**3GPP TSG-RAN WG4 Meeting #116bis R4-2514434**

**Prague, CZ, Oct 13th ‒ Oct 17th, 2025**

**Agenda item:** 6.23

**Source:** Moderator (Ericsson)

**Title:** Topic summary for [116bis][311] Rel-19 Demodulation\_Part1

**Document for:** Information

# Introduction

This topic summary summarizes the issues on UE and gNB demodulation requirement for Rel-19 NR\_duplex\_evo WI (RP-241614), and SAN and UE demodulation requirements for Rel-19 WI NTN for NR Phase 3 WI (RP-243300)

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| --- | --- | --- | --- | --- |
| **#** | **Title** | **Topic title** | **WI** | **Topic areas** |
| 311 | Rel-19 Demodulation\_Part1 | [116bis][311] Rel-19 Demodulation\_Part1 | NR\_duplex\_evo-Perf  NR\_NTN\_Ph3-Perf | SBFD, NTN demod |

For NR\_duplex\_evo WI, it contains the following objectives

* Objective 1: semi-static indication of time location of SBFD subbands
* Objective 2: semi-static indication of frequency domain location of SBFD subbands mode
* Objective 3: SBFD operation to support random access in SBFD symbols
* Objective 4: UE transmission, reception and measurement behavior and procedures in SBFD symbols
* Objective 5: Enhancements for CLI handling

For NR NTN phase 3, it contains the following objectives

* Objective 1: Uplink capacity/cell throughput enhancements
* Objective 2: Support of Rel-17 RedCap and Rel-18 eRedCap UEs

References:

* R4-2512615, “Way Forward for [116][328] NR\_duplex\_evo\_demod”, Samsung, RAN4#116
* R4-2512644, “Way Forward for [116][331] NR\_NTN\_Ph3\_demod”, Ericsson, RAN4#116.

# Topic #1: SBFD demodulation requirements

This topic discusses the SBFD demodulation requirements.

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2513399 | Samsung | **Observation 1: Self-interference can be modeled as additive white gaussian noise with fixed INR=-6dB targeting 1dB desense similar to SLS, and co-site inter-sector interference can be modelled as additive white gaussian noise with fixed INR=-X dB based on the assumption of co-site isolation** .  **Observation 2: Either option 1 and option 2 for gNB-gNB interference modeling, the interference level is derived based on a certain assumption of the topology of gNBs and UEs.**  **Observation 3: The overall of inter-sector gNB-gNB interference including the gNB-gNB self-interference can be modelled as additive white gaussian noise with fixed INR =-6dB targeting 1 dB UL receiver sensitivity degradation**  **Proposal 3: RAN4 consider INR with fading based modeling methodology for inter-site gNB-gNB interference when specifying the PUSCH requirement with UL symbol muting. If including the including the intra-sector gNB-gNB interference and gNB-gNB self-interference for specifying PUSCH requirement with UL muting, the additive white gaussian noise with fixed INR =-6dB for modeling can be considered.**  **Observation 4: For all the cases evaluated based on the candidate INR value proposed by company, there is at least around 0.15dB gain with using muting REs for interference covariance estimation**  **Observation 5: Under high INR condition, where two interferes are considered with INR1 larger than INR2, the performance gain achieved can be up to 0.9dB for 2 UL symbols muting scenario, and up to 0.8dB for 1 UL symbol scenario.**  **Proposal 2: RAN4 introduce the PUSCH requirement with UL symbols muting.**  **Proposal 3: RAN4 introduce the PUSCH requirement with UL symbols muting with the following assumption**  **Frequency Rang**  **Cover both FR1 and FR2-1 if agreed to introduce PUSCH demodulation requirement with UL muting**  **Waveform for wanted signal**  **Cover both CP-OFDM and DFT-s-OFDM waveforms if agreed to introduce PUSCH demodulation requirement with UL muting**  **sub-band pattern**  **considering sub-band configuration as {DU}, wherethe UL sub-band is located in the lower band**  **Channel Bandwidth for wanted signal**  **For FR1: 40MHz CBW (20MHz DL sub-band+ 20MHz UL sub-band) for 30kHz SCS**  **For FR2-1: 200MHz CBW (100MHz DL sub-band+ 100MHz UL sub-band) for 120kHz SCS**  **TDD patterns**  **30 kHz SCS: XXXXXXXXUU**  **120 kHz SCS: XXXXU**  **UL sub-band transmission could start from the first F slots**  **Skip U slots to simply simulation setup**  **Sub-band configuration in SBFD slot**  **Take SBFD UL sub-band spans all the symbols with a SBFD slot**  **Number of symbol muting**  **Consider 2 symbols muting configuration**  **Muting symbol configuration**    **PUSCH mapping type for wanted signal and interferers**  **Both mapping A and mapping B in FR1**  **Mapping B in FR**  **Number of DMRS symbols for wanted signal and interfers**  **Configure 2 DMRS symbols for defining SBFD PUSCH demodulation requirement in FR1 and FR2-1**  **Channel model**  **TDLC300-100 for wanted signal in FR1**  **TDLC300-0 for interference signal if considering INR based interference modelling in FR1**  **MCS and Rank**  **MCS16 for wanted signal in FR1 and FR2**  **16QAM for interference signal in FR1],**  **Rank 1 for wanted signal and interference signal**  **Antenna Configuration**  **Reuse the same antenna configuration assumption for evaluation SBFD PUSCH performance with UL muting as 1Tx/2Rx/4Rx/8Rx in FR1 and 1Tx/2Rx in FR2-1**  **Other Assumption**  **Reuse the same assumption for specifying SBFD PUSCH demodulation requirement in FR1 and FR2-1 as referred in Table: 8.2.1.1-1/ Table: 8.2.2.1-1 and Table 11.2.2.1.1-1/ Table 11.2.2.2.1-1, respectively.** |
| R4-2513439 | Huawei,HiSilicon |  |
| R4-2514138 | Ericsson | **Observation 1 The coupling loss assumption for in-channel adjacent subband blocking requirement in RF discussion is ~8dB higher than in option 1 in WF.**  **Proposal 1 Reduce interference INR values as in Table 2-1 for initial simulations.**  Table 2-1 Revised INR values for FR1   |  |  | | --- | --- | | Conditions | FR1 | | Interf1 > Interf2 | INR1 <= 9.2dB, INR2 <= -0.8dB  Trial simulation could try following sets: [INR1, INR2] = {[5, -5], [9, -1]} dB | | Interf1 = Interf2 | INR1 = INR2 <=3.2dB  Trial simulation could try following sets: [INR1, INR2] = {[-1, -1], [3, 3]} dB | | Note: The interference wave form could use PUSCH with 1+1 DM-RS and CP-OFDM to simplify simulation setup. | | |
| R4-2514139 | Ericsson | Simulation results |
| R4-2514145 | ZTE | ***Observation 1. 0.7dB receiver sensitivity desensitization is achieved by self-interference cancellation capability for feasibility study in RF session.***  ***Observation 2. The implementation of controlling the co-site inter sector co-channel inter-subband interference depends on spatial isolation, beam nulling/isolation, frequency isolation and digital interference suppression.***  ***Observation 3. Co-site inter-sector gNB-gNB interference is more similar to gNB self-interference.***  ***Observation 4. 0.7 dB receiver sensitivity desensitization may or may not be achieved by co-site inter-sector co-channel inter-subband interference.***  ***Observation 5. Based on our simulation results, the receiver’s ability to suppress interference is affected by the level of interference.***  ***Observation 6. According to our simulation results [3], the significant difference is that a gap of more than 1dB gap is observed between 1 symbol and two symbols muting schemes***  ***Proposal 1. Propose modelling as additive white Gaussian noise with 1dB receiver desensitization for gNB self-interference if RAN4 agrees to evaluate the self-interference.***  ***Proposal 2. Propose modelling as additive white Gaussian noise with 0.7dB receiver desensitization for gNB self-interference if RAN4 agrees to evaluate the intra-site inter sector interference.***  ***Proposal 3. If RAN4 agrees to use link budget approach to derive the interference profile, then the upper limit of interference reduction must be considered.***  ***Proposal 5. Propose to consider 1 symbol muting scheme when defining demodulation requirements.*** |
| R4-2514146 | ZTE | **Observation 1. Based on our simulation results, the significant difference is that a gap of more than 1dB gap is observed between 1 symbol and two symbols muting schemes. Also, no difference is observed between 1 symbol and two symbols muting schemes in some test cases.**  **Observation 2. Based on our simulation results, muting symbol scheme can achieve a better performance compared to muting disable scheme, especially when using a higher interference levels.**  **Observation 3. Based on our simulation results, the receiver’s ability to suppress interference is affected by the level of interference.** |
| R4- 2514288 | Nokia | **Observation 1: In SBFD, the PUSCH demodulation at SBFD-capable gNB is affected by the gNB self-interference and the gNB-to-gNB CLI.**  **Observation 2: Referring to TR 38.858, self-interference can be modelled as additive white gaussian noise with fixed INR = - 6 dB targeting 1 dB desense.**  **Observation 3: To properly model the gNB-to-gNB interference signals, similar to TR 36.884, join efforts from multiple companies are needed for the system level simulation activities, with a realistic deployment scenario and further alignment of the results, to have a reliable and accountable DIP for SBFD.**  **Observation 4: RAN Plenary has approved a WI for Rel-20 SBFD to consider SBFD BS to SBFD BS adjacent channel coexistence focusing on realistic deployment scenario.**  **Observation 5: For SBFD UE demodulation, as UE-to-UE CLI was considered difficult to model, it was agreed not to define SBFD UE demodulation requirements.**  **Proposal 1: If SBFD BS interference from a realistic deployment scenario cannot be properly modeled, RAN4 shall not define BS demodulation requirements.**  **Proposal 2: RAN4 to keep the specification impact discussion as FFS.** |

## Open issues summary

Last RAN4 meeting agreements in the WF R4-2512644

**Sub-topic 1-1 General Scope**

Issue 1-1-1 how to model interference modeling for performance evaluation

Issue 1-1-2 whether to introduce the PUSCH requirement with UL muting

**Sub-topic 1-2 Test setup for demodulation requirement if introduced**

Issue 1-2-1 Frequency Range

Issue 1-2-2 Waveform for wanted signal

Issue 1-2-3 sub-band pattern

Issue 1-2-4 Channel Bandwidth for wanted signal

Issue 1-2-5 TDD pattern

Issue 1-2-6 Sub-band configuration in SBFD slot

Issue 1-2-7 Number of symbol muting

Issue 1-2-8 Muting symbol configuration

Issue 1-2-9 PUSCH mapping type for wanted signal and interferers

Issue 1-2-10 Number of DMRS symbols for wanted signal

Issue 1-2-11 Channel model

Issue 1-2-12 MCS

Issue 1-2-13 Antenna Configuration

Issue 1-2-14 Other Assumption

### Sub-topic 1-1 General Scope

**Issue 1-1-2 how to model interference modeling for performance evaluation**

* Observations
  + Observation 1 (ZTE)
    - 0.7dB receiver sensitivity desensitization is achieved by self-interference cancellation capability for feasibility study in RF session
    - The implementation of controlling the co-site inter sector co-channel inter-subband interference depends on spatial isolation, beam nulling/isolation, frequency isolation and digital interference suppression
    - Co-site inter-sector gNB-gNB interference is more similar to gNB self-interference.
    - 0.7 dB receiver sensitivity desensitization may or may not be achieved by co-site inter-sector co-channel inter-subband interference.
    - Based on our simulation results, the receiver’s ability to suppress interference is affected by the level of interference
    - According to our simulation results [3], the significant difference is that a gap of more than 1dB gap is observed between 1 symbol and two symbols muting schemes
  + Observation 2 (Nokia)
    - In SBFD, the PUSCH demodulation at SBFD-capable gNB is affected by the gNB self-interference and the gNB-to-gNB CLI
    - Referring to TR 38.858, self-interference can be modelled as additive white gaussian noise with fixed INR = - 6 dB targeting 1 dB desense.
    - To properly model the gNB-to-gNB interference signals, similar to TR 36.884, join efforts from multiple companies are needed for the system level simulation activities, with a realistic deployment scenario and further alignment of the results, to have a reliable and accountable DIP for SBFD
    - RAN Plenary has approved a WI for Rel-20 SBFD to consider SBFD BS to SBFD BS adjacent channel coexistence focusing on realistic deployment scenario.
    - For SBFD UE demodulation, as UE-to-UE CLI was considered difficult to model, it was agreed not to define SBFD UE demodulation requirements.
  + Observation 3 (Samsung)
    - Self-interference can be modeled as additive white gaussian noise with fixed INR=-6dB targeting 1dB desense similar to SLS, and co-site inter-sector interference can be modelled as additive white gaussian noise with fixed INR=-X dB based on the assumption of co-site isolation .
    - Either option 1 and option 2 for gNB-gNB interference modeling, the interference level is derived based on a certain assumption of the topology of gNBs and UEs.
    - The overall of inter-sector gNB-gNB interference including the gNB-gNB self-interference can be modelled as additive white gaussian noise with fixed INR =-6dB targeting 1 dB UL receiver sensitivity degradation
  + Observation 4 (Ericsson)
    - The coupling loss assumption for in-channel adjacent subband blocking requirement in RF discussion is ~8dB higher than in option 1 in WF.
* Proposal
  + Option 1 (ZTE):
    - Propose modelling as additive white Gaussian noise with 1dB receiver desensitization for gNB self-interference if RAN4 agrees to evaluate the self-interference.
    - Propose modelling as additive white Gaussian noise with 0.7dB receiver desensitization for gNB self-interference if RAN4 agrees to evaluate the intra-site inter sector interference.
    - If RAN4 agrees to use link budget approach to derive the interference profile, then the upper limit of interference reduction must be considered.
  + Option 2 (Samsung): RAN4 consider INR with fading based modeling methodology for inter-site gNB-gNB interference when specifying the PUSCH requirement with UL symbol muting. If including the including the intra-sector gNB-gNB interference and gNB-gNB self-interference for specifying PUSCH requirement with UL muting, the additive white gaussian noise with fixed INR =-6dB for modeling can be considered.
  + Option 3 (Ericsson)

Table 2-1 Revised INR values for FR1

|  |  |
| --- | --- |
| Conditions | FR1 |
| Interf1 > Interf2 | INR1 <= 9.2dB, INR2 <= -0.8dB  Trial simulation could try following sets: [INR1, INR2] = {[5, -5], [9, -1]} dB |
| Interf1 = Interf2 | INR1 = INR2 <=3.2dB  Trial simulation could try following sets: [INR1, INR2] = {[-1, -1], [3, 3]} dB |
| Note: The interference wave form could use PUSCH with 1+1 DM-RS and CP-OFDM to simplify simulation setup. | |

* Recommended WF
  + *Moderator note: In last meeting, companies agreed to use TDL+INR type of interference model for evaluation, where the INR value derived based on link budget analysis can be considered with candidate values*

*Regarding the interference type, FFS on self-interference and intra-site inter sector interference, since the test purposed of verifying UL muting function and to estimate the interference covariance matrix more accurately, and meanwhile, according to TR, 38.858, self-interference can be modeled as additive white gaussian noise with fixed INR=-6dB targeting 1 dB densene. Considering the main dominate and test purpose, it is efficient to focus on inter-gNB interference only with INR based interference modeling.*

*Regarding how to derive INR value, derived based link budget is simplified procedure to meet the test purpose of UL muting, since there is no different baseband processing, no matter the INR value is derived based on link budget or SLS, while SLS will be time-consuming considering only 3 meeting left for this WI, suggest to focus on INR derived by link budget discussion with considering the alignment of RF discussion*

* + Need discussion and make decision in this meeting with high priority

**Issue 1-1-2 whether to introduce the PUSCH requirement with UL muting**

* Observations
  + Observation 1 (Nokia)
    - In SBFD, the PUSCH demodulation at SBFD-capable gNB is affected by the gNB self-interference and the gNB-to-gNB CLI
    - Referring to TR 38.858, self-interference can be modelled as additive white gaussian noise with fixed INR = - 6 dB targeting 1 dB desense.
    - To properly model the gNB-to-gNB interference signals, similar to TR 36.884, join efforts from multiple companies are needed for the system level simulation activities, with a realistic deployment scenario and further alignment of the results, to have a reliable and accountable DIP for SBFD
    - RAN Plenary has approved a WI for Rel-20 SBFD to consider SBFD BS to SBFD BS adjacent channel coexistence focusing on realistic deployment scenario.
    - For SBFD UE demodulation, as UE-to-UE CLI was considered difficult to model, it was agreed not to define SBFD UE demodulation requirements.
  + Observation 2 (ZTE)
    - Based on our simulation results, the significant difference is that a gap of more than 1dB gap is observed between 1 symbol and two symbols muting schemes. Also, no difference is observed between 1 symbol and two symbols muting schemes in some test cases.
    - Based on our simulation results, muting symbol scheme can achieve a better performance compared to muting disable scheme, especially when using a higher interference levels
    - Based on our simulation results, the receiver’s ability to suppress interference is affected by the level of interference
  + Observation 3 (Samsung)
    - Observation 4: For all the cases evaluated based on the candidate INR value proposed by company, there is at least around 0.15dB gain with using muting REs for interference covariance estimation
    - Observation 5: Under high INR condition, where two interferes are considered with INR1 larger than INR2, the performance gain achieved can be up to 0.9dB for 2 UL symbols muting scenario, and up to 0.8dB for 1 UL symbol scenario.
* Proposal
  + Option 1 (Nokia): If SBFD BS interference from a realistic deployment scenario cannot be properly modeled, RAN4 shall not define BS demodulation requirements
  + Option 2 (Samsung): RAN4 introduce the PUSCH requirement with UL symbols muting
* Recommended WF
  + *Moderator note: In the last meeting, RAN4 agreed to perform evaluation with TDL+INR type of interference model. Based on evaluation, RAN4 can further discuss whether to introduce the PUSCH requirement with UL muting. As 2 companies provided results, muting symbol scheme can achieve a better performance compared to muting disable scheme. Based on evaluation, the feasibility of UL symbol muting has already been verified.*
  + Need discussion and make decision in this meeting with high priority

### Sub-topic 1-2 Test setup for demodulation requirement if introduced

**Issue 1-2-1 Frequency Range**

* Proposals
  + Option 1 (Samsung)
    - Cover both FR1 and FR2-1
* Recommended WF
  + Option 1

**Issue 1-2-2 Waveform for wanted signal**

* Proposals
  + Option 1(Samsung)
    - Cover both CP-OFDM and DFT-s-OFDM waveforms
* Recommended WF
  + Option 1

**Issue 1-2-3 sub-band pattern**

* Proposals
  + Option 1 (Samsung)
    - considering sub-band configuration as {DU}, wherethe UL sub-band is located in the lower band
* Recommended WF
  + Option 1

**Issue 1-2-4 Channel Bandwidth for wanted signal**

* Proposals
  + Option 1 (Samsung)
    - For FR1: 40MHz CBW (20MHz DL sub-band+ 20MHz UL sub-band) for 30kHz SCS
    - For FR2-1: 200MHz CBW (100MHz DL sub-band+ 100MHz UL sub-band) for 120kHz SCS
* Recommended WF
  + Option 1

**Issue 1-2-5 TDD pattern**

* Proposals
  + Option 1
    - 30 kHz SCS: XXXXXXXXUU
    - 120 kHz SCS: XXXXU
    - UL sub-band transmission could start from the first F slots
    - Skip U slots to simply simulation setup
* Recommended WF
  + Option 1

**Issue 1-2-6 Sub-band configuration in SBFD slot**

* Proposals
  + Option 1
    - Take SBFD UL sub-band spans all the symbols with a SBFD slot
* Recommended WF
  + Option 1

**Issue 1-2-7 Number of symbol muting**

* Observations
  + Observation 1 (ZTE)
    - Based on our simulation results, the significant difference is that a gap of more than 1dB gap is observed between 1 symbol and two symbols muting schemes. Also, no difference is observed between 1 symbol and two symbols muting schemes in some test cases.
  + Observation 2 (Samsung)
    - Under high INR condition, where two interferes are considered with INR1 larger than INR2, the performance gain achieved can be up to 0.9dB for 2 UL symbols muting scenario, and up to 0.8dB for 1 UL symbol scenario.
* Proposals
  + Option 1 (ZTE): 1
  + Option 2 (Samsung): 2
* Recommended WF
  + Need discussion

**Issue 1-2-8 Muting symbol configuration**

* Proposals
  + Option 1 (Samsung):



* Recommended WF
  + Need discussion

**Issue 1-2-9 PUSCH mapping type for wanted signal and interferers**

* Proposals
  + Option 1:
    - Both mapping A and mapping B in FR1
    - Mapping B in FR2
* Recommended WF
  + Option 1

**Issue 1-2-10 Number of DMRS symbols for wanted signal**

* Proposals
  + Option 1 (Samsung): Configure 2 DMRS symbols for defining SBFD PUSCH demodulation requirement in FR1 and FR2-1
* Recommended WF
  + Need discussion

**Issue 1-2-11 Channel model**

* Proposals
  + Option 1 (Samsung)
    - TDLC300-100 for wanted signal in FR1
    - TDLC300-0 for interference signal if considering INR based interference modelling in FR1
* Recommended WF
  + Option 1

**Issue 1-2-12 MCS**

* Proposals
  + Option 1
    - MCS16 for wanted signal in FR1 and FR2
    - 16QAM for interference signal in FR1
    - Rank 1 for wanted signal and interference signal
* Recommended WF
  + Option 1

**Issue 1-2-13 Antenna Configuration**

* Proposals
  + Option 1 (Samsung): Reuse the same antenna configuration assumption for evaluation SBFD PUSCH performance with UL muting as 1Tx/2Rx/4Rx/8Rx in FR1 and 1Tx/2Rx in FR2-1
* Recommended WF
  + Option 1

**Issue 1-2-14 Other Assumption**

* Proposals
  + Option 1 (Samsung): Reuse the same assumption for specifying SBFD PUSCH demodulation requirement in FR1 and FR2-1 as referred in Table: 8.2.1.1-1/ Table: 8.2.2.1-1 and Table 11.2.2.1.1-1/ Table 11.2.2.2.1-1, respectively
* Recommended WF
  + Option 1

### Sub-topic 1-3 Inclusion in Specfication

**Issue 1-3-1 Specification Impact**

* Proposals
  + Option 1 (Nokia): RAN4 to keep the specification impact discussion as FFS
* Recommended WF
  + Postpone the discussion and focus on test scope and test setup discussion

# Topic #2: SAN demodulation requirements for NTN phase 3

This topic discusses the SAN demodulation requirements for NTN phase 3

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2513231 | CATT | **Proposal 1: For frequency offset of two multiplexed UEs, same CFO should be considered, and both 0Hz and 200 Hz offset are acceptable.**  **Proposal 2: For channel model of multiplexed UEs, same channel model should be applied, and the NTN-TDLC5-200 is acceptable.**  **Proposal 3: For test metric, the SNR at 70% of maximum throughput could be considered** |
| R4-2513396 | Samsung | **Proposal 1: Configure the same frequency offset as 0Hz for two UEs to specify the PUSCH requirement with inter-slot OCC feature.**  **Proposal 2: Select the channel model with NTN-TDLC5-200 for specifying PUSCH requirement with OCC feature.**  **Proposal 3: RAN4 apply the same test applicability rule for different antenna configuration for NR NTN PUSCH with inter-OCC feature testing**   |  | | --- | | **Unless otherwise stated, for a SAN supporting different numbers of *TAB connectors* (for *SAN type 1-H*) (see D.48 in table 4.6-1), the tests with low MIMO correlation level shall apply only for the highest number of supported connectors, and the specific connectors used for testing are based on manufacturer declaration. If performance requirement is not specified for the highest number of supported connectors, the tests shall be done by using performance requirement for the closest number of connectors lower than this highest number of supported connectors.** |   **Proposal 4: RAN4 can consider the following example to specify the PUSCH SNR requirement with inter-slot OCC feature**   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Number of TX antennas | Number of RX antennas | Cyclic prefix | Propagation conditions and correlation matrix (annex G) | Fraction of maximum throughput | FRC (annex A) | Additional DM-RS position | OCC index | SNR (dB) | | 1 | 1 | Normal | NTN-TDLC5-200 Low | 70% | TBD | 2 | 0 | TBD | | 1 | TBD |   **Observation 1: Compared with the single UE without OCC, there is a minor performance degradation for TDLC channel condition with inter-slot OCC enabling, while large performance degradation was suffered for TDLA channel condition**  **Observation 2: Compared with zero frequency offset scenario for each UE, around 0.7 dB performance degradation was suffered with non-zero frequency offset for both NTN TDLC5-200 and NTN TDLA100-200 channel condition, especially for 30KHz SCS scenario.** |
| R4-2513440 | Huawei | **Observation 1: There is no performance difference between frequency offsets 0Hz and 200Hz.**  **Proposal 1: Select 200Hz frequency offset for NTN SAN requirements.**  **Proposal 2: The existing SAN PUSCH demodulation requirements applicability between 1Rx and 2Rx requirements shall apply, i.e. only 2Rx need to be test if both 1Rx and 2Rx are supported.** |
| R4-2513960 | Ericsson | **Observation 1: There is no performance difference by setting CFO of 0 and 200Hz for both multiplexed UEs.**  **Observation 2: It is highly unlikely that two multiplexed UEs in one OCC group would have the same CFO.**  **Observation 3: It would be feasible to consider the worst-case scenario for CFO setting of the two UEs, i.e., the difference between the CFO of two UEs should be 200Hz. However, even in the worst case no significant performance difference (<0.5dB) is observed from our simulations.**  **Observation 4: Peak throughput can be achieved under the NTN-TDLC channel model; however, the same performance is not attainable under the NTN-TDLA channel model. Also, NTN-TDLC is more robust to frequency errors.**  **Proposal 5: As no performance difference in the worst case for two OCC multiplexed UEs, CFO of 200 Hz can be considered. However, RAN4 needs to evaluate how to highlight in the specification on the differential CFO between the UEs.**  **Proposal 6: Consider NTN-TDLC5-200 channel model SAN demodulation performance requirements with OCC.**  **Proposal 7: The current applicability rule apply for 1Rx and 2Rx SAN PUSCH demodulation requirements.** |
| R4- 2513961 | Ericsson | Simulation results |

## Open issues summary

Last RAN4 meeting agreements in the WF R4-2508625

**Sub-topic 2-1 Test setup for OCC length 2**

Issue 2-1-1 Frequency offset of two multiplexed UEs

Issue 2-1-2 Channel model

Issue 2-1-3 Test metric

Issue 2-1-4 Requirement specification for inter-slot OCC feature

Issue 2-1-5: Test applicability rule for different antenna configuration

### Sub-topic 2-1 Test setup for OCC length 2

**Issue 2-1-1: Frequency offset of two multiplexed UEs.**

* Observations
  + Observation 1 (Samsung)
    - Compared with zero frequency offset scenario for each UE, around 0.7 dB performance degradation was suffered with non-zero frequency offset for both NTN TDLC5-200 and NTN TDLA100-200 channel condition, especially for 30KHz SCS scenario.
  + Observation 2 (Huawei)
    - There is no performance difference between frequency offsets 0Hz and 200Hz.
  + Observation 3 (Ericsson)
    - There is no performance difference by setting CFO of 0 and 200Hz for both multiplexed UEs
    - It is highly unlikely that two multiplexed UEs in one OCC group would have the same CFO
    - It would be feasible to consider the worst-case scenario for CFO setting of the two UEs, i.e., the difference between the CFO of two UEs should be 200Hz. However, even in the worst case no significant performance difference (<0.5dB) is observed from our simulations.
* Proposals
  + Option 1: 0Hz (Samsung)
  + Option 2: 200Hz (Huawei, Ericsson)
  + Option 3: both 0Hz and 200H offset are acceptable (CATT)
  + Option 4 (Ericsson):
    - RAN4 SAN Demod to revisit and discuss the frequency offset assumption for two multiplexed UEs in one OCC group.
    - As no performance difference in the worst case for two OCC multiplexed UEs, CFO of 200 Hz can be considered. However, RAN4 needs to evaluate how to highlight in the specification on the differential CFO between the UEs.
* Recommended WF
  + *Moderator note: In practical scenario, it is true that the UE with OCC feature may has the same CFO, while from the baseband processing perspective, there is no differentiate with the same CFO or different CFO. It only impacts the requirement per UE. Considering RAN4 has already agreed with the same frequency offset, suggested to following the agreement and discuss the value of frequency offset*
  + Follow the agreement in the last meeting with setting the same frequency offset for two UEs
  + Set the same frequency offset for two UEs.
    - Discuss 0Hz or 200Hz (0.1ppm@2GHz)

**Issue 2-1-2: Channel model**

* Observations
  + Observation 1 (Samsung)
    - Compared with the single UE without OCC, there is a minor performance degradation for TDLC channel condition with inter-slot OCC enabling, while large performance degradation was suffered for TDLA channel condition
  + Observation 2 (Ericsson)
    - Peak throughput can be achieved under the NTN-TDLC channel model; however, the same performance is not attainable under the NTN-TDLA channel model. Also, NTN-TDLC is more robust to frequency errors.
* Proposals
  + Option 1 (Samsung, Ericsson, CATT): NTN-TDLC5-200
* Recommended WF
  + *Moderator note: Based on companies’ evaluation, larger performance degradation for NTN-TDLA channel, and less robust to frequency errors for TDLC channel*
  + Apply the same channel model with NTN-TDLC5-200 to two multiplexed UEs

**Issue 2-1-3: Test metric**

* Proposals
  + Option 1 (CATT): SNR at 70% of maximum throughput could be considered
* Recommended WF
  + Follow the agreement in the last meeting, and focus on how to specify the SNR requirement for each UE
    - SNR at 70% of maximum throughput.
    - Measure the PUSCH throughputs per UE.
      * UE1 uses Orthogonal sequence index 0
      * UE2 uses Orthogonal sequence index 1
    - Set the same SNR for PUSCH from two UEs if there is no performance difference.
    - FFS how to write the specification e.g., define PUSCH demodulation requirements for each UE.

**Issue 2-1-4: Requirement specification for inter-slot OCC feature**

* Proposals
  + Option 1 (Samsung): RAN4 can consider the following example to specify the PUSCH SNR requirement with inter-slot OCC feature

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Number of TX antennas | Number of RX antennas | Cyclic prefix | Propagation conditions and correlation matrix (annex G) | Fraction of maximum throughput | FRC (annex A) | Additional DM-RS position | OCC index | SNR (dB) |
| 1 | 1 | Normal | NTN-TDLC5-200 Low | 70% | TBD | 2 | 0 | TBD |
| 1 | TBD |

* Recommended WF
  + *Moderator note: Based on agreement in last meeting, to measure the PUSCH throughputs per UE with different OCC index, to differentiate the UE, company provide the example with adding one column into the requirement table*
  + Need discussion.

**Issue 2-1-5: Test applicability rule for different antenna configuration**

* Proposals
  + Option 1(Samsung, Ericsson, Huawei): RAN4 apply the same test applicability rule for different antenna configuration for NR NTN PUSCH with inter-OCC feature testing
    - Huawei: only 2Rx need to be tested if both 1Rx and 2Rx

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| **Unless otherwise stated, for a SAN supporting different numbers of *TAB connectors* (for *SAN type 1-H*) (see D.48 in table 4.6-1), the tests with low MIMO correlation level shall apply only for the highest number of supported connectors, and the specific connectors used for testing are based on manufacturer declaration. If performance requirement is not specified for the highest number of supported connectors, the tests shall be done by using performance requirement for the closest number of connectors lower than this highest number of supported connectors.** |

* Recommended WF
  + Reuse the existing SAN PUSCH demodulation requirements applicability between 1Rx and 2Rx requirements

|  |
| --- |
| **Unless otherwise stated, for a SAN supporting different numbers of *TAB connectors* (for *SAN type 1-H*) (see D.48 in table 4.6-1), the tests with low MIMO correlation level shall apply only for the highest number of supported connectors, and the specific connectors used for testing are based on manufacturer declaration. If performance requirement is not specified for the highest number of supported connectors, the tests shall be done by using performance requirement for the closest number of connectors lower than this highest number of supported connectors.** |

# Topic #3: UE demodulation requirements for NTN phase 3

This topic discusses the UE demodulation requirements for NTN phase 3

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2513440 | Huawei | **UE side**   1. Use DMRS 1+1 for NTN RedCap and eRedCap UE requirements. |
| R4-2513547 | MediaTek inc. | **Proposal 1: Consider 12 DM-RS REs (1+1) for NTN RedCap and eRedCap UE requirements and introduce new FRCs for cases of MCS4/52PRB.**  **NTN RedCap 1Rx**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** | | 1 | MCS4, 52PRB | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD | | 2 | MCS4, 52PRB | NTN-TDLC5-200 | 32 | 1x1 | New FRC for FDD  New FRC for HD-FDD | | 3 | MCS13, 52PRB | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-2.1 FDD  R.PDSCH. 1-1.2 HD-FDD |   **NTN eRedCap 1Rx/2Rx UE without baseband bandwidth reduction capability**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** | | 1 | MCS4, 52 | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD | | 2 | MCS13, 40 | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-12.3 FDD  R.PDSCH.1-2.4 HD-FDD | | 3 | MCS4, 52 | NTN-TDLA100-200 | 16 | 1x2 | New FRC for FDD  New FRC for HD-FDD | | 4 | MCS13, 40 | NTN-TDLC5-200 | 16 | 1x2 | R.PDSCH.1-12.3 FDD  R.PDSCH.1-2.4 HD-FDD |   **NTN eRedCap 1Rx/2Rx UE with baseband bandwidth reduction capability**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** | | 1 | MCS4, 25 | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD | | 2 | MCS13, 25 | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-25.1 FDD  R.PDSCH.1-2.3 HD-FDD | | 3 | MCS4, 25 | NTN-TDLA100-200 | 16 | 1x2 | New FRC for FDD  New FRC for HD-FDD | | 4 | MCS13, 25 | NTN-TDLC5-200 | 16 | 1x2 | R.PDSCH.1-25.1 FDD  R.PDSCH.1-2.3 HD-FDD | |
| R4-2513603 | Apple | **Observation 1: It is unclear what reusing FRC from 38.101-4 means.**  **Observation 2: All requirements defined in 38.101-5 would need a corresponding FRC in 38.101-5.**  **Observation 3: HD-FDD test cases in 38.101-5 would need a new FRC based on test configuration.**  **Proposal 1: Define new FRCs for HD-FDD test cases applicable to RedCap and eRedCap.** |
| R4-2513960 | Ericsson | **Proposal 1: Define a new HD-FDD reference channel for MCS4/52PRB tests, e.g. configure 12 DM-RS REs**  **Proposal 2: Reuse R.PDSCH.1-25.1 FDD and R.PDSCH.1-2.3 HD-FDD in TS38.101-4 for NR NTN eRedCap UEs with reduced bandwidth**  **Proposal 3: Open to consider applying the NGSO model for Rel-19 NTN enhancement requirements to (e)RedCap UE PDSCH demodulation requirements.** |
| R4- 2513961 | Ericsson | Simulation results |
| R4-2514485 | QUALCOMM Europe Inc. - Spain | **Observation 1: The Rel-19 NTN channel model for NGSO enables realistic UE testing by incorporating dynamic satellite propagation, thereby addressing the limitations of the Rel-17 model, which is constrained by assumptions of fixed Doppler shift and propagation delay.**  **Proposal 1: Define demodulation performance requirements for Redcap/eRedCap UEs with Rel-19 NTN channel model in NGSO scenarios.** |

## Open issues summary

Last RAN4 meeting agreements in the WF R4-2512644

**Sub-topic 3-1 RedCap and eRedCap demodulation for NTN**

Issue 3-1-1: FRC for HD-FDD RedCap/eRedCap demodulation

**Sub-topic 3-2 Channel Model for requirements**

Issue3-2-1: Applicability of time-varying Doppler shift and time-varying channel model to NTN RedCap/eRedCap demodulation requirements.

### Sub-topic 3-1 RedCap and eRedCap demodulation for NTN

**Issue 3-1-1: FRC for HD-FDD RedCap/eRedCap demodulation**

* Observations
  + Observation 1 (Apple):
    - It is unclear what reusing FRC from 38.101-4 means
    - All requirements defined in 38.101-5 would need a corresponding FRC in 38.101-5
    - HD-FDD test cases in 38.101-5 would need a new FRC based on test configuration
* Proposals
  + Option 1 (Apple): Define new FRCs for HD-FDD test cases applicable to RedCap and eRedCap.
  + Option 2 (Huawei, MTK): Use DMRS 1+1 for NTN RedCap and eRedCap UE requirements and introduce new FRCs for cases of MCS4/52PRB
    - Test cases

**NTN RedCap 1Rx**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** |
| 1 | MCS4, 52PRB | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 2 | MCS4, 52PRB | NTN-TDLC5-200 | 32 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 3 | MCS13, 52PRB | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-2.1 FDD  R.PDSCH. 1-1.2 HD-FDD |

**NTN eRedCap 1Rx/2Rx UE without baseband bandwidth reduction capability**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** |
| 1 | MCS4, 52 | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 2 | MCS13, 40 | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-12.3 FDD  R.PDSCH.1-2.4 HD-FDD |
| 3 | MCS4, 52 | NTN-TDLA100-200 | 16 | 1x2 | New FRC for FDD  New FRC for HD-FDD |
| 4 | MCS13, 40 | NTN-TDLC5-200 | 16 | 1x2 | R.PDSCH.1-12.3 FDD  R.PDSCH.1-2.4 HD-FDD |

**NTN eRedCap 1Rx/2Rx UE with baseband bandwidth reduction capability**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** |
| 1 | MCS4, 25 | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 2 | MCS13, 25 | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-25.1 FDD  R.PDSCH.1-2.3 HD-FDD |
| 3 | MCS4, 25 | NTN-TDLA100-200 | 16 | 1x2 | New FRC for FDD  New FRC for HD-FDD |
| 4 | MCS13, 25 | NTN-TDLC5-200 | 16 | 1x2 | R.PDSCH.1-25.1 FDD  R.PDSCH.1-2.3 HD-FDD |

* + Option 3 (Ericsson):
    - RedCap: Define a new HD-FDD reference channel for MCS4/52PRB tests, e.g. configure 12 DM-RS Res
    - eRedCap: Reuse R.PDSCH.1-25.1 FDD and R.PDSCH.1-2.3 HD-FDD in TS38.101-4 for NR NTN eRedCap UEs with reduced bandwidth
* Recommended WF
  + *Moderator note: All requirements defined in 38.101-5 would need a corresponding FRC in 38.101-5. For specific test case with MCS4/52 PRB, all companies proposed to define a new HD-FDD FRC for RedCap UEs,*
  + Use DMRS 1+1 for NTN RedCap and eRedCap UE requirements and introduce new FRCs for cases of MCS4/52PRB

**NTN RedCap 1Rx**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** |
| 1 | MCS4, 52PRB | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 2 | MCS4, 52PRB | NTN-TDLC5-200 | 32 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 3 | MCS13, 52PRB | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-2.1 FDD  R.PDSCH. 1-1.2 HD-FDD |

**NTN eRedCap 1Rx/2Rx UE without baseband bandwidth reduction capability**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** |
| 1 | MCS4, 52 | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 2 | MCS13, 40 | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-12.3 FDD  R.PDSCH.1-2.4 HD-FDD |
| 3 | MCS4, 52 | NTN-TDLA100-200 | 16 | 1x2 | New FRC for FDD  New FRC for HD-FDD |
| 4 | MCS13, 40 | NTN-TDLC5-200 | 16 | 1x2 | R.PDSCH.1-12.3 FDD  R.PDSCH.1-2.4 HD-FDD |

**NTN eRedCap 1Rx/2Rx UE with baseband bandwidth reduction capability**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test number** | **MCS/PRB** | **Channel model** | **HARQ process** | **Antenna configuration** | **Reference channel** |
| 1 | MCS4, 25 | NTN-TDLA100-200 | 16 | 1x1 | New FRC for FDD  New FRC for HD-FDD |
| 2 | MCS13, 25 | NTN-TDLC5-200 | 16 | 1x1 | R.PDSCH.1-25.1 FDD  R.PDSCH.1-2.3 HD-FDD |
| 3 | MCS4, 25 | NTN-TDLA100-200 | 16 | 1x2 | New FRC for FDD  New FRC for HD-FDD |
| 4 | MCS13, 25 | NTN-TDLC5-200 | 16 | 1x2 | R.PDSCH.1-25.1 FDD  R.PDSCH.1-2.3 HD-FDD |

### Sub-topic 3-2 Channel Model for requirements

**Issue 3-2-1: Applicability of time-varying Doppler shift and time-varying channel model to NTN RedCap/eRedCap demodulation requirements.**

* Observations
  + Observation 1 (QC): The Rel-19 NTN channel model for NGSO enables realistic UE testing by incorporating dynamic satellite propagation, thereby addressing the limitations of the Rel-17 model, which is constrained by assumptions of fixed Doppler shift and propagation delay.
* Proposals
  + Option 1 (Ericsson): Open to consider applying the NGSO model for Rel-19 NTN enhancement requirements to (e)RedCap UE PDSCH demodulation requirements.
  + Option 2 (QC): Define demodulation performance requirements for Redcap/eRedCap UEs with Rel-19 NTN channel model in NGSO scenario
* Recommended WF
  + *Moderator note: Rel-19 WI NR\_IoT\_NTN\_req\_test\_enh has completed the DL Doppler shift and propagation delay modeling with NGSO satellite and RAN4 is discussing the performance impact to the existing Rel-17 NTN PDSCH demodulation requirements if the model is applied. As agreed, additional margin added for NR NTN PDSCH requirement with selected cases. The NGSO channel model should be the common issue for all the NTN related requirements, not only (e)RedCap UEs. If it is also applied, companies also need to discuss the demod impact and whether additional margin will be considered*
  + Further discussion

# Recommend for Tdoc

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Recommend** |
| R4-2513399 | Samsung, | noted |
| R4-2513439 | Huawei,HiSilicon | noted |
| R4-2514138 | Ericsson | noted |
| R4-2514139 | Ericsson | noted |
| R4-2514145 | ZTE Corporation, Sanechips | noted |
| R4-2514146 | ZTE Corporation, Sanechips | noted |
| R4-2514288 | Nokia | noted |
| R4-2513231 | CATT | noted |
| R4-2513396 | Samsung | noted |
| R4-2513440 | Huawei | noted |
| R4-2513960 | Ericsson | noted |
| R4-2513961 | Ericsson | noted |
| R4-2513547 | MediaTek inc | noted |
| R4-2513603 | Apple | noted |
| R4-2514485 | QUALCOMM Europe Inc. - Spain | noted |