson)**:** Define punctured PDCCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.
    - 15PRBs, 3 symbols, non-interleaved, AL4, DCI 1\_0 (35 bits for 15 PRBs), TDLC300-100, 2Tx, 2Rx
    - Use CCEs #4, #5, #6, and #7 to transmit PDCCH with DCI 1\_0.
  + **Proposal 6** (Huawei): RAN4 define non-punctured PDCCH requirements, don’t define the PDCCH requirements with CORESET#0
  + **Proposal 3** (MediaTek): For UE supporting less than 5MHz, do not define PDCCH demodulation requirements for punctured case.
* Candidate options / tentative agreements:
  + Option 1 [Nokia, Samsung, Ericsson]: Define punctured PDCCH demodulation requirements with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW
    - Option 1-a [Nokia]: with 3 symbols AL 8 PDCCH with 3 MHz CBW, interleaved.
    - Option 1-b [Ericsson]: 15PRBs, 3 symbols, non-interleaved, AL4, DCI 1\_0 (35 bits for 15 PRBs); Use CCEs #4, #5, #6, and #7 to transmit PDCCH with DCI 1\_0.
  + Option 2 [ZTE]: Introduce requirements, if testability issue is resolved.
  + Option 2 [Apple, Huawei, MediaTek]: Do not introduce new requirements for punctured PDCCH with focus on CORESET#0 puncturing.
* Recommended WF
  + Discuss the options during the meeting.

#### Issue 1-3-3: PDCCH requirements in HST conditions

* Proposals and Observations:
  + **Proposal 12** (Nokia): Use single-tap propagation conditions for 500km/h HST PDCCH requirement definition.
  + **Proposal 6** (Samsung): Not to introduce HST scenario for PDCCH requirements
  + **Proposal 3** (Huawei): RAN4 only define PDSCH requirements with HST channel and define PDCCH and PBCH requirements with TDL channel.
* Candidate options / tentative agreements:
  + Option 1 [Nokia]: Introduce PDCCH requirements at 3MHz CBW in HST conditions.
  + Option 2 [Samsung, Huawei]: Not to introduce HST scenario for PDCCH requirements.
* Recommended WF
  + Discuss during the meeting.

### Sub-topic 1-4: PBCH requirements

*Sub-topic description:*

In this sub-topic the proposals related to the PBCH requirements for less than 5Mhz CBW are summarised

Agreements and WF from RAN4#108bis:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Issue 1-3-1: Need for new requirement**  **Agreement**   * Define requirements for 12 PRB PBCH with 3 MHz CBW, 15kHz SCS, FDD, unknown SSB/PBCH index * No requirement for known SSB index   **Issue 1-3-2: Test metric**  **Agreement**   * Reuse the Rel-15 PBCH demodulation test metric for punctured PBCH demodulation requirements.   **Issue 1-3-3: PBCH parameters**  **Agreement**   * Use the follwoing parameters as a starting point  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **Duplex** | **Bandwidth (MHz) / Subcarrier spacing (kHz)** | **SSB/PBCH index** | **Propagation condition** | **Antenna configuration and correlation matrix** | **Reference value** | | | **Pm-bch (%)** | **SNR (dB)** | | FDD | 3 / 15 | Unknown | TDLC300-100 | 1 x 2 Low,  [FFS, 1x4] | 1 | TBD |   **Issue 1-3-4: Whether to consider HST conditions for PBCH**  **Way forward**  The issue requires further discussion:   * + Option 1: Not to consider HST conditions for PBCH   + Option 2: Further check the impact of HST conditions on PBCH performance.     - Interested companies are encouraged to bring simulations results at the next meeting. |

#### Issue 1-4-1: Number of RX antenna

* Proposals and Observations:
  + **Proposal 8** (Apple): Do not consider 1x4 antenna configuration scenario for PBCH since this is not a mandatory scenario. Frequency bands considered in this WI only require mandatory support of 2Rx.
  + **Proposal 13** (Nokia): Define PBCH requirements for both 1Tx2Rx and 1Tx4Rx antenna
  + **Proposal 1** (ZTE): Only Considering 2Rx for PBCH demodulation requirements.
  + **Proposal 5** (MadiaTek): Consider only 2Rx case for PBCH requirements in less 5MHz.
* Candidate options / tentative agreements:
  + Option 1 [Nokia]: Consider 4Rx for PBCH requirements
  + Option 2 [Apple, ZTE, MediaTek]: Do not consider 4Rx requirements.
* Recommended WF
  + Check whether options 2 can be agreed based on majority view.

#### Issue 1-4-2: PBCH requirement in HST conditions

* Proposals and Observations:
  + **Proposal 9** (Apple): Do not define additional PBCH requirements under the HST scenario, since this is not a bottleneck situation for the UE or for the network.
  + Observation 14 (Nokia): Our simulation results show 1.9dB to 3.6dB difference in performance between non-HST and HST cases when using 417Hz max doppler (900MHz).
  + **Proposal 14** (Nokia): Define PBCH requirements for HST conditions. Use the following configurations as starting point:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Duplex** | **Bandwidth (MHz) / Subcarrier spacing (kHz)** | **SSB/PBCH index** | **Propagation condition** | **Antenna configuration and correlation matrix** | **Reference value** | |
| **Pm-bch (%)** | **SNR (dB)** |
| FDD | 3 / 15 | Unknown | [HST417] | 1Tx/2Rx Low | 1 | TBD |
| FDD | 3 / 15 | Unknown | [HST417] | 1Tx/4Rx Low | 1 | TBD |

* + **Proposal 7** (Samsung): Not to introduce HST scenario for PBCH requirements.
  + **Proposal 3** (Huawei): RAN4 only define PDSCH requirements with HST channel and define PDCCH and PBCH requirements with TDL channel.
* Candidate options / tentative agreements:
  + Option 1 [Nokia]: Define PBCH requirements in HST conditions.
  + Option 2 [Apple, Samsung, Huawei]: Not to introduce HST scenario for PBCH requirements.
* Recommended WF
  + Discuss Options during the meeting.

### Sub-topic 1-5: CSI reporting requirements

*Sub-topic description:*

In this sub-topic the proposals related to the CSI reporting requirements for less than 5Mhz CBW are summarised

Way Forward from RAN4#108bis:

|  |
| --- |
| **Issue 1-4-1: A need for new requirements**  **Way forward:**  Further discussion is needed whether to introduce new CSI reporting requirements for channel bandwidth less than 5MHz:   * Option1: Define CSI requirements for CBW=3MHz and SCS=15kHz: PMI, CQI and RI. * Option 2: Do not CSI requirements.   FFS, requirements and applicability rules if UE supports only less then 5MHz CBW |

#### Issue 1-5-1: Introduction and scope of the requirements

* Proposals and Observations:
  + **Proposal 10** (Apple): For operation in less than 5MHz, do not define additional CSI reporting requirements for legacy UEs. Only define requirements, via applicability rules, if UE supports only less then 5MHz CBW
  + **Proposal 2** (Huawei): RAN4 focus on demodulation requirements and deprioritize the CSI requirements
  + **Proposal 15** (Nokia): Define CSI requirements for CBW=3MHz and SCS=15kHz: PMI, CQI and RI. Further discuss if applicability rules can be introduced.
  + **Proposal 8** (Samsung): Introduce CSI reporting requirements.
  + **Proposal 6** (ZTE). For CSI requirements, propose to don’t define requirements in less than 5MHz.
* Candidate options / tentative agreements:
  + Option 1 [Nokia, Samsung, Ericsson, MediaTek]: Define CSI requirements for CBW=3MHz and SCS=15kHz.
  + Option 2 [Apple]: Only define CSI requirements, via applicability rules, if UE supports only less then 5MHz CBW.
  + Option 3 [Huawei]: Deprioritize the CSI requirements
  + Option 4 [ZTE]: Don’t define requirements in less than 5MHz
* Recommended WF
  + Discuss whether it is agreeable to define CSI reporting requirements for less than 5MHz CBW
  + FFS for applicability conditions.

#### Issue 1-5-2: CQI reporting

* Candidate options:
  + Option 1 [Nokia]: Use existing RedCap requirements as starting point (Clauses 6.2.2.1.1.4 and 6.2.2.1.2.4)
  + Option 2 [Ericsson, MediaTek]:
    - Static channel
      * Use Table 6.2.2.1.1.1-1 as a starting point
      * 15PRBs, CQI Table 2, 2Tx Rank 2, 2Rx, 2 SNR test points.
      * Reuse the same metric as Rel-15 CQI definition test in static condition.
    - Fading channel condition
      * Use Table 6.2.2.1.2.1-1 as a starting point
      * 15PRBs, CQI Table 2, 2T2R, Rank 1, TDLA30-5, 2 SNR test points
      * Reuse the same metric as Rel-15 CQI reporting test in fading condition
* Recommended WF
  + Discuss options during the meeting.

#### Issue 1-5-3: PMI reporting

* Proposals and Observations:
  + **Proposal 17** (Nokia): For PMI requirements use existing requirements for “Single PMI with 4Tx TypeI-SinglePanel Codebook” as starting point.
  + **Proposal 10** (Ericsson): Define PMI reporting test with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.
    - 15PRB, Single PMI, Type I, MCS13 (16QAM, 0.48), Rank 1, 4 CSI-RS ports, 4Tx XPOL, TDLA30-5, 2Rx.
    - Reuse the same metric as Rel-15 4TX PMI reporting requirements.
  + Proposal 8 (Mediatek): Define PMI reporting test with 15PRBs for UE supporting less than 5MHz
    - Use Table 6.3.2.1.1-1 as a starting point
    - 15PRB, Single PMI, TypeI-SinglePanel, MCS13 (16QAM, 0.48), Rank 1, 4 CSI-RS ports, High XP 4 x 2, TDLA30-5
    - Reuse the same metric as Rel-15 4Tx PMI reporting requirements
* Tentative agreements:
  + Define PMI reporting test with 15PRBs for UE supporting less than 5MHz
    - Use Table 6.3.2.1.1-1 “Single PMI with 4Tx TypeI-SinglePanel Codebook” as a starting point
    - 15PRB, Single PMI, TypeI-SinglePanel, MCS13 (16QAM, 0.48), Rank 1, 4 CSI-RS ports, High XP 4 x 2, TDLA30-5
    - Reuse the same metric as Rel-15 4Tx PMI reporting requirements.
* Recommended WF
  + Discuss whether tentative agreement in agreeable.

#### Issue 1-5-4: RI reporting

* Proposals and Observations:
  + **Proposal 18** (Nokia): For RI requirements use existing requirements for 2Rx and 4Rx as starting point. FSS to down select after initial simulation results are available.
  + **Proposal 11** (Ericsson): Define RI reporting test with 15PRBs for UE supporting NR\_FR1\_lessthan\_5MHz\_BW.
    - 15PRBs, CQI Table 2, SNR=[0dB], 2Tx, low antenna correlation, TDLA30-5, 2Rx, fixed RI=2 vs. follow RI
    - 15PRBs, CQI Table 2, SNR=20dB, 2Tx, low antenna correlation, TDLA30-5, 2Rx, fixed RI=1 vs. follow RI
    - 15PRBs, CQI Table 2, SNR=20dB, 2Tx, high antenna correlation, TDLA30-5, 2Rx, fixed RI=1 vs. follow RI
    - Reuse the same metric as Rel-15 RI reporting requirements.
  + **Proposal 9** (MediaTek): Define RI reporting test with 15PRBs for UE supporting less than 5MHz
    - Use Table 6.4.2.1-1 Test 1 as a starting point
    - 15PRBs, CQI Table 2, SNR=0dB, ULA Low 2x2, TDLA30-5, fixed RI=2 vs. follow RI
    - Reuse the same metric as Rel-15 RI reporting requirements
* Recommended WF
  + Further discuss necessary RI requirements during the metting.

#### Issue 1-5-5: PDCCH parameters for CSI reporting

* Proposals and Observations:
  + **Proposal 12** (Ericsson): Revisit PDCCH AL configuration to fit to 3MHz when RAN4 define CSI reporting requirements with 3MHz CBW. Possible configuration is to set AL2 without puncturing. If necessary, set higher SNR test points especially for RI/CQI tests to ensure low PDCCH BLER.
* Recommended WF
  + Discuss the proposal during the meeting.

# Topic #2: BS Demod

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2318041](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318041.zip) | Nokia, Nokia Shanghai Bell | **Discussion on BS Demodulation on Less than 5 MHz**  Observation 1: For less than 5MHz supporting devices, it is assumed the CP-OFDM will be the default waveform.  **Proposal 1**: RAN4 shall define requirements for PUSCH for less than 5MHz with precoding disabled (CP-OFDM).  Observation 2: For less than 5MHz supporting devices some of these will be operating at cell edge, and as such there would be a desire for low PAPR support with increased coverage, as such implying that precoding may be enabled.  **Proposal 3**: RAN4 shall define requirements for PUSCH for less than 5MHz with precoding enabled (DFT-s-OFDM)  Observation 3: UCI Multiplexing should have little impact on PUSCH performance.  **Proposal 3**: RAN4 shall NOT define requirements for UCI multiplexed on PUSCH for the less than 5MHz work item.  Observation 4: There is little performance difference on PUSCH for less than 5MHz between 12 and 15 PRBs  Observation 5: Some bands will support 12 and 15 PRB, with 12 PRB being the minimum PRB allocation.  **Proposal 4**: RAN4 shall define requirements for PUSCH on Less than 5MHz with 12 PRBs.  Observation 6: Bands other than n100 will only be required to support 15 PRB allocation, as such requirements should also be defined for 15 PRB.  **Proposal 5**: RAN4 shall define requirements for PUSCH on Less than 5MHz with 15 PRBs.  Observation 7: PUSCH with less than 5MHz has demonstratable worse performance in TDLB 100-400 compared to TDLA 30-10 whilst both deployment scenarios are valid in accordance with the WID.  **Proposal 6**: RAN 4 shall define PUSCH requirements for less than 5MHz in both TDLA 30-10 and TDLB 100-400.  Observation 8: In TDLB 100-400 for reasonable performance additional DMRS should be used with position (1+1)  **Proposal 7**: RAN4 shall define PUSCH requirements for less than 5MHz with additional DMRS in position (1+1).  Observation 9: There is no need to define performance requirements based on UL timing adjustment for Less than 5MHz BS Demodulation.  Observation 10: A doppler shift of 815 Hz corresponds to a velocity of 500 km/h in BS Demod.  **Proposal 8**: If adopted, RAN4 shall use a maximum doppler of 815 Hz for a HST scenario.  **~~Proposal 9~~**~~: RAN4 shall use PUCCH formats 1,3 and 4 to initially agree the impact from moving to a bandwidth less than 5 MHz.~~  **Proposal 10**: RAN4 shall enable Frequency Hopping for PUCCH requirements definition.  **Proposal 11**: RAN4 shall use TDLC 300-100 Low channels to define requirements for PUCCH with Less than 5MHz.  Observation 11: PUCCH performance may decrease at with propagation conditions worse than TDLC 300-100.  **Proposal 12**: RAN4 to discuss regarding further degraded propagation conditions for PUCCH performance requirements beyond TDLC 300-100.  Observation 12: It may be that only Format 2 has impacted performance for less than 5MHz allocation  **Proposal 13**: An Applicability rule shall be introduced into TS 38.141 to enable a base station declaring to support less than 5MHz to conduct a new test with only Format 2 for PUCCH, wording FFS.  **Proposal 14**: Add a statement into clause 8.1.2.3.3 of TS 38.141 with the following wording [For BS supporting less than 5MHz carrier bandwidth only test requirements relating to short RACH preamble formats with 15kHz SCS, and long PRACH formats with 1.25kHz SCS shall apply] |
| [R4-2318042](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2318042.zip) | Nokia, Nokia Shanghai Bell | **Supporting Simulations for BS Demodulation on Less than 5 MHz**  In the following contribution we will provide simulation results Nokia’s view on the background and scope for RAN4 to specify BS demodulation requirements related to less than 5MHz CBW. |
| [R4-2319315](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319315.zip) | Ericsson | **Discussion on NR less than 5MHz BS demodulation requirements**  Observation 1 : 3MHz channel bandwidth is optional UE capability on most of supporting bands.  Observation 2 : BS should support mandatory UE channel bandwidth on certain band at the first, and optional UE channel bandwidth support could depend on manufactory declaration.  **Proposal 1**: Introduce new BS manufactory declaration for 3MHz.  Observation 3: A BS would not likely only support n106 which only support 3MHz channel bandwidth.  **Proposal 2**: Only consider limited test cases for 3MHz channel bandwidth tests.  **PUSCH:**  Observation 4 : The PUSCH performance difference is very small between 3MHz and 5MHz in all normal PUSCH requirements.  **Proposal 4**: Only introduce normal PUSCH demodulation requirement with CP-OFDM for 3MHz with following configuration:   * Number of PRBs: 12 * MCS: MCS16 or MCS20 * 1T2R, 1 layer   **PUCCH:**  Observation 5: There is obvious performance difference on PUCCH format 2 for UCI BLER test case between 5MHz and 3MHz.  Proposal 5 : Introduce new PUCCH format 2 for UCI BLER requirements for 3MHz.  **PRACH:**  Proposal 6 : No need to add applicability rule or note for long RACH sequences in less than 5 MHz bandwidths. |
| [R4-2319316](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319316.zip) | Ericsson | **Simualtion results for NR less than 5MHz BS demodulation requirements**  This contribution delivers some trial simulation results to compare performance difference between 5MHz and 3MHz on PUSCH and PUCCH. |
| [R4-2319543](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319543.zip) | ZTE Corporation | **Discussion on BS demodulation performance requirements for less than 5MHz**  Observation 1. There is no significant performance difference between 25PRB and 12PRB for PUSCH.  **Proposal 1**. If RAN4 defines PUSCH requirements for 3MHz, propose to introduce limited test cases.  Observation 2. The flexibility of PUCCH configurations in frequency domain for 3MHz can be supported with no significant impact.  **Proposal 2**. From RAN4 demodulation perspective, RAN4 could consider defining 3MHz requirements for PUCCH in 15kHz . |
| [R4-2319544](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319544.zip) | ZTE Corporation | **Simulation results for BS demodulation performance for less than 5MHz.**  This contribution contains initial simulation results for the <5MHz WID [1]. The results are provided to aid in determining where new requirements can/should be introduced. |
| [R4-2319844](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2319844.zip) | Samsung | **Discussion and initial results for BS demodulation requirement for less than 5MHz**  **Proposal 1**: RAN4 only define PUSCH requirements with CP-OFDM waveform and DFT-s-OFDM for 3MHz CBWs if BS supporting only less than 5MHz CBW  **Proposal 2**: RAN4 define PUSCH requirements with CP-OFDM waveform and DFT-s-OFDM for 3MHz CBWs if BS supporting multiple CBWs including less than 5MHz  **Proposal 3**: UL timing adjustment and PUSCH requirements with related with UE speed 500km/h could be introduced.  **Proposal 4**: If agreed to introduce PUCCH requirements with 3MHz, only limited test cases of PUCCH requirement are considered.  **Proposal 5**: If no PUCCH requirements with 3MHz introduced, the test configuration with 5MHz should be modified to support PUCCH requirement with 3MHz test, where the value of first PRB after frequency hopping should be updated with a note as following   |  |  | | --- | --- | | First PRB after frequency hopping1 | The largest PRB index – (Number of PRBs – 1) | | Note1:   * The largest PRB index is 11 for 3MHz test at n100 * The largest PRB index is 14 for 3MHz test except for n100 * The largest PRB index is 24 for 5MHz test | |   Observation 1: Existing long PRACH formats with 1.25KHz SCS with sequence length LRA=839, and long PRACH formats with 15KHz SCS with sequence length LRA=139 can support 3MHz channel bandwidth.  Observation 2: Existing PRACH formats with 15KHz SCS with sequence length LRA=1151, cannot apply for 3MHz channel bandwidth.  Observation 3: A note is added to indicate PRACH formats and configurations are not fitting into transmission BW are not applicable in RAN1 agreement  **Proposal 6**: FFS to add a note indicate the existing short PRACH formats with 15KHz SCS with sequence length LRA=1151 cannot apply for 3MHz channel bandwidth  Proposal 7: TDL channel model could be considered for specifying BS demodulation requirement. Single tap can be considered for specifying BS modulation requirement under HST condition.  Proposal 8: Existing Doppler value as 100Hz can be considered for PUSCH requirement with normal UE speed  Proposal 9: The maximum Doppler is 815Hz assuming UE with 500km/h speed if HST single tap is introduced. The existing Ds (Ds=700m) and Dmin (Dmin=100m) in Rel-16 FR1 NR HST deployment can be reused as a starting point to derive the Doppler shift trajectory.  Proposal 10: Specify BS demodulation requirement with 1T2Rx only  Proposal 11: Specify PUSCH requirement with DMRS mapping type A  Proposal 12: Specify PUSCH requirement with 2 DMRS symbols for normal UE speed and Specify PUSCH with 3DMRS if HST single tap is introduced  Proposal 13: Specify PUSCH requirement with CP-OFDM and DFT-s-OFDM waveform for normal UE speed  Proposal 14: Specify PUSCH requirement with CP-OFDM for HST if HST single tap is introduced  Proposal 15: The following MCS could be considered as a starting point for specifying PUSCH requirement   * MCS 2, MCS 16 and MCS 20 * FFS on down selection one of MCS for requirement   Proposal 16: Reusing existing PUSCH test parameters for specifying PUSCH requirement with 3MHz under normal UE speed  Table 1: Test parameters for PUSCH requirement with normal UE speed   |  |  |  | | --- | --- | --- | | Parameter | | Value | | Transform precoding | | Disabled and Enabled | | HARQ | Maximum number of HARQ transmissions | 4 | |  | RV sequence | 0, 2, 3, 1 | | DM-RS | DM-RS configuration type | 1 | |  | DM-RS duration | single-symbol DM-RS | |  | Additional DM-RS position | [Pos1] | |  | Number of DM-RS CDM group(s) without data | 2 | |  | Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB | |  | DM-RS port | [0] | |  | DM-RS sequence generation | NID0=0, nSCID =0 | | Time domain | PUSCH mapping type | A | | resource | Start symbol | 0 | | assignment | Allocation length | 14 | | Frequency domain resource | RB assignment | Full applicable test bandwidth | | assignment | Frequency hopping | Disabled | | Code block group based PUSCH transmission | | Disabled |   Table 2: Test parameters for PUSCH requirement with UE 500km/h speed if introduced   |  |  |  | | --- | --- | --- | | Parameter | | Value | | Transform precoding | | Disabled | | HARQ | Maximum number of HARQ transmissions | 4 | |  | RV sequence | 0, 2, 3, 1 | | DM-RS | DM-RS configuration type | 1 | |  | DM-RS duration | single-symbol DM-RS | |  | Additional DM-RS position | [Pos2] | |  | Number of DM-RS CDM group(s) without data | 2 | |  | Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB | |  | DM-RS port | [0] | |  | DM-RS sequence generation | NID0=0, nSCID =0 | | Time domain | PUSCH mapping type | A | | resource | Start symbol | 0 | | assignment | Allocation length | 14 | | Frequency domain resource | RB assignment | Full applicable test bandwidth | | assignment | Frequency hopping | Disabled | | Code block group based PUSCH transmission | | Disabled |   Proposal 17: Introduce PUCCH requirement with 3MHz under 1Tx2Rx antenna configuration.  Proposal 18: Reusing the existing PUCCH test parameters for specifying PUCCH requirement with 3MHz  Table 3: Test parameters of PUCCH format 0   |  |  | | --- | --- | | Parameter | Test | | Number of UCI information bits | 1 | | Number of PRBs | 1 | | First PRB prior to frequency hopping | 0 | | Intra-slot frequency hopping | N/A for 1 symbol Enabled for 2 symbols | | First PRB after frequency hopping | The largest PRB index – (Number of PRBs - 1) | | Group and sequence hopping | neither | | Hopping ID | 0 | | Initial cyclic shift | 0 | | First symbol | 13 for 1 symbol  12 for 2 symbols | | Test metric | DTX to ACK probability  ACK missed detection probability |   Table 4: Test parameters of PUCCH format 1   |  |  | | --- | --- | | Parameter | Test | | Number of information bits | 2 | | Number of PRBs | 1 | | Number of symbols | 14 | | First PRB prior to frequency hopping | 0 | | Intra-slot frequency hopping | enabled | | First PRB after frequency hopping | The largest PRB index – (nrofPRBs – 1) | | Group and sequence hopping | neither | | Hopping ID | 0 | | Initial cyclic shift | 0 | | First symbol | 0 | | Index of orthogonal cover code (*timeDomainOCC*) | 0 | | Test metric | NACK to ACK probability  ACK missed detection probability |   Table 5: Test parameters of PUCCH format 2   |  |  | | --- | --- | | Parameter | Value | | Modulation order | QSPK | | Starting RB location | 0 | | Intra-slot frequency hopping | N/A | | Number of PRBs | 4 | | Number of symbols | 1 | | The number of UCI information bits | 4 | | First symbol | 13 | | DM-RS sequence generation | *NID*0=0 | | Test metric | DTX to ACK probability  ACK missed detection probability |   Table 6: Test parameters of PUCCH format 2   |  |  | | --- | --- | | Parameter | Value | | Modulation order | QSPK | | First PRB prior to frequency hopping | 0 | | Intra-slot frequency hopping | enabled | | Frist PRB after frequency hopping | The largest PRB index – (Number of PRBs – 1) | | Number of PRBs | 9 | | Number of symbols | 2 | | The number of UCI information bits | 22 | | First symbol | 12 | | DM-RS sequence generation | *NID*0=0 | | Test metric | BLER |   Table 7: Test parameters of PUCCH format 3   |  |  |  | | --- | --- | --- | | Parameter | Test 1 | Test 2 | | Modulation order | QPSK | | | First PRB prior to frequency hopping | 0 | | | Intra-slot frequency hopping | enabled | | | First PRB after frequency hopping | The largest PRB index – (Number of PRBs – 1) | | | Group and sequence hopping | neither | | | Hopping ID | 0 | | | Number of PRBs | 1 | 3 | | Number of symbols | 14 | 4 | | The number of UCI information bits | 16 | 16 | | First symbol | 0 | 0 | | Test metric | BLER | |   Table 8: Test parameters of PUCCH format 4   |  |  | | --- | --- | | Parameter | Value | | Modulation order | QPSK | | First PRB prior to frequency hopping | 0 | | Number of PRBs | 1 | | Intra-slot frequency hopping | enabled | | First PRB after frequency hopping | The largest PRB index – (Number of PRBs – 1) | | Group and sequence hopping | neither | | Hopping ID | 0 | | Number of symbols | 14 | | The number of UCI information bits | 22 | | First symbol | 0 | | Length of the orthogonal cover code | n2 | | Index of the orthogonal cover code | n0 | | Test metric | BLER |   Observation 4: Similar performance can be achieved with 3MHz and 5MHz CBW |
| [R4-2320199](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_109/Docs/R4-2320199.zip) | Huawei,HiSilicon | **Discussions on BS requirements for dedicated sprectrum less than 5MHz for FR1**  Observation1: It’s very rare for a BS to only support 3MHz bandwidth  **Proposal 1**: Don’t define PUSCH requirements with 3MHz bandwidth  Observation2: For cases with intra-slot frequency hopping disabled, existing PUCCH requirements are same for 3MHz and larger bandwidth.  Observation3: For cases with intra-slot frequency hopping enabled, the frequency diversity gain is only valid for 2Rx, for large number of Rx, e.g. 8Rx, the frequency diversity gain is replaced by spatial diversity gain, and the performance for 3MHz and 5MHz are almost same.  Observation 4: Most Base stations have large number of Rx, which means 3MHz and 5MHz have same performance with intra-slot frequency hopping enabled.  **Proposal 2**: Don’t define PUCCH requirements with 3MHz bandwidth.  Proposal 3: Revise existing the applicability of performance requirements for PRACH with LRA =1151 and LRA =571 for different bandwidth to:   * Unless otherwise stated, for the subcarrier spacing to be tested, the test requirements shall apply only for anyone channel bandwidth not less than 20MHz declared to be supported (see D.14 in table 4.6-1). |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1: General

*Sub-topic description:*

In this sub-topic the proposals related to the PUSCH requirements for less than 5Mhz CBW are summarized.

#### Issue 1-1-1: Manufacturer declaration for 3MHz CBW

* Proposals and Observations:
  + Observation 1 (Ericsson): 3MHz channel bandwidth is optional UE capability on most of supporting bands.
  + Observation 2 (Ericsson): BS should support mandatory UE channel bandwidth on certain band at the first, and optional UE channel bandwidth support could depend on manufactory declaration.
  + **Proposal 1** (Ericsson): Introduce new BS manufactory declaration for 3MHz.
* Recommended WF
  + Discuss proposal during the meeting.

### Sub-topic 2-2: PUSCH requirements

*Sub-topic description:*

In this sub-topic the proposals related to the PUSCH requirements for less than 5Mhz CBW are summarized.

WF from RAN4#108bis:

|  |
| --- |
| **Issue 2-1-1: Introduction of requirements**  **Way forward:**   * Further discuss the scope of PUSCH requirements:   + FFS, whether to introduce full set of Rel-15 requirements for PUSCH for BS supporting only less than 5 MHz CBW, e.g.,     - PUSCH with precoding disabled.     - PUSCH with precoding enabled.     - UCI multiplexed on PUSCH.   + FFS, the limited set of requirements for PUSCH for BS supporting multiple CBWs (i.e., less and more than 5MHz CBW)   + FFS, on applicability rules for PUSCH depending on the supported BW. |

#### Issue 2-2-1: A need for PUSCH requirements with less than 5MHz CBW

* Proposals and Observations:
  + **Proposal 4/5** (Nokia): RAN4 shall define requirements for PUSCH on Less than 5MHz with 12/15 PRBs.
  + Observation 1 (ZTE). There is no significant performance difference between 25PRB and 12PRB for PUSCH.
  + **Proposal 1** (ZTE). If RAN4 defines PUSCH requirements for 3MHz, propose to introduce limited test cases.
  + Observation 3 (Ericsson): A BS would not likely only support n106 which only support 3MHz channel bandwidth.
  + **Proposal** **2** (Ericsson): Only consider limited test cases for 3MHz channel bandwidth tests.
  + Observation1 (Huawei): It’s very rare for a BS to only support 3MHz bandwidth
  + **Proposal 1** (Huawei): Don’t define PUSCH requirements with 3MHz bandwidth
* Candidate options / tentative agreements:
  + Option 1 [Nokia, ZTE, Ericsson, Samsung]: Introduce limited set of PUSCH requirements for less than 5MHz.
  + Option 2 [Huawei]: Don’t define PUSCH requirements with 3MHz bandwidth.
* Recommended WF
  + Check if Option 1 can be agreed.
    - FFS the limited set/scope of requirements (following issues).

#### Issue 2-2-2: Testing of PUSCH with/without precoding enabled (CP-OFDM / DFT-s-OFDM):

* Proposals and Observations:
  + Observation 1 (Nokia): For less than 5MHz supporting devices, it is assumed the CP-OFDM will be the default waveform.
  + **Proposal 1** (Nokia): RAN4 shall define requirements for PUSCH for less than 5MHz with precoding disabled (CP-OFDM).
  + Observation 2 (Nokia): For less than 5MHz supporting devices some of these will be operating at cell edge, and as such there would be a desire for low PAPR support with increased coverage, as such implying that precoding may be enabled.
  + **Proposal 3** (Nokia): RAN4 shall define requirements for PUSCH for less than 5MHz with precoding enabled (DFT-s-OFDM)
  + **Proposal 4** (Ericsson): Only introduce normal PUSCH demodulation requirement with CP-OFDM...
  + **Proposal 1** (Samsung): RAN4 only define PUSCH requirements with CP-OFDM waveform and DFT-s-OFDM for 3MHz CBWs if BS supporting only less than 5MHz CBW
  + **Proposal 2** (Samsung): RAN4 define PUSCH requirements with CP-OFDM waveform and DFT-s-OFDM for 3MHz CBWs if BS supporting multiple CBWs including less than 5MHz
  + **Proposal 13** (Samsung): Specify PUSCH requirement with CP-OFDM and DFT-s-OFDM waveform for normal UE speed
  + **Proposal 14** (Samsung): Specify PUSCH requirement with CP-OFDM for HST if HST single tap is introduced.
* Candidate options / tentative agreements:
  + Option 1 [Nokia]: Define requirements for PUSCH for less than 5MHz with precoding with precoding enabled (DFT-s-OFDM) and disabled (CP-OFDM).
  + Option 2 [Samsung]: Define requirements for PUSCH for less than 5MHz with precoding with precoding enabled (DFT-s-OFDM) and disabled (CP-OFDM) in normal UE speed and only with CP-OFDM for HST.
  + Option 3 [Ericsson]: Only introduce normal PUSCH demodulation requirement with CP-OFDM.
* Recommended WF
  + Discuss options during the meeting.

#### Issue 2-2-3: UCI multiplexed on PUSCH

* Proposals and Observations:
  + Observation 3 (Nokia): UCI Multiplexing should have little impact on PUSCH performance.
  + **Proposal 3** (Nokia): RAN4 shall NOT define requirements for UCI multiplexed on PUSCH for the less than 5MHz work item.
* Recommended WF
  + Check whether proposal can be agreed.

#### Issue 2-2-4: PUSCH requirement parameters in normal conditions

* Proposals and Observations:
  + Observation 4 (Nokia): There is little performance difference on PUSCH for less than 5MHz between 12 and 15 PRBs
  + Observation 5 (Nokia): Some bands will support 12 and 15 PRB, with 12 PRB being the minimum PRB allocation.
  + **Proposal 4** (Nokia): RAN4 shall define requirements for PUSCH on Less than 5MHz with 12 PRBs.
  + Observation 6: Bands other than n100 will only be required to support 15 PRB allocation, as such requirements should also be defined for 15 PRB.
  + **Proposal 5** (Nokia): RAN4 shall define requirements for PUSCH on Less than 5MHz with 15 PRBs.
  + Observation 8 (Nokia): In TDLB 100-400 for reasonable performance additional DMRS should be used with position (1+1)
  + **Proposal 7** (Nokia): RAN4 shall define PUSCH requirements for less than 5MHz with additional DMRS in position (1+1).
  + Observation 4 (Ericsson): The PUSCH performance difference is very small between 3MHz and 5MHz in all normal PUSCH requirements.
  + **Proposal 4** (Ericsson): Only introduce normal PUSCH demodulation requirement with CP-OFDM for 3MHz with following configuration:
    - Number of PRBs: 12
    - MCS: MCS16 or MCS20
    - 1T2R, 1 layer
  + **Proposal 10** (Samsung): Specify BS demodulation requirement with 1T2Rx only
  + **Proposal 11** (Samsung): Specify PUSCH requirement with DMRS mapping type A
  + **Proposal 12** (Samsung): Specify PUSCH requirement with 2 DMRS symbols for normal UE speed and Specify PUSCH with 3DMRS if HST single tap is introduced
  + **Proposal 15** (Samsung): The following MCS could be considered as a starting point for specifying PUSCH requirement
    - MCS 2, MCS 16 and MCS 20
    - FFS on down selection one of MCS for requirement
  + **Proposal 16** (Samsung): Reusing existing PUSCH test parameters for specifying PUSCH requirement with 3MHz under normal UE speed

Table 1: Test parameters for PUSCH requirement with normal UE speed

|  |  |  |
| --- | --- | --- |
| Parameter | | Value |
| Transform precoding | | Disabled and Enabled |
| HARQ | Maximum number of HARQ transmissions | 4 |
|  | RV sequence | 0, 2, 3, 1 |
| DM-RS | DM-RS configuration type | 1 |
|  | DM-RS duration | single-symbol DM-RS |
|  | Additional DM-RS position | [Pos1] |
|  | Number of DM-RS CDM group(s) without data | 2 |
|  | Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB |
|  | DM-RS port | [0] |
|  | DM-RS sequence generation | NID0=0, nSCID =0 |
| Time domain | PUSCH mapping type | A |
| resource | Start symbol | 0 |
| assignment | Allocation length | 14 |
| Frequency domain resource | RB assignment | Full applicable test bandwidth |
| assignment | Frequency hopping | Disabled |
| Code block group based PUSCH transmission | | Disabled |

* Candidate options / tentative agreements:
  + Option 1 [Nokia]:
    - Number of PRBs: 12, 15
    - MCS: MCS16
    - DMRS: (1+1) for TDLB 100-400
  + Option 2 [Ericsson]:
    - Number of PRBs: 12
    - MCS: MCS16 or MCS20
    - 1T2R, 1 layer
  + Option 3 [Samsung]:
    - MCS: MCS 2, MCS 16 and MCS 20, FFS on downselection
    - 1T2Rx only
    - DMRS: (1+1), mapping type A
* Recommended WF
  + Further discuss the parameters for the requirements.

#### Issue 2-2-5: PUSCH propagation conditions (non-HST)

* Proposals and Observations:
  + Observation 7 (Nokia): PUSCH with less than 5MHz has demonstratable worse performance in TDLB 100-400 compared to TDLA 30-10 whilst both deployment scenarios are valid in accordance with the WID.
  + **Proposal 6** (Nokia): RAN 4 shall define PUSCH requirements for less than 5MHz in both TDLA 30-10 and TDLB 100-400.
  + **Proposal 7** (Samsung): TDL channel model could be considered for specifying BS demodulation requirement.
  + **Proposal 8** (Samsung): Existing Doppler value as 100Hz can be considered for PUSCH requirement with normal UE speed
* Candidate options / tentative agreements:
  + Option 1 [Nokia]: TDLB 100-400 and TDLA 30-10
  + Option 2 [Samsung]: Doppler value as 100Hz
* Recommended WF
  + Discuss the options during the meeting.

#### Issue 2-2-6: PUSCH requirements in HST conditions

* Proposals and Observations:
  + Observation 9 (Nokia): There is no need to define performance requirements based on UL timing adjustment for Less than 5MHz BS Demodulation.
  + **Proposal 3** (Samsung): UL timing adjustment and PUSCH requirements with related with UE speed 500km/h could be introduced.
* Candidate options / tentative agreements:
  + Option 1 [Nokia]: Introduce PUSCH requirements without UL timing adjustment at UE speed 500km/h
  + Option 2 [Samsung]: UL timing adjustment and PUSCH requirements with related with UE speed 500km/h
* Recommended WF
  + Further discuss a need for HST requirements with less than 5 MHz CBW.

#### Issue 2-2-7: PUSCH parameters in HST conditions

* Proposals and Observations:
  + Proposal 12 (Samsung): Specify PUSCH with 3DMRS if HST single tap is introduced.
  + Proposal 14 (Samsung): Specify PUSCH requirement with CP-OFDM for HST if HST single tap is introduced.
* Table 2: Test parameters for PUSCH requirement with UE 500km/h speed if introduced

|  |  |  |
| --- | --- | --- |
| Parameter | | Value |
| Transform precoding | | Disabled |
| HARQ | Maximum number of HARQ transmissions | 4 |
|  | RV sequence | 0, 2, 3, 1 |
| DM-RS | DM-RS configuration type | 1 |
|  | DM-RS duration | single-symbol DM-RS |
|  | Additional DM-RS position | [Pos2] |
|  | Number of DM-RS CDM group(s) without data | 2 |
|  | Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB |
|  | DM-RS port | [0] |
|  | DM-RS sequence generation | NID0=0, nSCID =0 |
| Time domain | PUSCH mapping type | A |
| resource | Start symbol | 0 |
| assignment | Allocation length | 14 |
| Frequency domain resource | RB assignment | Full applicable test bandwidth |
| assignment | Frequency hopping | Disabled |
| Code block group based PUSCH transmission | | Disabled |

* Recommended WF
  + Further discuss the requirement parameters in HST conditions during the meeting.

#### Issue 2-2-8: HST propagation conditions

* Proposals and Observations:
  + Observation 10 (Nokia): A doppler shift of 815 Hz corresponds to a velocity of 500 km/h in BS Demod.
  + **Proposal 8** (Nokia): If adopted, RAN4 shall use a maximum doppler of 815 Hz for a HST scenario.
  + **Proposal 7** (Samsung): Single tap can be considered for specifying BS modulation requirement under HST condition.
  + **Proposal 9** (Samsung): The maximum Doppler is 815Hz assuming UE with 500km/h speed if HST single tap is introduced. The existing Ds (Ds=700m) and Dmin (Dmin=100m) in Rel-16 FR1 NR HST deployment can be reused as a starting point to derive the Doppler shift trajectory.
* Candidate options / tentative agreements:
  + The existing High Speed Train condition (Clause G.3 in TS 38.104) at 500km/h can be reused as a starting point
    - Ds (Ds=700m) and Dmin (Dmin=100m)
    - Maximum Doppler shift f\_d = 815Hz
* Recommended WF
  + Further check the proposed tentative agreement.

### Sub-topic 2-3: PUCCH requirements

*Sub-topic description:*

In this sub-topic the proposals related to the PUCCH requirements for less than 5Mhz CBW are summarized.

WF from RAN4#108bis:

|  |
| --- |
| **Issue 2-2-1: Performance evaluation/simulations**  **Agreement:**   * Evaluate PUCCH demodulation performance for 3MHz with 15kHz SCS ahead of defining requirements:   + Enable Frequency Hopping for PUCCH   + Number of PRBs:     - 15, 12 for 3MHz CBW     - 25 as a baseline for 5MHz CBW   + Channel: TDLC300-100   + Antenna configuration: 1T2R as a starting point   + Use the following PUCCH Formats and paramters as a astarting point :     - Format 0: UCI bits = 1; RB = 1; OFDM Symbols = 1,2     - Format 1: UCI bits = 2; RB = 1; OFDM Symbols = 1     - Format 2: UCI bits = 4 (when OFDM==1), 22 (when OFDM==2); RB = 4 (when OFDM==1), 9 (when OFDM==2); OFDM Symbols = 1,2     - Format 3: UCI bits = 16; RB = 1 (when OFDM==14), 3 (when OFDM==4); OFDM Symbols = 4,14     - Format 4: UCI bits = 22; RB = 1; OFDM Symbols = 14   + Note: Other paramters are not precluded   **Issue 2-2-2: Introduction of requirements**  **Way forward**   * Based on the performance evaluation:   + Introduce new requirements for all formats/cases if the performance difference is observed in any of the formats * FFS, on applicability rules for PUCCH depending on the supported BW |

#### Issue 2-3-1: Introduction of PUCCH requirements

* Proposals and Observations:
  + Observation 12 (Nokia): It may be that only Format 2 has impacted performance for less than 5MHz allocation
  + **Proposal 13** (Nokia): An Applicability rule shall be introduced into TS 38.141 to enable a base station declaring to support less than 5MHz to conduct a new test with only Format 2 for PUCCH, wording FFS.
  + Observation 5 (Ericsson): There is obvious performance difference on PUCCH format 2 for UCI BLER test case between 5MHz and 3MHz.
  + **Proposal 5** (Ericsson): Introduce new PUCCH format 2 for UCI BLER requirements for 3MHz.
  + Observation 2 (ZTE). The flexibility of PUCCH configurations in frequency domain for 3MHz can be supported with no significant impact.
  + **Proposal 2** (ZTE). From RAN4 demodulation perspective, RAN4 could consider defining 3MHz requirements for PUCCH in 15kHz .
  + Observation2 (Huawei): For cases with intra-slot frequency hopping disabled, existing PUCCH requirements are same for 3MHz and larger bandwidth.
  + Observation3 (Huawei): For cases with intra-slot frequency hopping enabled, the frequency diversity gain is only valid for 2Rx, for large number of Rx, e.g. 8Rx, the frequency diversity gain is replaced by spatial diversity gain, and the performance for 3MHz and 5MHz are almost same.
  + Observation 4 (Huawei): Most Base stations have large number of Rx, which means 3MHz and 5MHz have same performance with intra-slot frequency hopping enabled.
  + **Proposal 2** (Huawei): Don’t define PUCCH requirements with 3MHz bandwidth.
  + **Proposal 4** (Samsung): If agreed to introduce PUCCH requirements with 3MHz, only limited test cases of PUCCH requirement are considered.
* Candidate options / tentative agreements:
  + Option 1 [Nokia, Ericsson]: Introduce new PUCCH format 2 for UCI BLER requirements for 3MHz
    - FFS the need for the other new PUCCH requirements for less than 5MHz
  + Option 2 [Huawei]: Don’t define PUCCH requirements with 3MHz bandwidth.
* Recommended WF
  + Check if Option 1 is agreeable.

#### Issue 2-3-2: Frequency hopping and antenna configuration for PUCCH requirements

* Proposals and Observations:
  + Observation3 (Huawei): For cases with intra-slot frequency hopping enabled, the frequency diversity gain is only valid for 2Rx, for large number of Rx, e.g. 8Rx, the frequency diversity gain is replaced by spatial diversity gain, and the performance for 3MHz and 5MHz are almost same.
  + Observation 4 (Huawei): Most Base stations have large number of Rx, which means 3MHz and 5MHz have same performance with intra-slot frequency hopping enabled.
  + **Proposal 10** (Nokia): RAN4 shall enable Frequency Hopping for PUCCH requirements definition.
  + **Proposal 17** (Samsung): Introduce PUCCH requirement with 3MHz under 1Tx2Rx antenna configuration.
* Candidate options / tentative agreements:
  + Option 1 [Nokia, Samsung]: Introduce new PUCCH requirement with frequency hopping for 1Tx2Rx antenna configuration.
* Recommended WF
  + Further discuss the candidate option during the meeting.

#### Issue 2-3-4: PUCCH channel conditions

* Proposals and Observations:
  + **Proposal 11** (Nokia): RAN4 shall use TDLC 300-100 Low channels to define requirements for PUCCH with Less than 5MHz.
  + Observation 11 (Nokia): PUCCH performance may decrease at with propagation conditions worse than TDLC 300-100.
  + **Proposal 12** (Nokia): RAN4 to discuss regarding further degraded propagation conditions for PUCCH performance requirements beyond TDLC 300-100.
* Candidate options / tentative agreements:
  + Use TDLC 300-100 channel conditions for PUCCH requirement in less than 5 MHz CBW, if decided to be introduced.
    - FFS for other channel conditions beyond TDLC 300-100.
* Recommended WF
  + Check the proposed tentative agreement.

#### Issue 2-3-5: Other PUCCH requirement parameters

* Proposals and Observations:
  + **Proposal 5** (Samsung): If no PUCCH requirements with 3MHz introduced, the test configuration with 5MHz should be modified to support PUCCH requirement with 3MHz test, where the value of first PRB after frequency hopping should be updated with a note as following

|  |  |
| --- | --- |
| First PRB after frequency hopping1 | The largest PRB index – (Number of PRBs – 1) |
| Note1:   * The largest PRB index is 11 for 3MHz test at n100 * The largest PRB index is 14 for 3MHz test except for n100 * The largest PRB index is 24 for 5MHz test | |

* + **Proposal 18** (Samsung): Reusing the existing PUCCH test parameters for specifying PUCCH requirement with 3MHz

Table 3: Test parameters of PUCCH format 0

|  |  |
| --- | --- |
| Parameter | Test |
| Number of UCI information bits | 1 |
| Number of PRBs | 1 |
| First PRB prior to frequency hopping | 0 |
| Intra-slot frequency hopping | N/A for 1 symbol Enabled for 2 symbols |
| First PRB after frequency hopping | The largest PRB index – (Number of PRBs - 1) |
| Group and sequence hopping | neither |
| Hopping ID | 0 |
| Initial cyclic shift | 0 |
| First symbol | 13 for 1 symbol  12 for 2 symbols |
| Test metric | DTX to ACK probability  ACK missed detection probability |

Table 4: Test parameters of PUCCH format 1

|  |  |
| --- | --- |
| Parameter | Test |
| Number of information bits | 2 |
| Number of PRBs | 1 |
| Number of symbols | 14 |
| First PRB prior to frequency hopping | 0 |
| Intra-slot frequency hopping | enabled |
| First PRB after frequency hopping | The largest PRB index – (nrofPRBs – 1) |
| Group and sequence hopping | neither |
| Hopping ID | 0 |
| Initial cyclic shift | 0 |
| First symbol | 0 |
| Index of orthogonal cover code (*timeDomainOCC*) | 0 |
| Test metric | NACK to ACK probability  ACK missed detection probability |

Table 5: Test parameters of PUCCH format 2

|  |  |
| --- | --- |
| Parameter | Value |
| Modulation order | QSPK |
| Starting RB location | 0 |
| Intra-slot frequency hopping | N/A |
| Number of PRBs | 4 |
| Number of symbols | 1 |
| The number of UCI information bits | 4 |
| First symbol | 13 |
| DM-RS sequence generation | *NID*0=0 |
| Test metric | DTX to ACK probability  ACK missed detection probability |

Table 6: Test parameters of PUCCH format 2

|  |  |
| --- | --- |
| Parameter | Value |
| Modulation order | QSPK |
| First PRB prior to frequency hopping | 0 |
| Intra-slot frequency hopping | enabled |
| Frist PRB after frequency hopping | The largest PRB index – (Number of PRBs – 1) |
| Number of PRBs | 9 |
| Number of symbols | 2 |
| The number of UCI information bits | 22 |
| First symbol | 12 |
| DM-RS sequence generation | *NID*0=0 |
| Test metric | BLER |

Table 7: Test parameters of PUCCH format 3

|  |  |  |
| --- | --- | --- |
| Parameter | Test 1 | Test 2 |
| Modulation order | QPSK | |
| First PRB prior to frequency hopping | 0 | |
| Intra-slot frequency hopping | enabled | |
| First PRB after frequency hopping | The largest PRB index – (Number of PRBs – 1) | |
| Group and sequence hopping | neither | |
| Hopping ID | 0 | |
| Number of PRBs | 1 | 3 |
| Number of symbols | 14 | 4 |
| The number of UCI information bits | 16 | 16 |
| First symbol | 0 | 0 |
| Test metric | BLER | |

Table 8: Test parameters of PUCCH format 4

|  |  |
| --- | --- |
| Parameter | Value |
| Modulation order | QPSK |
| First PRB prior to frequency hopping | 0 |
| Number of PRBs | 1 |
| Intra-slot frequency hopping | enabled |
| First PRB after frequency hopping | The largest PRB index – (Number of PRBs – 1) |
| Group and sequence hopping | neither |
| Hopping ID | 0 |
| Number of symbols | 14 |
| The number of UCI information bits | 22 |
| First symbol | 0 |
| Length of the orthogonal cover code | n2 |
| Index of the orthogonal cover code | n0 |
| Test metric | BLER |

* + Observation 4 (Samsung): Similar performance can be achieved with 3MHz and 5MHz CBW
* Recommended WF
  + Further discuss the PUCCH parameters during the meeting, also depending on the agreements in the other issues.

### Sub-topic 2-4: RACH requirements

*Sub-topic description:*

In this sub-topic the proposals related to the PRACH requirements for less than 5Mhz CBW are summarized.

#### Issue 2-4-1: Applicability rule or note for long RACH sequences

* Background

Agreement from RAN4#108bis:

|  |
| --- |
| **Issue 2-3-1: Introduction of requirement**  **Agreement**   * No new PRACH requirement need to be introduced for Less than 5MHz channel bandwidth. * FFS whether applicability rule or note for long RACH sequences in less than 5 MHz bandwidths are needed. |

* Proposals and Observations:
  + **Proposal 14** (Nokia): Add a statement into clause 8.1.2.3.3 of TS 38.141 with the following wording
    - [For BS supporting less than 5MHz carrier bandwidth only test requirements relating to short RACH preamble formats with 15kHz SCS, and long PRACH formats with 1.25kHz SCS shall apply].
  + **Proposal 6** (Ericsson): No need to add applicability rule or note for long RACH sequences in less than 5 MHz bandwidths.
  + Observation 1 (Samsung): Existing long PRACH formats with 1.25KHz SCS with sequence length LRA=839, and long PRACH formats with 15KHz SCS with sequence length LRA=139 can support 3MHz channel bandwidth.
  + Observation 2 (Samsung): Existing PRACH formats with 15KHz SCS with sequence length LRA=1151, cannot apply for 3MHz channel bandwidth.
  + Observation 3 (Samsung): A note is added to indicate PRACH formats and configurations are not fitting into transmission BW are not applicable in RAN1 agreement
  + **Proposal 6** (Samsung): FFS to add a note indicate the existing short PRACH formats with 15KHz SCS with sequence length LRA=1151 cannot apply for 3MHz channel bandwidth
  + **Proposal 3** (Huawei): Revise existing the applicability of performance requirements for PRACH with LRA =1151 and LRA =571 for different bandwidth to:
    - Unless otherwise stated, for the subcarrier spacing to be tested, the test requirements shall apply only for anyone channel bandwidth not less than 20MHz declared to be supported (see D.14 in table 4.6-1).
* Candidate options / tentative agreements:
  + Option 1 [Nokia, Samsung, Huawei]: add applicability rule or note
    - Option 1-a [Nokia]: For BS supporting less than 5MHz carrier bandwidth only test requirements relating to short RACH preamble formats with 15kHz SCS, and long PRACH formats with 1.25kHz SCS shall apply.
    - Option 1-b [Huawei]: Unless otherwise stated, for the subcarrier spacing to be tested, the test requirements shall apply only for anyone channel bandwidth not less than 20MHz declared to be supported (see D.14 in table 4.6-1).
  + Option 2 [Ericsson]: No need to add applicability rule or note.
* Recommended WF
  + Further discuss a need and formulation of the applicability rule.