**3GPP TSG-RAN WG4 Meeting #110bis R4-2405845**

**Changsha, China, 15th – 19th April, 2024**

**Agenda item:** 6.17.3

**Source:** Moderator (China Telecom)

**Title:** Topic summary for [110bis][326] NR\_cov\_enh2\_demod

**Document for:** Information

# Introduction

This contribution summarizes the open issues, candidate options as well as the recommended WF for the performance part for the Rel-18 further coverage enhancement WI under agenda 6.17.2.

# Topic #1: Multiple PRACH transmission reuqirements (Open Issues)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2404132 | Nokia | Observation 1: The difference between the performance of 2 and 4 repetitions can be seen to be of the order of 2dB.Proposal 1: RAN4 shall define requirements for both 2 and 4 PRACH repetitions.Observation 2: Simulation assumptions are included as an annex in our companion TDocObservation 3: Despite a small number of commercial deployments of 60 kHz SCS for FR2-1, this is the minimum SCS for FR2-1 as such requirements are needed.Proposal 2: RAN4 shall define requirements for 60 kHz SCS.Proposal 3: RAN4 shall use the candidate option identified in the WF from RAN4#110 for Timing Error tolerance.Proposal 4: RAN4 shall use the candidate option identified in the WF from RAN4#110 for manufacturer declaration.Proposal 5: RAN4 shall use the candidate option identified in the WF from RAN4#110 for an applicability rule. |
| R4-2404134 | Nokia | Simulations for Coverage Enhancement BS Demodulation |
| R4-2404387 | China Telecom | Proposal 1: For Format A2 and C2, PRACH repetitions can be occurred within the same slot. For Format B4, PRACH repetitions can be occurred within the time consecutive slots if time consecutive RO configuration is reasonable from infra vendors’ perspective.Proposal 2: Test 2 repetitions in case reasonable performance gain can be shown over the baseline (i.e., no PRACH repletion).Proposal 3: Reuse the same configuration for the existing PRACH normal mode tests, i.e., cover 60kHz SCS and 120kHz SCS for FR2.Proposal 4: For timing error tolerance for PRACH repetition. reuse the same value for other PRACH performance requirements.Proposal 5: Use the above candidate option as the manufacturer declarations for PRACH repetition test requirements.Proposal 6: Use the above candidate option as the applicability for PRACH repetition test requirements. |
| R4-2404388 | China Telecom | Summary of simulation results for Rel-18 NR coverage enhancements BS demodulation requirements |
| R4-2405123 | Huawei, HiSilicon | Proposal 1: Do not consider 60kHz in FR2-1 for PRACH requirements.Proposal 2: For the timing error tolerance for PRACH repetition test requirements, we confirm to use the candidate option in the WF.Proposal 3: For the manufacturer declarations for PRACH repetition test requirements, we confirm to use the candidate option in the WF.Proposal 4: For the applicability for PRACH repetition test requirements, we confirm to use the candidate option in the WF.Proposal 5: Suggest to align PRACH Config Index in simulation results alignment. |
| R4-2405124 | Huawei, HiSilicon | Simulation results on BS demodulation requirements for further coverage enhancements |
| R4-2405201 | ZTE | Simulation results for multiple PRACH |
| R4-2405202 | ZTE | Proposal 1. To consider the following TDD pattern for multiple PRACH.3D1S1U for 15KHz, 60kHz and 120kHz7D1S2U for 30kHzProposal 2. To consider the following PRACH repetition interval for multiple PRACH.5 slots for 15KHz, 60kHz and 120kHz1 slot for 30kHzProposal 3. To consider both 120kHz and 60kHz for FR2-1 multiple PRACH requirements. |
| R4-2405550 | Ericsson | Observation 1 Only PRACH configuration indexes for FDD frame structure are used in LTE CE demodulation requirements.Observation 2 The time interval between repetitions in LTE CE demodulation requirements is 10ms.Observation 3 Different SSB implementation would have different impact on SSB index and RO relationship.Observation 4 The performance difference can reach to 2.3dB between the minimum interval (1 slot) and the large interval.Observation 5 The performance gets constant when the interval is larger than a certain value, e.g., 10ms for FR1 and 5ms for FR2-1.Observation 6 Different PRACH configuration indexes are used for FR1 paired spectrum (FDD) and unpaired spectrum (TDD).Observation 7 Different PRACH configuration indexes are used for frame structures of different SCS.Observation 8 It is general that there are multiple PRACH occasions in a subframe for FR1 or a 60kHz slot for FR2-1.Observation 9 No PRACH configuration index for B4 in FR1 paired spectrum (FDD) can be applied in 15kHz SCS frame structure.Observation 10 A note on how to choose PRACH configuration index for different TDD patterns might be needed.Based on the discussion in the previous sections we propose the following:Proposal 1 Keep the previous agreement to use 2 repetitions for multiple PRACH transmission demodulation requirements.Proposal 2 Only consider PRACH configuration index for typical TDD pattern in demodulation requirements to avoid complexity.Proposal 3 Only use the first PRACH occasion in each PRACH group.Proposal 4 Use PRACH configuration index with 10ms interval for FR1 and 5ms interval for FR2-1 between two PRACH repetitions.Proposal 5 Consider following configurations as the start point of discussion for PRACH repetition demodulation requirements to cover typical TDD pattern.• Set ssb-perRACH-Ocassion =1 if necessary.• FR1 TDD:o Take PRACH Configuration Indexes {100, 159, 202} for A2, B4 and C2 respectively.o No msg1-RepetitionTimeOffsetROGroup is configured.• FR2-1 TDD:o Take PRACH Configuration Indexes {41, 135, 185} for A2, B4 and C2 respectively.o For A2 and C2, no msg1-RepetitionTimeOffsetROGroup is configured.o For B4, msg1-RepetitionTimeOffsetROGroup = n4 is configured.Proposal 6 Check with TE vendors on corresponding limitations of implementation.Proposal 7 Don’t consider 60kHz SCS requirements to save effort.Proposal 8 Take following manufactory declarations for conducted conformance tests and radiated conformance tests separately.Proposal 9 Take candidate applicability rule above for PRACH repetition demodulation requirements in separate section in specification.Proposal 10 Add a note to the requirement table to indicate the applicability for other TDD patterns. |
| R4-2405551 | Ericsson | Simulation results for Rel-18 NR PRACH repetitions demodulation requirements |
| R4- 2405862 | Samsung | Proposal 1: only consider 120KHz SCS for specifying the PRACH requirementObservation 1: PRACH configuration index was defined for requirements derivation for LTE eMTC coverage enhancement. The interval between two ROs is 10msProposal 2: Similar as LTE eMTC, applying the interval between two ROs as 10ms for requirement derivation of PRACH with repetition transmission. Proposal 3: The following principle can be considered for choosing PRACH configuration index - Msg1-FDM =1- ssb-perRACH-Occasion =four (one to one mapping)- TDD pattern- 15KHz: 3D1S1U- 30KHz: 7D1S2U- 120KHz: 3D1S1U- Less ROs are transmitted within 10ms, e.g., less than 8 Proposal 4: The following PRACH configuration index can be considered as - 15KHz SCS- Format A2- PRACH configuration index, 127, number of RO within 10ms =3, number of SSB within 10ms=3- Format B4- PRACH configuration index, 210, number of RO within 10ms =1, number of SSB within 10ms=1- Format C2- PRACH configuration index, 246, number of RO within 10ms =2, number of SSB within 10ms=2- 30KHz SCS- Format A2- PRACH configuration index 96, number of RO within 10ms =3, number of SSB within 10ms=3- Format B4- PRACH configuration index, 156, number of RO within 10ms =1, number of SSB within 10ms=1- Format C2- PRACH configuration index, 201, number of RO within 10ms =2, number of SSB within 10ms=2- 120KHz SCS- Format A2- PRACH configuration index 41, number of RO within 10ms=4, number of SSB within 10ms =4- Format B4- PRACH configuration index, 124, number of RO within 10ms=4, number of SSB within 10ms =4- Format C2- PRACH configuration index, 185, number of RO within 10ms =4, number of SSB within 10ms=4 |

## Open issues summary

**Issue 1-1: PRACH repetition number for BS performance requirements for Multiple PRACH transmission**

* Status in the WF R4-2321061 in RAN4#109:

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| * + *PRACH repetition number 2, with companies encouraged to provide simulations to confirm gain at RAN4#110.*
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* Status in the WF R4-2402866 in RAN4#110:

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| * + *For the repetition number, keep the previous meeting agreement before simulation assumption agreed.*
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* Proposals:
	+ Option 1: Consider both 2 and 4 PRACH repetitions (Nokia)
	+ Option 2: Consider 2 PRACH repetitions (Ericsson, [Huawei, ZTE], China Telecom in case reasonable performance gain can be shown)
* Summary of companies’ simulation results with repetition number = 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| PRACH FR1 1T2R | Propagation condition | Frequency offset (Hz) | Ericsson | Huawei | ZTE | Samsung | **Average** ideal simulation results w/o PRACH repetition (Copied from Rel-15 R4-1907932) |
| Format A2 | 15kHz | AWGN | 0 | -17.4 | -19.1 | -18.5 | -16.85 | -14.6 |
| TDLC300-100 Low | 400 | -11.3 | -11.6 | -11.1 | -10.54 | -7.2 |
| 30kHz | AWGN | 0 | -17.5 | -19.2 | -18.5 | -16.78 | -14.4 |
| TDLC300-100 Low | 400 | -11.4 | -11.7 | -12.9 | -12.11 | -8.1 |
| Format B4 | 15kHz | AWGN | 0 |  | -20.1 | -21.7 | -21.62 | -18.7 |
| TDLC300-100 Low | 400 | -15.7 | -14.8 | -13 | -15.32 | -11.0 |
| 30kHz | AWGN | 0 |  | -20.6 | -21.7 | -21.43 | -18.6 |
| TDLC300-100 Low | 400 | -16.2 | -15.2 | -17.1 | -16.58 | -12.0 |
| Format C2 | 15kHz | AWGN | 0 |  | -19.1 | -18.6 | -16.8 | -14.6 |
| TDLC300-100 Low | 400 | -11.6 | -11.3 | -11.2 | -10.67 | -7.3 |
| 30kHz | AWGN | 0 |  | -19.3 | -18.6 | -16.69 | -14.3 |
| TDLC300-100 Low | 400 | -11.3 | -11.8 | -12.7 | -12.3 | -8.0 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PRACH FR2-1 1T2R | Propagation condition | Frequency offset (Hz) | Nokia | Ericsson | Huawei | ZTE | Samsung | **Average** ideal simulation results w/o PRACH repetition (Copied from Rel-15 R4-1907932) |
| Format A2 | 60kHz | AWGN | 0 | -18.7 | -17.9 | -18.9 | -17 | -16.65 | -14.4 |
| TDLA30-300 Low | 4000 | -11.1 | -10.3 | -9.9 | -10.5 | -10.88 | -6.4 |
| 120kHz | AWGN | 0 | -18.8 | -17.7 | -18.8 | -18.6 | -16.70 | -14.1 |
| TDLA30-300 Low | 4000 | -12.1 | -10.6 | -11.4 | -11.3 | -11.81 | -6.9 |
| Format B4 | 60kHz | AWGN | 0 | -23.5 | -22.2 | -20 | -21.7 | -20.90 | -18.5 |
| TDLA30-300 Low | 4000 | -4.8 |  | -12.9 | -11.1 | -13.76 | -6.1 |
| 120kHz | AWGN | 0 | -23.5 | -22.2 | -19.7 | -21.7 | -20.90 | -18.3 |
| TDLA30-300 Low | 4000 | -14.8 | -12.8 | -14.7 | -13.8 | -15.45 | -10.0 |
| Format C2 | 60kHz | AWGN | 0 | -18.7 | -17.8 | -19.1 | -17 | -16.64 | -14.3 |
| TDLA30-300 Low | 4000 | -11.4 | -10.6 | -10.1 | -10.6 | -10.92 | -6.5 |
| 120kHz | AWGN | 0 | -18.8 | -17.7 | -18.9 | -18.6 | -16.61 | -14.0 |
| TDLA30-300 Low | 4000 | -12.3 | -10.9 | -11.2 | -11.3 | -11.69 | -6.8 |

* Recommended WF
	+ Based on the companies’ simulation results, the performance gain for repetition number = 2 can be confirmed.
	+ Agree PRACH repetition number 2 based on previous agreements.

**Issue 1-2: PRACH repetition interval and TDD pattern for Multiple PRACH transmission**

* Status in the WF R4-2402866 in RAN4#110:

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| * + *Companies to further check the simulation assumptions including TDD pattern, PRACH repetition interval for both FR1 and FR2.*
 |

* TDD pattern for requirement definition:
	+ Proposal 1: 3D1S1U for 15KHz, 60kHz and 120kHz, 7D1S2U for 30kHz (ZTE, Samsung)
* Proposals on PRACH repetition interval:
	+ Proposal 1: For Format A2 and C2, PRACH repetitions can be occurred within the same slot. For Format B4, PRACH repetitions can be occurred within the time consecutive slots if time consecutive RO configuration is reasonable from infra vendors’ perspective. (China Telecom)
	+ Proposal 2: 5 slots for 15KHz, 60kHz and 120kHz, 1 slot for 30kHz (ZTE)
	+ Proposal 3: 10ms interval for FR1 and 5ms interval for FR2-1 (Ericsson)
	+ Proposal 4: applying the interval between two ROs as 10ms (Samsung)
* Detailed PRACH configuration:
	+ Ericsson:
		- FR1 TDD:
* Take PRACH Configuration Indexes {100, 159, 202} for A2, B4 and C2 respectively.
* No msg1-RepetitionTimeOffsetROGroup is configured.
	+ - FR2-1 TDD:
* Take PRACH Configuration Indexes {41, 135, 185} for A2, B4 and C2 respectively.
* For A2 and C2, no msg1-RepetitionTimeOffsetROGroup is configured.
* For B4, msg1-RepetitionTimeOffsetROGroup = n4 is configured.
	+ Huawei:
		- PRACH configuration index for FR1 and paired spectrum: A2: 135 | B4: 217 | C2: 254
		- PRACH configuration index for FR2 and unpaired spectrum: A2: 58 | B4: 143 | C2: 201
	+ Samsung:
		- 15KHz SCS
* Format A2: PRACH configuration index, 127, number of RO within 10ms =3, number of SSB within 10ms=3
* Format B4: PRACH configuration index, 210, number of RO within 10ms =1, number of SSB within 10ms=1
* Format C2: PRACH configuration index, 246, number of RO within 10ms =2, number of SSB within 10ms=2
	+ - 30KHz SCS
* Format A2: PRACH configuration index 96, number of RO within 10ms =3, number of SSB within 10ms=3
* Format B4: PRACH configuration index, 156, number of RO within 10ms =1, number of SSB within 10ms=1
* Format C2: PRACH configuration index, 201, number of RO within 10ms =2, number of SSB within 10ms=2
	+ - 120KHz SCS
* Format A2: PRACH configuration index 41, number of RO within 10ms=4, number of SSB within 10ms =4
* Format B4: PRACH configuration index, 124, number of RO within 10ms=4, number of SSB within 10ms =4
* Format C2: PRACH configuration index, 185, number of RO within 10ms =4, number of SSB within 10ms=4
* Recommended WF
	+ Discussion needed.

**Issue 1-3: Sub Carrier Spacing for BS performance requirements for PRACH repetitions**

* Status in the WF R4-2402866 in RAN4#110:

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| * + *For FR1: 15kHz and 30kHz*
	+ *For FR2-1: Agree with 120 kHz and FFS for 60 kHz. Encourage operators to provide input.*
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* Proposals for FR2-1:
	+ Option 1: Cover 60kHz SCS and 120kHz SCS (China Telecom, Nokia, ZTE)
	+ Option 2: 120kHz only (Huawei, Ericsson, Samsung)
* Recommended WF
	+ Decision needed.

**Issue 1-4: Timing error tolerance for PRACH repetition test requirements**

* Status in the WF R4-2402866 in RAN4#110:

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| * + *FR1:*

|  |  |  |
| --- | --- | --- |
| *PRACH* | *PRACH SCS* | *Time error tolerance* |
| *preamble* | *(kHz)* | *AWGN* | *TDLC300-100* |
| *B4, A2, C2* | *15* | *0.52 us* | *2.03 us* |
|  | *30* | *0.26 us* | *1.77 us* |

* + *FR2-1*

|  |  |  |
| --- | --- | --- |
| *PRACH* | *PRACH SCS* | *Time error tolerance* |
| *preamble* | *(kHz)* | *AWGN* | *TDLA30-300* |
| *B4, A2, C2* | *60* | *0.13 us* | *0.28 us* |
|  | *120* | *0.07 us* | *0.22 us* |

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* Proposals:
	+ FR1:
		- Option 1: (Nokia, Huawei, Ericsson, [Samsung], China Telecom, Same as the legacy PRACH tests in Table 8.4.2.1-1 of TS38.104)

|  |  |  |
| --- | --- | --- |
| PRACH   | PRACH SCS   | Time error tolerance  |
| preamble  | (kHz)  | AWGN  | TDLC300-100  |
| B4, A2, C2 | 15  | 0.52 us  | 2.03 us  |
|   | 30  | 0.26 us  | 1.77 us  |

* + FR2-1
		- Option 1: (Nokia, Huawei, Ericsson, China Telecom, [Samsung], Same as the legacy PRACH tests in Table 11.4.2.2-1 of TS38.104)

|  |  |  |
| --- | --- | --- |
| PRACH   | PRACH SCS   | Time error tolerance  |
| preamble  | (kHz)  | AWGN  | TDLA30-300  |
| B4, A2, C2 | 60  | 0.13 us  | 0.28 us  |
|   | 120  | 0.07 us  | 0.22 us  |

* Recommended WF
	+ The above options seem agreeable.

**Issue 1-5: Manufacturer declarations for PRACH repetition test requirements**

* Status in the WF R4-2402866 in RAN4#110:

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| *Declaration* | *Description* | *Applicability**(Note 1)* |
| --- | --- | --- |
|  |  | *BS type 1-H**(Note 2)* | *BS type 1-O* | *BS type 2-O* |
| *PRACH format and SCS for Multiple PRACH transmission* | *Declaration of the supported PRACH format(s) as specified in TS 38.211 for Multiple PRACH transmission, i.e., format: A2, B4, C2.**Declaration of the supported SCS(s) per supported PRACH format with short sequence for Multiple PRACH transmission, as specified in TS 38.211, i.e.:* *- For BS type 1-O: 15 kHz, 30 kHz or both.**- For BS type 2-O: 60 kHz, 120 kHz or both.* | *c* | *x* | *x* |

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* Proposals:
	+ Option 1 (Nokia, China Telecom, Huawei)

| **Declaration identifier** | **Declaration** | **Description** | **Applicability****(Note 1)** |
| --- | --- | --- | --- |
|  |  |  | **BS type 1-H****(Note 2)** | **BS type 1-O** | **BS type 2-O** |
|  | PRACH format and SCS for Multiple PRACH transmission | Declaration of the supported PRACH format(s) as specified in TS 38.211 for Multiple PRACH transmission, i.e., format: A2, B4, C2.Declaration of the supported SCS(s) per supported PRACH format with short sequence for Multiple PRACH transmission, as specified in TS 38.211, i.e.: - For BS type 1-O: 15 kHz, 30 kHz or both.- For BS type 2-O: 60 kHz, 120 kHz or both. | c | x | x |

* + Option 2: Only mention applied formats A2, B4, C2 in the declaration (Ericsson)
		- E///: There already has declaration for SCS (D.14), so it is no need to duplicate SCS declaration here.
* Recommended WF
	+ Encourage feedback on option 2.

**Issue 1-6: Applicability for PRACH repetition test requirements**

* Status in the WF R4-2402866 in RAN4#110:

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| --- |
| *Applicability of requirements for different formats**Unless otherwise stated, Multiple PRACH transmission requirements shall apply only for each PRACH format declared to be supported.**Applicability of requirements for different subcarrier spacings**Unless otherwise stated, for each PRACH format with short sequence for Multiple PRACH transmission requirements declared to be supported, for each FR, the tests shall apply only for the smallest supported subcarrier spacing in the FR.* *Applicability of requirements for different channel bandwidths**Unless otherwise stated, for the subcarrier spacing to be tested, Multiple PRACH transmission requirements shall apply only for anyone channel bandwidth declared to be supported.* |

* Proposals:
	+ Option 1 (Nokia, China Telecom, Huawei, Ericsson)

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| --- |
| Applicability of requirements for different formatsUnless otherwise stated, Multiple PRACH transmission requirements shall apply only for each PRACH format declared to be supported.Applicability of requirements for different subcarrier spacingsUnless otherwise stated, for each PRACH format with short sequence for Multiple PRACH transmission requirements declared to be supported, for each FR, the tests shall apply only for the smallest supported subcarrier spacing in the FR. Applicability of requirements for different channel bandwidthsUnless otherwise stated, for the subcarrier spacing to be tested, Multiple PRACH transmission requirements shall apply only for anyone channel bandwidth declared to be supported. |

* Recommended WF
	+ Option 1 can be agreeable.

**Issue 1-7: Additional applicability for different TDD patterns**

* Proposals:
	+ Option 1 (Ericsson)

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| Note: Under fading channel, the PRACH detection performance may be significantly different with different PRACH Configuration Indexes. The requirements in this table are defined based on the simulation results with PRACH Configuration Indexes {[100], [159], [202]} for format A2, B4 and C2 respectively with UL-DL configuration DDDSU. The requirement could be applied for other TDD pattern if the time interval between repetitions is >=10ms by selected PRACH Configuration index and msg1-RepetitionTimeOffsetROGroup. |

* Recommended WF
	+ Related to the discussion outcome in Issue 1-2.

# Topic #2: Multiple PRACH transmission reuqirements (Draft CRs)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Draft CR on** |
| R4-2404133 | Nokia | [NR\_cov\_enh2-Perf] DraftBigCR for TS 38.104 |
| R4-2404135 | Nokia | [NR\_cov\_enh2-Perf] draftCR for 38.141-2, update to PRACH Preambles |
| R4-2404389 | China Telecom | Draft CR on multiple PRACH transmission BS performance requirements for FR1 |
| R4-2404390 | China Telecom | Draft big CR for further coverage enhancements requirements for TS38.141-2 |
| R4-2405125 | Huawei, HiSilicon | Draft CR on manufacturer declarations and applicability of PRACH performance requirements for Multiple PRACH transmission (TS38.141-1, Rel-18) |
| R4-2405126 | Huawei, HiSilicon | Draft CR on manufacturer declarations and applicability of PRACH performance requirements for Multiple PRACH transmission (TS38.141-2, Rel-18) |
| R4-2405199 | ZTE Corporation | Draft CR on 38.104 Test preambles for multiple PRACH with repetition |
| R4-2405200 | ZTE Corporation | Draft CR on 38.141-1 Test preambles for multiple PRACH with repetition |
| R4-2405552 | Ericsson | (NR\_cov\_enh2-Perf) Draft CR for 38.104 on FR2-1 multiple PRACH transmission demodulation requirements |
| R4-2405553 | Ericsson | (NR\_cov\_enh2-Perf) Draft CR for 38.141-1 on FR1 multiple PRACH transmission demodulation requirements |
| R4-2405861 | Samsung | Draft CR on test requirements for multiple PRACH transmission in TS 38.141-2 |
| R4-2405871 | Samsung | Draft big CR on test requirements for multiple PRACH transmission in TS 38.141-1 |

## Open issues

**Issue 2-1: Draft CR review**

* Companies to provide comments and response under e-mail thread [110bis][326] NR\_cov\_enh2\_demod – draft CR review.