3GPP TSG RAN WG1 #116 R1-240xxxx

Athens, Greece, February 26 – March 1, 2024

Agenda Item: 8.4

Source: Moderator (Nokia)

Title: Feature lead summary 1 on FR2-NTN discussions

Document for: Discussion

# Introduction

At RAN1#113, RAN1 received an LS from RAN4 on the potential support of NR over NTN for the frequency bands defined as part of FR2-NTN [1]. The LS was not treated at RAN1#113, but at RAN1#114 there was a contribution discussing some of the aspects related to the operation of NR over NTN for frequency bands defined as part of FR2-NTN [17]. At RAN1#114-bis there were further discussions on the topic, with some conclusions/working assumptions being reached, which were followed by a few conclusions at RAN1#115. These are outlined at the end of this document (extracted from chairman minutes available at the end of the meetings). The latest moderator summary from RAN1#116 is located in [2].

## Guidelines for the discussion.

The summary is split into two main parts;

* The discussion of open topic (**Section 2**), where the topics that have been raised for this meeting are discussed. Since we need to integrate the agreements on capturing FR2-NTN operation into specifications.
* Discussion on text proposals (**Section 7**) to capture the existing agreements to specifications. Each specification with targeted changes is listed in this section, where it is possible to provide comments and indicate whether companies want to co-source the final CR.

As this topic is expected to have very little time for offline and online discussions it is preferable that the comments are provided already before:

**1st round deadline: Monday 15th of April, 19.00 Local time.**

## Reserved tdoc numbers

This moderator summary is targeted at discussing various aspects related to this topic.

Table to be filled with reserved Tdoc numbers for this contribution when needed:

|  |  |
| --- | --- |
| R1-2403083 | Feature lead summary 1 on FR2-NTN discussions |
| R1-2403084 | Feature lead summary 2 on FR2-NTN discussions |

# Discussion

## Background

The considered bands for operation are n510, n511 and n512, which are defined as follows [1]:

|  |  |  |
| --- | --- | --- |
| **NTN operating band** | **UL**  **Earth-to-Space** | **DL**  **Space-to-Earth** |
| n5121 | 27.5 - 30.0 GHz | 17.3 - 20.2 GHz |
| n5112 | 28.35 - 30.0 GHz | 17.3 - 20.2 GHz |
| n5103 | 27.5 - 28.35 GHz | 17.3 - 20.2 GHz |
| Note 1: This band is applicable in the countries subject to CEPT ECC Decision(05)01 and ECC Decision (13)01.  Note 2: This band is applicable in the USA subject to FCC 47 CFR part 25.  Note 3: This band is applicable for Earth Station operations in the USA subject to FCC 47 CFR part 25. FCC rules currently do not include ESIM operations in this band (47 CFR 25.202). | | |

Operation in such bands for NR over NTN may potentially face a number of challenges, which will be discussed in the following. Companies are encouraged to provide their views in the relevant tables.

## Topic 1: PRACH configuration [open]

At the last RAN1#116 meeting there was a conclusion:

**Conclusion**

RAN1 will decide at RAN1#116bis on whether to reuse Table 6.3.3.2-4 of TS 38.211 without modification for NR over NTN for FR2-NTN in Rel-18, or to reuse the table with modifications.

This means that the working group need to reach an agreement on whether to reuse the table without modifications or to reuse the table with modifications.

From the proposals that have been submitted for this meeting, there are three general directions:

* Reuse Table 6.3.3.2-4 without modification.
  + **Supported by (8 companies)**: Vivo, OPPO, Huawei, HiSilicon, ZTE, Nokia, Nokia Shanghai Bell, Apple
* Reuse Table 6.3.3.2-4 with modification of starting symbol for entries with non-zero value and extend the number of ROs in a slot.
  + **Supported by (4 companies)**: Ericsson, (Thales – through co-signed draft CR), NTT DOCOMO (though not mentioning extending the number of ROs in a slot), Sharp (though not mentioning extending the number of ROs in a slot),
* Reuse Table 6.3.3.2-4 with replacing entire rows with new configurations for Frame index and slot index/indices, starting symbol of RO, Number of PRACH slots within a 60 kHz slot, as well as extending the number or RO in a slot.
  + **Supported by (1 company)**: Thales

Based on the above indications (and based on discussions in the past meetings) it is the moderator understanding that it is better to target reusing Table 6.3.3.2-4 from TS 38.211 without modification, which leads to the following proposal:

**Proposal 2.2-1 for agreement:**

**For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is used without modification.**

Please provide views on this proposal here and please be aware that we are supposed to reach consensus at this meeting:

|  |  |  |
| --- | --- | --- |
| **Companies** | **Support/Not support** | **Comments and Views** |
| vivo | agree | NW can select the proper entries that are applicable to FR2-NTN, there is need for further enhancement. |
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### Summary of views on Topic 1:

## Topic 2: Common TA related aspects [open]

As part of the Rel-17 discussions for NR over NTN, there was a long discussion on how the Common TA should be modelled. In general, the Common TA is used to describe the non-linear development of the feeder link delay (as well as potential additional delays that may be seen in the system). The end result from the Rel-17 discussions was that a polynomial description of the Common TA would be sufficient, where it was agreed that 0th, 1st and 2nd order derivatives of the Common TA would be provided by the gNB along with an “Epoch time”, which would allow the UE to make a model of the time-wise development of the Common TA as a function of elapsed time from the Epoch time. The equation for estimating the Common TA is captured in TS 38.213, section 4.2.

At RAN1#114-bis and further in RAN1#115 as well as during RAN1#116 multiple views were presented, but the discussion did not really progress. For this meeting, the views may be outlined as follows:

* Use/introduce 3rd order derivative (3 companies): Ericsson, NTT DOCOMO, Thales
* No need for 3rd order derivative (6 companies): Huawei, HiSilicon, ZTE, Nokia, Nokia Shanghai Bell, Apple

From moderators reading, the arguments provided at this meeting (as well as the views presented at RAN1#114-bis, RAN1#115 and RAN1#116) are more or less the same as were presented at the Rel-17 NR over NTN discussions. It appears that there is not any strong consensus for introducing enhancements to the Common TA modeling.

**Proposal 2.3-1 for conclusion:**

**RAN1 concludes that it is not possible to reach consensus on any enhancements to the Common TA modelling for operation in FR2-NTN.**

Please provide views below while keeping in mind that we need to reach a conclusion on this topic at this meeting.

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| --- | --- | --- |
| **Companies** | **Support/Not support** | **Comments and Views** |
| vivo | agree | This issue has been discussed for several meeting without consensus, we don’t see a strong need to enhance common TA in such late stage. |
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### Summary of views on Topic 2:

## Topic 3: Timing advance for UE updating information from SIB19 [open]

In [9] the aspect of the UE reading the SIB19 and starting to apply this information is raised. In the contribution it is illustrated that whenever a UE reads new information from the SIB19 (whether it being the Common TA parameters or the satellite ephemeris information would cause the same effect), there is a risk that a UE’s old transmit timing has been such that the gNB have provided dedicated TA commands to correct for systematic errors, and the reading of SIB19 and applying the new information (satellite ephemeris and Common TA related parameters) will cause a timing jump, where the old accumulated TA would carry over to the new transmit timing. This is illustrated in the below figure from [9].

A graph of a graph

Description automatically generated with medium confidence

Fig.1: TA error jump

In [9] it is proposed that the UE should reset its N\_TA value (initialize to zero) when new SIB19 parameters related to UE autonomous transmit timing is read (and applied).

This topic has been raised earlier with no progress (at least as part of the Rel-17 discussions). For operation in frequency bands covered by FR2-NTN, it is expected that the subcarrier spacing is larger, and hence the sensitivity towards timing error for the closed loop timing advance commands is correspondingly larger due to the shorter cyclic prefix. It should be noted that the transmit timing errors from RAN4 does not account for systematic modeling errors from the 2nd order polynomial description of the Common TA.

**Alternative 1:**

**Proposed conclusion 2.4-1:**

**For FR2-NTN, RAN1 cannot reach consensus on actions related to N\_TA for cases where a UE receives and applies updated information from SIB19.**

**Alternative 2.4-2:**

**Proposed agreement:**

**For FR2-NTN, whenever a UE receives and applies information from SIB19, the UE shall set N\_TA to zero.**

**NOTE: LS will be sent to RAN2 to ask them to provide indication mechanism to obtain information of when new SIB19 values are applied.**

**Question: Which of the alternatives would you support?**

Please provide views on this here:

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| **Companies** | **Alternative** | **Comments and Views** |
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### Summary of views on Topic 3:

## Topic 4: Timing accuracy requirements [open]

At RAN1#115 an LS was sent to RAN4, and for this meeting we have received a response. A few companies have discussed the LS response in their contributions, where the following opinions have been provided:

* No need for further discussions on timing accuracy requirements: Nokia, Nokia Shanghai Bell, Apple, (ZTE)
* Timing accuracy requirements are tight for FR2-NTN with higher SCS: Thales, Ericsson

**Proposal 2.5-1 for conclusion:**

**For FR2-NTN, RAN1 concludes that there is no need for enhancements related to increased timing accuracy requirements.**

Please provide views below.

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| **Companies** | **Support/Not support** | **Comments and Views** |
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### Summary of views on Topic 4:

## Topic 5: Other topics [open]

In case there are additional topics that may need to be discussed in this context or not captured by the moderator, please provide these below with some added explanation such that this may be further considered in the next round of discussions.

**View 5-1: Anything additional that would need to be considered for NR over NTN for FR2-NTN?**

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| **Companies** | **Topics that need further consideration** |
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### Summary of views on Topic 5:

No topics were raised during this first round of comments – suggesting to close this section.

# Summary

To be filled with summary after discussions.

# Collection of observations and proposals submitted for RAN1#116

|  |  |
| --- | --- |
| [R1-2402214](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402214.zip), vivo | ***Proposals 1:***   * ***Support to reuse the table 6.3.3.2-4 of TS 38.211 without modification for PRACH configuration operation in FR2-NTN.*** |
| [R1-2402310](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402310.zip), OPPO | **Observation : Further optimization for PRACH configuration for R18 at this late stage of the maintenance phase is not recommended according to chairman’s guidance.**  **Proposal : RAN1 does not pursuit further optimization for For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is used without modification.** |
| [R1-2402002](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402002.zip), Huawei, HiSilicon | ***Proposal 1: Reuse Table 6.3.3.2-4 of TS 38.211 without modification for PRACH configuration for operation in FR2-NTN.***  ***Proposal 2: No enhancement is needed to introduce Common TA 3rd order derivative.*** |
| [R1-2402606](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402606.zip), Ericsson | **Observation 1 Table 6.3.3.2-4 is designed for terrestrial networks and FR2-TDD operations, taking into account the impact of TDD DL-UL scheduling and SSBs periods. Thus, the entries designed for TDD impose unnecessary limitations for non-terrestrial networks with FR2-FDD operations.**  **Observation 2 Using a non-zero starting symbol for FDD PRACH configurations unnecessarily limits the number of time-domain PRACH occasions within a PRACH slot.**  **Observation 3 Using a non-zero starting symbol for FDD PRACH configurations leaves unused fractions of UL slots that are difficult to utilize for other UL channels.**  **Observation 4 The RAN4 timing accuracy requirements for FR2-NTN are very tight and leave no margin for impairments in gNB, e.g., Common TA errors.**  **Observation 5 The transmission timing accuracy can be significantly increased, or the NTN-SIB update rate significantly reduced, if a 3rd order term of common TA is introduced.**    Based on the discussion in the previous sections we propose the following:  **Proposal 1 For PRACH configurations for FDD operation in FR2-NTN, introduce a new table (Table 6.3.3.2-x) in TS 38.211, which is a copy of Table 6.3.3.2-4, except for the following revision suiting FDD:**  **• For PRACH configurations with non-zero starting symbol for which changing their starting symbol to zero does not make them identical to another configurations, change the starting symbol to zero and increase (if possible) the number of time domain PRACH occasions.**  **Proposal 2 Introduce a 3rd order term of common TA for FR2-NTN.** |
| [R1-2402618](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402618.zip), ZTE | ***Proposal 1:*** *For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 in TS 38.211 is directly reused without modification.*  ***Observation 1:*** *Current common TA modelling can satisfy RAN4 timing requirements*  ***Proposal 2:*** *No need of enhancement for common TA modelling.* |
| [R1-2403079](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403079.zip), Nokia, Nokia Shanghai Bell | **Observation 1: Reusing Table 6.3.3.2-4 of TS 38.211 without modification would cause marginal specification impact and would not impact the amount of test cases.**  **Observation 2: Modifications to the PRACH configuration table would bring PRACH capacity increase at the cost of PUSCH capacity**  **Observation 3: Modifications to the PRACH configuration table would reduce the PRACH configuration granularity due to some entries offering approximately the same PRACH capacity.**  **Observation 4: There is still some unclarity as to which modifications would be needed for an updated/modified PRACH configuration table.**  **Observation 5: Current PRACH configuration table as outlined in Table 6.3.3.2-4 of TS 38.211 would be sufficient for supporting FR2-NTN.**  **Observation 6: RAN4 already agreed** Error! Reference source not found. **on tighter timing requirements for operation of NR over NTN in FR2-NTN bands, so no further actions would be needed by RAN1 on this matter.**  **Observation 7: When a UE transmits the random access preamble, after applying the UL pre-compensation at UE side, the errors between the time the gNB has received the UE signal and the expected UL synchronization time can all be attributed to UE inaccuracies.**  **Proposal 1: Current PRACH configuration table as defined in Table 6.3.3.2-4 of TS 38.211 is assumed to be applicable without modification for operation in frequency bands defined by FR2-NTN.**  **Proposal 2: No need to discuss further aspects related to tighter timing requirements for operation of NR over NTN in FR2-NTN bands.**  **Proposal 3: If the UE updates its GNSS position, and difference between the TA calculated using the new UE position and the previous UE position is above the UL Transmit Timing inaccuracy, UE shall perform a new random access procedure to reacquire the correct transmit timing.**  **Proposal 4: For reducing the systematic error at UE side, multiple readings of SIB19 should be seen as the preferred solution.**  **Proposal 5: UEs should be supporting backwards propagation of Ephemeris information to reduce the impact of Common TA modelling errors.**  **Proposal 6: RAN1 should not introduce new IE to improve the Common TA modelling.** |
| [R1-2403223](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403223.zip), NTT DOCOMO, INC. | **Proposal 1:**   * **For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 is re-used with only one modification:**   + **For PRACH configurations with non-zero starting symbol for which changing their starting symbol to zero does not make them identical to another configuration, change the starting symbol to zero.**   **Proposal 2:**   * **For UE autonomous timing advance in FR2-NTN, third order derivative of common TA is introduced and signaled in SIB.**   **Proposal 3:**   * **For UE autonomous timing advance in FR2-NTN,**    + **N\_TA value is initialized to zero when new common TA parameters and/or satellite ephemeris parameters are acquired and start to be used.** |
| [R1-2403289](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403289.zip), Sharp | **Observation 1:** In Rel-19 NR-NTN discussion, it is assumed that active time of one DL Tx beam on satellite in FR2 is limited to 1.5 %.  **Observation 2:** The same active time limitations as DL Tx beam due to antenna array structures at the satellite apply to UL Rx beam as well.  **Observation 3:** Enhancement of PRACH configuration in future release will require additional PRACH partitioning which causes the reduction of PRACH capacity for Rel-18 FR2-NTN UEs.  **Proposal 1:** PRACH capacity issue should be considered in Rel-18 FR2-NTN.  **Proposal 2:** For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is used with modification of starting symbol. |
| [R1-2403406](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403406.zip), Ericsson, Thales | No proposals, Draft CR |
| [R1-2403407](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403407.zip), Ericsson | No proposals, Draft CR |
| [R1-2403408](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403408.zip), Ericsson | No proposals, Draft CR |
| [R1-2401989](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2401989.zip), THALES | **Observation 1:** Compared with FDD, the PRACH configuration tables for TDD FR1 and FR2 considered the downlink resources (e.g. SS/PBCH block, RMSI) and semi-static DL/UL locations, in order to reduce the potential collisions between RACH transmission occasions (ROs) and SS/PBCH block/DL part.  **Observation 2:** For FR2 TDD, PRACH occasion was designed to occupy the end of a semi-static UL/DL configuration period. We propose that this constraint should be removed for the PRACH configuration for FR2-NTN with FDD duplexing mode.  **Observation 3:** In Table 6.3.3.2-4 of TS 38.211, there are 158 over 256 PRACH configurations with a periodicity of 10ms (one frame) and only 19 configurations with a periodicity of 160ms . While these configurations with lower periodicity could be beneficial for low latency services, we do not think that such configurations are needed in NTN where the beam sweeping cycle and the beam illumination plan with large beam hopping period may not allow such low PRACH periodicity.  **Observation 4:** To reduce the probability of root sequence collision (RSI), the following strategy is preferred: All the cells within the same satellite/gNB are allocated a common Root sequence index but a different combination of a PRACH configuration index and PRACH frequency offset. A New PRACH configuration index table for FR2 FDD should be introduced to allow such RSI planning method .  Proposal 1:  Adopt the following table for Random access configurations for FR2 and paired spectrum:  **[Table with proposed PRACH configuration table]**  **Observation 5.** The timing error limits are tight for SCS=60 kHz and SCS=120 kHz in FR2-NTN.  **Proposal 2:** Higher-layer parameter TACommonThirdOrder can be indicated with the following range, granularity and bits allocation:   | Parameter name | Value range | Granularity | Bits allocation | | --- | --- | --- | --- | | TACommonThirdOrder | -4912…+4912  (-0.015 …+0.015 ) |  | 14 bits | | Value range is given in unit of corresponding granularity | | | | |
| [R1-2402861](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402861.zip), Apple | ***Proposal 1:*** *RAN1 does not increase satellite position accuracy and UE position accuracy for FR2-NTN.*  ***Proposal 2:*** *RAN1 does not enhance the common TA parameters for FR2-NTN.*  ***Proposal 3:*** *For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is reused without modifications.*  ***Proposal 4:*** *RAN1 to adopt the following text proposal:*   * *Reason for change: Support NR over FR2-NTN* * *Summary of change: Extend FR2-TDD band random access configurations to FR2-FDD band* * *Consequences if not approved: NR over FR2-NTN is not supported*  |  | | --- | | **TS 38.211** Error! Reference source not found.  6.3.3.2 Mapping to physical resources  ……  **Table 6.3.3.2-4: Random access configurations for FR2 ~~and unpaired spectrum.~~**  …… | |

# References

1. [R1-2304309](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_113/Docs/R1-2304309.zip)/R4-230592: LS on the system parameters for NTN above 10 GHz, May 2023

1. [R1-2401846](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2401846.zip), “ Discussion on FR2-NTN aspects at RAN1#116, third round”, Moderator (Nokia)
2. [R1-2402214](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402214.zip), “Discussions of the LS on the system parameters for NTN above 10 GHz” , vivo
3. [R1-2402310](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402310.zip), “Discussion on RAN4 LS for FR2 NTN”, OPPO
4. [R1-2402002](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402002.zip), “Discussion on RAN1 impact to support the RAN4 work on NTN above 10GHz”, Huawei, HiSilicon
5. [R1-2402606](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402606.zip), “Discussion on RAN4 LS on the system parameters for NTN above 10 GHz”, Ericsson
6. [R1-2402618](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402618.zip), “Further discussion on LS on the system parameters for NTN above 10 GHz”, ZTE
7. [R1-2403079](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403079.zip), “Further discussion on NR over NTN operation in frequency bands defined by FR2-NTN”, Nokia, Nokia Shanghai Bell

1. [R1-2403223](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403223.zip), “Discussion on FR2-NTN”, NTT DOCOMO, INC.
2. [R1-2403289](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403289.zip), “Discussion on RAN4 LS on FR2-NTN aspectshai”, Sharp
3. [R1-2403406](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403406.zip), “Draft CR for 38.211 on Introduction of FR2-NTN”, Ericsson, Thales
4. [R1-2403407](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403407.zip), “Draft CR for 38.213 on Introduction of FR2-NTN”, Ericsson
5. [R1-2403408](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2403408.zip), “Draft CR for 38.214 on Introduction of FR2-NTN”, Ericsson
6. [R1-2401989](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2401989.zip), “Considerations on the system parameters for FR2-NTN” , THALES
7. [R1-2402861](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_116b/Docs/R1-2402861.zip), “On RAN4 LS on the system parameters for NTN above 10 GHz” , Apple

1. [R1-2306408](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_114/Docs/R1-2306408.zip), Discussion on RAN4 LS on the system parameters for NTN above 10 GHz, THALES

1. [R1-2312142](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_115/Docs/R1-2312142.zip), “Summary #2 for FR2-NTN, Moderator (Nokia)
2. [R1-2400349](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2400349.zip), “Further discussion on LS on the system parameters for NTN above 10 GHz”, ZTE
3. [R1-2400404](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2400404.zip), “Discussion on FR2 issues for Rel-18 NTN”, CATT

1. [R1-2400816](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2400816.zip" \t "_parent), “Considerations on the system parameters for FR2-NTN”, THALES

1. [R1-2400968](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2400968.zip" \t "_parent), “Further discussion on NR over NTN operation in bands defined by FR2-NTN”, Nokia, Nokia Shanghai Bell
2. [R1-2400975](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2400975.zip), “Discussion on RAN4 LS on the system parameters for NTN above 10 GHz”, Ericsson
3. [R1-2400980](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2400980.zip), “Discussion of RAN4 LS on the system parameters for NTN above 10 GHz”, Apple
4. [R1-2401163](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2401163.zip), “Discussions on RAN4 LS on FR2-NTN aspects”, Sharp
5. [R1-2401379](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2401379.zip), “Discussion on RAN1 impact to support the RAN4 work on NTN above 10GHz”, Huawei, HiSilicon

1. [R1-2401096](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_116/Docs/R1-2401096.zip), “Maintenance of NR NTN enhancements”, NTT DOCOMO, INC.

# Agreements from past meeting(s)

## RAN1#114-bis:

Working assumption

For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is used as baseline.

FFS: Whether further modifications would be needed

**Conclusion**

For operation in FR2-NTN, the value range in ms for K\_offset and K-MAC shall be the same as for Rel-17 NR over NTN.

Working assumption

For operation in FR2-NTN, use a reference SCS of 15 kHz for the indication of K\_offset and K\_MAC.

Working assumption:

For operation in FR2-NTN, for cell search procedure, at least Case D in TS 38.213 is used to allow FDD operation in bands defined by FR2-NTN without any update to SSB pattern.

FFS: whether Case E can also be used

**Conclusion**

For operation in FR2-NTN and for Rel-18, no additional MAC CE TCI application delay is introduced to facilitate mechanical beam steering with VSAT.

Working assumption

From RAN1 perspective, for operation in FR2-NTN, the granularity used for TA reporting is the same as corresponding to the reference subcarrier spacing applied for K\_offset.

## RAN1#115:

Agreement

Confirm working assumption from RAN1#114-bis on reference SCS for K\_offset and K\_MAC.

Agreement

Confirm working assumption from RAN1#114-bis on the TA reporting granularity.

Agreement

The working assumption for cell search procedure is replaced with the following, and confirmed:

* For operation in FR2-NTN, for cell search procedure, Case D and Case E in TS 38.213 are used to allow FDD operation in bands defined by FR2-NTN without any update to SSB pattern.

Agreement

Confirm the working assumption from RAN1#114-bis on the PRACH configuration.

Working assumption

For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is used as baseline.

FFS: Whether further modifications to the PRACH configuration Table would be needed

Agreement

Create an LS response for RAN4 with the following text, and copy the relevant RAN1 agreements and conclusions made for FR2-NTN in the LS:

**Overall description**

RAN1 would like to thank RAN4 for their LS R4-2305926 (R1-2304309) on the operation of NR over NTN in frequency bands above 10 GHz.

RAN1 have had discussion on the topic over the past meetings and have reached a number of agreements, but some topics are still under consideration. The topics still under consideration are mainly related to the timing requirements associated to operation in bands defined by FR2-NTN. To help RAN1 progressing on the topic, it would be appreciated if RAN4 could provide the timing requirements for supporting NR over NTN in bands defined by FR2-NTN.

**Actions:**

RAN1 respectfully asks RAN4 to provide a response to the above question in order to aid the RAN1 discussions related to timing accuracy requirements.

**R1-2312553**

Final LS is agreed in R1-2312553.

## RAN1#116:

**Conclusion**

RAN1 does not pursue the aspects on negative timing advance indication through TAC in MAC RAR for FR2-NTN unless specifically requested by RAN4.

**Conclusion**

For frequency bands defined by FR2-NTN, RAN1 will not consider expanding the scope of extended cyclic prefix to cover SCS other than 60 kHz in Rel-18.

**Conclusion**

RAN1 will decide at RAN1#116bis on whether to reuse Table 6.3.3.2-4 of TS 38.211 without modification for NR over NTN for FR2-NTN in Rel-18, or to reuse the table with modifications.

# Text proposals for specifications

## Text proposals for TS 38.211:

Companies are invited to comment on the text proposals for 38.211 here:

|  |  |
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| **Companies** | **Comments related to the text proposals** |
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**Companies wanting to co-source CR:**

**Test prepared for the CR starts here:**

Reason for change: Introduction of NR over NTN for frequency bands defined by FR2-NTN

Summary of change: Update references and abbreviations to include definition of FR2-NTN. Update of Table 6.3.3.2-4 to include FR2-NTN

Consequence if not approved: NR over NTN in frequency bands defined by FR2-NTN will not be complete.

Clauses affected: 2, 3.3, 6.3.3.2

<unchanged parts omitted>

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.201: "NR; Physical Layer – General Description"

[3] 3GPP TS 38.202: "NR; Services provided by the physical layer"

[4] 3GPP TS 38.212: "NR; Multiplexing and channel coding"

[5] 3GPP TS 38.213: "NR; Physical layer procedures for control "

[6] 3GPP TS 38.214: "NR; Physical layer procedures for data "

[7] 3GPP TS 38.215: "NR; Physical layer measurements"

[8] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"

[9] void

[10] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities"

[11] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[12] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

[13] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state"

[14] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

[15] 3GPP TS 38.101-5: "User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements NR"

<unchanged parts omitted>

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BWP Bandwidth Part

CCE Control Channel Element

CORESET Control Resource Set

CRB Common Resource Block

CSI Channel-State Information

CSI-RS CSI Reference Signal

DCI Downlink Control Information

DM-RS Demodulation Reference Signal

FR1 Frequency Range 1 as defined in TS 38.104 [8]

FR2 Frequency Range 2 as defined in TS 38.104 [8]

FR2-NTN Frequency Range 2 for Non-terrestrial networks as defined in TS 38.101-5 [15]

IAB Integrated Access and Backhaul

IAB-MT IAB Mobile Termination

IE Information Element

NCR Network-Controlled repeater

NCR-MT NCR Mobile Termination

PBCH Physical Broadcast Channel

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PRACH Physical Random-Access Channel

PRB Physical Resource Block

PSS Primary Synchronization Signal

PT-RS Phase-tracking reference signal

PUCCH Physical Uplink Control Channel

PUSCH Physical Uplink Shared Channel

RAR Random Access Response

REG Resource-Element Group

RIM Remote Interference Management

RIM-RS Remote Interference Management Reference Signal

SRS Sounding Reference Signal

SSS Secondary Synchronization Signal

VRB Virtual Resource Block

<unchanged parts omitted>

#### 6.3.3.2 Mapping to physical resources

<unchanged parts omitted>

Table 6.3.3.2-4: Random access configurations for FR2 and unpaired spectrum, and for FR2-NTN and paired spectrum.

<unchanged parts omitted>

## Text proposals for TS 38.213:

Companies are invited to comment on the text proposals for 38.213 here:

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| **Companies** | **Comments related to the text proposals** |
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**Companies wanting to co-source CR:**

**Test prepared for the CR starts here:**

Reason for change: Introduction of NR over NTN for frequency bands defined by FR2-NTN

Summary of change: Update references and abbreviations to include definition of FR2-NTN, update of cell search procedure to include FR2-NTN, update of RACH procedure to include FR2-NTN, and update of UE procedure for reporting control information to include FR2-NTN.

Consequence if not approved: NR over NTN in frequency bands defined by FR2-NTN will not be complete.

Clauses affected: 2, 3.3, 4.1, 8.1, 9

<unchanged parts omitted>

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 38.201: "NR; Physical Layer – General Description"

[3] 3GPP TS 38.202: "NR; Services provided by the physical layer"

[4] 3GPP TS 38.211: "NR; Physical channels and modulation"

[5] 3GPP TS 38.212: "NR; Multiplexing and channel coding"

[6] 3GPP TS 38.214: "NR; Physical layer procedures for data"

[7] 3GPP TS 38.215: "NR; Physical layer measurements"

[8-1] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

[8-2] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone"

[8-3] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios"

[8-4] 3GPP TS 38.101-4: "NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements"

[8-5] 3GPP TS 38.101-5: "User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements NR"

[9] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"

[10] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

<unchanged parts omitted>

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in [1, TR 21.905].

BPRE Bits Per Resource Element

BWP Bandwidth Part

CB Code Block

CBG Code Block Group

CBR Channel Busy Ratio

CCE Control Channel Element

CORESET Control Resource Set

CP Cyclic Prefix

CRC Cyclic Redundancy Check

C-RNTI Cell RNTI

CS-RNTI Configured Scheduling RNTI

CSI Channel State Information

CSS Common Search Space

DAI Downlink Assignment Index

DAPS Dual Active Protocol Stack

DC Dual Connectivity

DCI Downlink Control Information

DL Downlink

DL-SCH Downlink Shared Channel

EPRE Energy Per Resource Element

EN-DC E-UTRA NR Dual Connectivity with MCG using E-UTRA and SCG using NR

FR1 Frequency Range 1

FR2 Frequency Range 2

FR2-NTN Frequency Range 2 for non-terrestrial networks [8-5]

G-CS-RNTI Group Configured Scheduling RNTI

G-RNTI Group RNTI

GSCN Global Synchronization Channel Number

HARQ-ACK Hybrid Automatic Repeat reQuest Acknowledgement

<unchanged parts omitted>

4.1 Cell search

Cell search is the procedure for a UE to acquire time and frequency synchronization with a cell and to detect the physical layer Cell ID of the cell.

A UE receives the following synchronization signals (SS) in order to perform cell search: the primary synchronization signal (PSS) and secondary synchronization signal (SSS) as defined in [4, TS 38.211].

A UE assumes that reception occasions of a physical broadcast channel (PBCH), PSS, and SSS are in consecutive symbols, as defined in [4, TS 38.211], and form a SS/PBCH block. The UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE. The UE may assume that the ratio of PSS EPRE to SSS EPRE in a SS/PBCH block is either 0 dB or 3 dB. If the UE has not been provided dedicated higher layer parameters, the UE may assume that the ratio of PDCCH DMRS EPRE to SSS EPRE is within -8 dB and 8 dB when the UE monitors PDCCHs for a DCI format 1\_0 with CRC scrambled by SI-RNTI, P-RNTI, or RA-RNTI, or for a DCI format 2\_7, or for a DCI format 4\_0.

For a half frame with SS/PBCH blocks, the first symbol indexes for candidate SS/PBCH blocks are determined according to the SCS of SS/PBCH blocks as follows, where index 0 corresponds to the first symbol of the first slot in a half-frame.

- Case A - 15 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes of .

- For operation without shared spectrum channel access:

- For carrier frequencies smaller than or equal to 3 GHz, .

- For carrier frequencies within FR1 larger than 3 GHz, .

- For operation with shared spectrum channel access, as described in [15, TS 37.213], .

- Case B - 30 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies smaller than or equal to 3 GHz, . For carrier frequencies within FR1 larger than 3 GHz, .

- Case C - 30 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes .

- For operation without shared spectrum channel access

- For paired spectrum operation

- For carrier frequencies smaller than or equal to 3 GHz, . For carrier frequencies within FR1 larger than 3 GHz, .

- For unpaired spectrum operation

- For carrier frequencies smaller than 1.88 GHz, . For carrier frequencies within FR1 equal to or larger than 1.88 GHz, .

- For operation with shared spectrum channel access, .

- Case D - 120 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies within FR2 and FR2-NTN, .

- Case E - 240 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies within FR2-1 and FR2-NTN, .

- Case F – 480 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies within FR2-2,

<unchanged parts omitted>

8.1 Random access preamble

<unchanged parts omitted>

For a PRACH transmission by a UE triggered by a PDCCH order, the PRACH mask index field, if the value of the random access preamble index field is not zero, indicates the PRACH occasion for the PRACH transmission where the PRACH occasions are associated with the SS/PBCH block index indicated by the SS/PBCH block index field of the PDCCH order and, if any, a cell indicator field indicates a cell for the PRACH transmission [5, TS 38.212]. If the UE is provided by *cellSpecificKoffset*, the PRACH occasion is after slot where is the slot of the UL BWP for the PRACH transmission that overlaps with the end of the PDCCH order reception assuming , and is the SCS configuration for the PRACH transmission with the exception for FR2-NTN where is used. If the PDCCH reception for the PDCCH order includes two PDCCH candidates from two linked search space sets based on *searchSpaceLinkingId*, as described in clause 10.1, the last symbol of the PDCCH reception is the last symbol of the PDCCH candidate that ends later. The PDCCH reception includes the two PDCCH candidates also when the UE is not required to monitor one of the two PDCCH candidates as described in clauses 10 (except clause 10.4), 11.1, 11.1.1 and 17.2.

<unchanged parts omitted>

9 UE procedure for reporting control information

<unchanged parts omitted>

For the remaining of this clause, if a UE is provided by *cellSpecificKoffset* or by a MAC CE command, reference to a slot for a PUCCH transmission or PUSCH transmission corresponds to a slot for the PUSCH or the PUCCH transmission, and reference to a slot corresponds to slot , where is the SCS configuration for the PUCCH transmission or PUSCH transmission, is defined in clause 4.2, and in FR1 and in FR2-NTN. If *cellSpecificKoffset* or if the MAC CE command is not provided, or , respectively. If the PUCCH or PUSCH transmission is scheduled by a DCI format, or if SRS transmission is triggered by a DCI format, the value of is the one that is applicable at the slot overlapping with the last symbol of the PDCCH reception providing the DCI format. If the PUCCH transmission or the PUSCH transmission is scheduled by a DCI format with CRC scrambled by TC-RNTI, . If the UE is provided a value by a MAC CE command, the UE applies the MAC CE command in the first slot that is after slot where is the slot where the UE would transmit a PUCCH with HARQ-ACK information for the PDSCH providing the MAC CE command, is the SCS configuration for the PUCCH transmission that is determined in the slot when the MAC CE command is applied.

<unchanged parts omitted>

## Text proposals for TS 38.214:

Companies are invited to comment on the text proposals for 38.214 here:

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| --- | --- |
| **Companies** | **Comments related to the text proposals** |
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**Companies wanting to co-source CR:**

**Test prepared for the CR starts here:**

Reason for change: Introduction of NR over NTN for frequency bands defined by FR2-NTN

Summary of change: Update references and abbreviations to include definition of FR2-NTN, update of procedures related to scheduling and feedback (Koffset and Kmac) to include FR2-NTN

Consequence if not approved: NR over NTN in frequency bands defined by FR2-NTN will not be complete.

Clauses affected: 2, 3.3, 5.1.4.2, 5.1.5, 5.2.1.5.2, 5.2.2.5, 6.1.2.1, 6.2.1

<unchanged parts omitted>

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 38.201: " NR; Physical Layer – General Description"

[3] 3GPP TS 38.202: "NR; Services provided by the physical layer"

[4] 3GPP TS 38.211: "NR; Physical channels and modulation"

[5] 3GPP TS 38.212: "NR; Multiplexing and channel coding"

[6] 3GPP TS 38.213: "NR; Physical layer procedures for control"

[7] 3GPP TS 38.215: "NR; Physical layer measurements"

[8] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

[9] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"

[10] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[11] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

[12] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification"

[13] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities"

[14] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)"

[15] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation"

[16] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access"

[17] 3GPP TS 37.355: "LTE Positioning Protocol (LPP)"

[18] 3GPP TS 38.822: "NR; User Equipment (UE) feature list"

[19] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures"

[20] 3GPP TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN"

[21] 3GPP TS 38.101-5: "User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements NR"

<unchanged parts omitted>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ARP Antenna Reference Point

BWP Bandwidth Part

CBG Code Block Group

CJT Coherent Joint Transmission

CLI Cross Link Interference

CP Cyclic Prefix

CQI Channel Quality Indicator

CPU CSI Processing Unit

CRB Common Resource Block

CRC Cyclic Redundancy Check

CRI CSI-RS Resource Indicator

CSI Channel State Information

CSI-RS Channel State Information Reference Signal

CSI-RSRP CSI Reference Signal Received Power

CSI-RSRQ CSI Reference Signal Received Quality

CSI-SINR CSI Signal-to-Interference-plus-Noise Ratio

CW Codeword

DCI Downlink Control Information

DL Downlink

DM-RS Demodulation Reference Signal

DRX Discontinuous Reception

EPRE Energy Per Resource Element

FR2-NTN Frequency Range 2 for Non-terrestrial networks as defined in TS 38.101-5 [15]

IAB-MT Integrated Access and Backhaul – Mobile Termination

L1-RSRP Layer 1 Reference Signal Received Power

LI Layer Indicator

LoS Line of Sight

MCS Modulation and Coding Scheme

NCJT Non-Coherent Joint Transmission

NCR Network-controlled Repeater

NCR-MT Network controlled repeater – Mobile Termination

NLoS Non-Line of Sight

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PSS Primary Synchronisation Signal

PUCCH Physical Uplink Control Channel

QCL Quasi Co-Location

PMI Precoding Matrix Indicator

PRB Physical Resource Block

PRG Precoding Resource block Group

PRS Positioning Reference Signal

PT-RS Phase-Tracking Reference Signal

<unchanged parts omitted>

5.1.4.2 PDSCH resource mapping with RE level granularity

The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying the parameters of *aperiodicZP-CSI-RS-ResourceSetsToAddModListDCI-1-2* instead of *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList*. The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_3.

The procedures for PDSCH scheduled by PDCCH with DCI format 1\_0 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_1 and the procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_2, by applying the parameters of *aperiodicZP-CSI-RS-ResourceSetsToAddModList in pdsch-ConfigMulticast* instead of *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList in PDSCH-Config*.

A UE may be configured with any of the following higher layer parameters:

*-* REs indicated by the '*RateMatchPatternLTE-CRS*'in *lte-CRS-ToMatchAround* in *ServingCellConfig* or *ServingCellConfigCommon* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH.

*-* REs indicated by *'RateMatchPatternLTE-CRS'* in *lte-CRS-PatternList1-r16* or *lte-CRS-PatternList3-r18* in *ServingCellConfig* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for PDSCH.

- For the UE for broadcast reception or multicast reception in RRC\_INACTIVE\_state, REs indicated by *'RateMatchPatternLTE-CRS'* in *pdsch-ConfigMCCH* or *pdsch-ConfigMTCH* configuring cell-specific RS, in 15 kHz subcarrier spacing applicable only to 15 kHz subcarrier spacing PDSCH, of one LTE carrier in a serving cell are declared as not available for broadcast PDSCH. The total number of *RateMatchPatternLTE-CRS* for broadcast reception or multicast reception in RRC\_INACTIVE\_state that a UE can be configured with is the same as for unicast in Rel-15.

- Each *RateMatchPatternLTE-CRS* configuration contains *v-Shift* consisting of LTE-CRS-vshift(s), *nrofCRS-Ports* consisting of LTE-CRS antenna ports 1, 2 or 4 ports, *carrierFreqDL* representing the offset in units of 15 kHz subcarriers from (reference) point A to the LTE carrier centre subcarrier location, *carrierBandwidthDL* representing the LTE carrier bandwidth, and may also configure *mbsfn-SubframeConfigList* representing MBSFN subframe configuration. A UE determines the CRS position within the slot according to Clause 6.10.1.2 in [15, TS 36.211], where slot corresponds to LTE subframe.

- If the UE is configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet* and is also configured by the higher layer parameter *lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16* in *ServingCellConfig*, the following REs are declared as not available for PDSCH:

- if the UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, REs indicated by the CRS pattern(s) in *lte-CRS-PatternList1-r16* if the PDSCH is associated with *coresetPoolIndex* set to '0', or the CRS pattern(s) in *lte-CRS-PatternList2-r16* if PDSCH is associated with *coresetPoolIndex* set to '1';

- otherwise, REs indicated by *lte-CRS-PatternList1-r16* and *lte-CRS-PatternList2-r16,* in *ServingCellConfig*.

- If the UE is not configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet*, and if the UE is configured by higher layer parameter *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig*, REs indicated by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* are declared as not available for PDSCH.

- If the UE is configured by higher layer parameter *PDCCH-Config* with two different values of *coresetPoolIndex* in *ControlResourceSet* and is also configured by the higher layer parameter *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18* in *ServingCellConfig*, the following REs are declared as not available for PDSCH:

- if the UE is configured with *crs-RateMatch-PerCoresetPoolIndex*, REs indicated by the CRS pattern(s) in *lte-CRS-PatternList3-r18* if the PDSCH is associated with *coresetPoolIndex* set to '0', or the CRS pattern(s) in *lte-CRS-PatternList4-r18* if PDSCH is associated with *coresetPoolIndex* set to '1';

- otherwise, REs indicated by *lte-CRS-PatternList3-r18* and *lte-CRS-PatternList4-r18,* in *ServingCellConfig*.

- Within a BWP, the UE can be configured with one or more ZP CSI-RS resource set configuration(s) for aperiodic, semi-persistent and periodic time-domain behaviours (higher layer parameters *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList,*  *sp-ZP-CSI-RS-ResourceSetsToAddModList* and *p-ZP-CSI-RS-ResourceSet* respectively comprised in *PDSCH-Config*), with each ZP CSI-RS resource set consisting of at most 16 ZP CSI-RS resources (higher layer parameter *ZP-CSI-RS-Resource*) in numerology of the BWP. The REs indicated by *p-ZP-CSI-RS-ResourceSet* are declared as not available for PDSCH. The REs indicated by *sp-ZP-CSI-RS-ResourceSetsToAddModList* and aperiodic-ZP-CSI-RS-ResourceSetsToAddModList are declared as not available for PDSCH when their triggering and activation are applied, respectively. The following parameters are configured via higher layer signaling for each ZP CSI-RS resource configuration:

- *zp-CSI-RS-ResourceId* in *ZP-CSI-RS-Resource* determines ZP CSI-RS resource configuration identity.

- *nrofPorts* in *CSI-RS-ResourceMapping* defines the number of CSI-RS ports, where the allowable values are given in Clause 7.4.1.5 of [4, TS 38.211].

- *cdm-Type* in *CSI-RS-ResourceMapping* defines CDM values and pattern, where the allowable values are given in Clause 7.4.1.5 of [4, TS 38.211].

- *resourceMapping* in *ZP-CSI-RS-Resource* defines the OFDM symbol and subcarrier occupancy of the ZP CSI-RS resource within a slot that are given in Clause 7.4.1.5 of [4, TS 38.211].

- *periodicityAndOffset* in*ZP-CSI-RS-Resource* defines the ZP-CSI-RS periodicity and slot offset for periodic/semi-persistent ZP CSI-RS.

- For the UE in RRC\_CONNECTED mode for multicast reception, *p-ZP-CSI-RS-ResourceSet* can be configuredin *pdsch-ConfigMulticast* for GC-PDSCH rate matching, subject to UE capability. The REs indicated by *p-ZP-CSI-RS-ResourceSet* are declared as not available for GC-PDSCH. The REs indicated by *p-ZP-CSI-RS-ResourceSet* configured in *PDSCH-Config* for unicast do not apply for GC-PDSCH and the REs indicated by *p-ZP-CSI-RS-ResourceSet* configured in *pdsch-ConfigMulticast* for multicast do not apply for unicast PDSCH. The total number of periodic *ZP-CSI-RS-Resources* that a UE can be configured with is the same as for unicast in Rel-16. If *p-ZP-CSI-RS-ResourceSet* is configured in both *PDSCH-Config* and *pdsch-ConfigMulticast*, it is subject to UE capability whether the *p-ZP-CSI-RS-ResourceSet* configured in *pdsch-ConfigMulticast* can be different from the *p-ZP-CSI-RS-ResourceSet* configured in *PDSCH-Config*.

- For the UE in RRC\_CONNECTED mode for multicast reception, s*p-ZP-CSI-RS-ResourceSet* can be configuredin *pdsch-ConfigMulticast* for GC-PDSCH rate matching, subject to UE capability. The REs indicated by s*p-ZP-CSI-RS-ResourceSet* are declared as not available for GC-PDSCH when their triggering and activation delivered by unicast PDSCH are applied. The REs indicated by s*p-ZP-CSI-RS-ResourceSet* configured in *PDSCH-Config* for unicast do not apply for GC-PDSCH and the REs indicated by s*p-ZP-CSI-RS-ResourceSet* configured in *pdsch-ConfigMulticast* for multicast do not apply for unicast PDSCH. The total number of semi-persistent *ZP-CSI-RS-Resources* that a UE can be configured with is the same as for unicast.

The UE may be configured with a DCI field for triggering the aperiodic ZP CSI-RS. A list of *ZP-CSI-RS-ResourceSet(s)*, provided by higher layer parameter *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList* in*PDSCH-Config*, is configured for aperiodic triggering. The maximum number of aperiodic *ZP-CSI-RS-ResourceSet(s)* configured per BWP is 3. The bit-length of DCI field *ZP CSI-RS trigger* depends on the number of aperiodic *ZP-CSI-RS-ResourceSet(s)*configured (up to 2 bits). Each non-zero codepoint of '*ZP CSI-RS' trigger* in DCI format 1\_1 triggers one aperiodic 'ZP-CSI-RS-ResourceSet' in the list *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList* by indicating the aperiodic ZP CSI-RS resource set ID. The DCI codepoint '01' triggers the resource set with 'ZP-CSI-RS-ResourceSetId' set to '1', the DCI codepoint '10' triggers the resource set with 'ZP-CSI-RS-ResourceSetId' set to '2', and the DCI codepoint '11' triggers the resource set with 'ZP-CSI-RS-ResourceSetId' set to '3'. Codepoint '00' is reserved for not triggering aperiodic ZP CSI-RS. When receiving PDSCH scheduled by DCI format 1\_0 or PDSCHs with SPS activated by DCI format 1\_0, the REs corresponding to configured resources in *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList* or in *aperiodicZP-CSI-RS-ResourceSetsToAddModListDCI-1-2* are available for PDSCH.

When the UE is configured with multi-slot and single-slot PDSCH scheduling or *pdsch-TimeDomainAllocationListForMultiPDSCH*, the triggered aperiodic ZP CSI-RS is applied to all the slot(s) of the PDSCH(s) scheduled or the PDSCHs with SPS activated by the PDCCH containing the trigger.

For a UE configured with a list of semi-persistent *ZP-CSI-RS-ResourceSet(s)* provided by higher layer parameter *sp-ZP-CSI-RS-ResourceSetsToAddModList*:

- when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the activation command, as described in clause 6.1.3.19 of [10, TS 38.321], for ZP CSI-RS resource(s), the corresponding action in [10, TS 38.321] and the UE assumption on the PDSCH RE mapping corresponding to the activated ZP CSI-RS resource(s) shall be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH and is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN, and is provided by *K-Mac* or if *K-Mac* is not provided.

- when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the deactivation command, as described in clause 6.1.3.19 of [10, TS 38.321], for activated ZP CSI-RS resource(s), the corresponding action in [10, TS 38.321] and the UE assumption on cessation of the PDSCH RE mapping corresponding to the de-activated ZP CSI-RS resource(s) shall be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH and is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN, and is provided by *K-Mac* or if *K-Mac* is not provided.

~~<unchanged parts omitted>~~

5.1.5 Antenna ports quasi co-location

The UE can be configured with a list of up to *M* *TCI-State* configurations within the higher layer parameter *PDSCH-Config* to decode PDSCH according to a detected PDCCH with DCI intended for the UE and the given serving cell, where M depends on the UE capability *maxNumberConfiguredTCIstatesPerCC*. Each *TCI-State* contains parameters for configuring a quasi co-location relationship between one or two downlink reference signals and the DM-RS ports of the PDSCH, the DM-RS port of PDCCH or the CSI-RS port(s) of a CSI-RS resource. The quasi co-location relationship is configured by the higher layer parameter *qcl-Type1* for the first DL RS, and *qcl-Type2* for the second DL RS(if configured). For the case of two DL RSs, the QCL types shall not be the same, regardless of whether the references are to the same DL RS or different DL RSs. The quasi co-location types corresponding to each DL RS are given by the higher layer parameter *qcl-Type* in *QCL-Info* and may take one of the following values:

- 'typeA': {Doppler shift, Doppler spread, average delay, delay spread}

- 'typeB': {Doppler shift, Doppler spread}

- 'typeC': {Doppler shift, average delay}

- 'typeD': {Spatial Rx parameter}

The UE can be configured with a list of up to *128* *TCI-State* configurations, within the higher layer parameter *dl-OrJointTCI-StateList* in *PDSCH-Config* for providing a reference signal for the quasi co-location for DM-RS of PDSCH and DM-RS of PDCCH in a BWP/CC, for CSI-RS, and to provide a reference, if applicable, for determining UL TX spatial filter for dynamic-grant and configured-grant based PUSCH and PUCCH resource in a BWP/CC, and SRS.

If the *TCI-State* or *TCI-UL-State* configurations are absent in a BWP of the CC, the UE can apply the *TCI-State* or *TCI-UL-State* configurations from a reference BWP of a reference CC configured by *unifiedTCI-StateRef*. The UE is not expected to be configured with *tci-StatesToAddModList*, *SpatialRelationInfo* or *PUCCH-SpatialRelationInfo*, except *SpatialRelationInfoPos* in a CC in a band, if the UE is configured with *dl-OrJointTCI-StateList* or *ul-TCI-StateList* in any CC in the same band. The UE can assume that when the UE is configured with *tci-StatesToAddModList* in any CC in the CC list configured by *simultaneousTCI-UpdateList1-r16, simultaneousTCI-UpdateList2-r16,* *simultaneousSpatial-UpdatedList1-r16, or simultaneousSpatial-UpdatedList2-r16,* the UE is not configured with *dl-OrJointTCI-StateList* or *ul-TCI-StateList* in any CC within the same band in the CC list.

The UE receives an activation command, as described in clause 6.1.3.xx of [10, TS 38.321], 6.1.3.47 of [10, TS 38.321] or 6.1.4.xx of [10, TS 38.321], used to map up to 8 TCI states and/or pairs of TCI states, with one TCI state for DL channels/signals and/or one TCI state for UL channels/signals to the codepoints of the DCI field *'Transmission Configuration Indication'* for one or for a set of CCs/DL BWPs, [and/] or up to 8 sets of TCI states, where each set is comprised of up to two TCI state(s) for DL and UL signals/channels, or up to two TCI state(s) for DL channels/signals and up to two TCI state(s) for UL channels/signals to the codepoints of the DCI field *'Transmission Configuration Indication'* for one or for a set of CCs/DL BWPs, and if applicable, for one or for a set of CCs/UL BWPs. When a set of TCI state IDs are activated for a set of CCs/DL BWPs and if applicable, for a set of CCs/UL BWPs, where the applicable list of CCs is determined by the indicated CC in the activation command, the same set of TCI state IDs are applied for all DL and/or UL BWPs in the indicated CCs. If the activation command maps *TCI-State(s)* and/or *TCI-UL-State(s)* to only one TCI codepoint, the UE shall apply the indicated *TCI-State(s)* and/or *TCI-UL-State(s)* to one or to a set of CCs /DL BWPs, and if applicable, to one or to a set of CCs /UL BWPs once the indicated mapping for the one single TCI codepoint is applied as described in [11, TS 38.133].

When the *bwp-id* or *cell* for QCL-TypeA/D source RS in a QCL-Info of the TCI state is not configured, the UE assumes that QCL-TypeA/D source RS is configured in the CC/DL BWP where TCI state applies.

When *tci-PresentInDCI* is set as 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET, a UE configured with *dl-OrJointTCI-StateList* with activated *TCI-State* or *ul-TCI-StateList* with activated *TCI-UL-State* receives DCI format 1\_1/1\_2/1\_3 providing indicated *TCI-State(s)* and/or *TCI-UL-State(s)* for a CC or all CCs in the same CC list configured by *simultaneousU-TCI-UpdateList1-r17, simultaneousU-TCI-UpdateList2-r17, simultaneousU-TCI-UpdateList3-r17, simultaneousU-TCI-UpdateList4-r17*. The DCI format 1\_1/1\_2 can be with or without, if applicable, DL assignment. If the DCI format 1\_1/1\_2/ is without DL assignment, the UE can assume the following:

- CS-RNTI is used to scramble the CRC for the DCI

- The values of the following DCI fields are set as follows:

- RV = all '1's

- MCS = all '1's

- NDI = 0

- Set to all '0's for FDRA Type 0, or all '1's for FDRA Type 1, or all '0's for dynamicSwitch (same as in Table 10.2-4 of [6, TS 38.213]).

After a UE receives an initial higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* and before application of an indicated TCI state from the configured TCI states:

- The UE assumes that DM-RS of PDSCH and DM-RS of PDCCH and the CSI-RS applying the indicated TCI state are quasi co-located with the SS/PBCH block the UE identified during the initial access procedure

After a UE receives an initial higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* or *ul-TCI-StateList* with more than one *TCI-UL-State* and before application of an indicated TCI state from the configured TCI states:

- The UE assumes that the UL TX spatial filter, if applicable, for dynamic-grant and configured-grant based PUSCH and PUCCH, and for SRS applying the indicated TCI state, is the same as that for a PUSCH transmission scheduled by a RAR UL grant or a MsgA PUSCH transmission during the initial access procedure

After a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* as part of a Reconfiguration with sync procedure as described in [12, TS 38.331]and before applying an indicated TCI state from the configured TCI states:

- The UE assumes that DM-RS of PDSCH and DM-RS of PDCCH, and the CSI-RS applying the indicated TCI state are quasi co-located with the SS/PBCH block or the CSI-RS resource the UE identified during the random access procedure initiated by the Reconfiguration with sync procedure as described in [12, TS 38.331].

After a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* or more than one *TCI-UL-State* as part of a Reconfiguration with sync procedure as described in [12, TS 38.331] and before applying an indicated TCI state from the configured TCI states:

- The UE assumes that the UL TX spatial filter, if applicable, for dynamic-grant and configured-grant based PUSCH and PUCCH, and for SRS applying the indicated TCI state, is the same as that for a PUSCH transmission scheduled by a RAR UL grant or a MsgA PUSCH transmission during random access procedure initiated by the Reconfiguration with sync procedure as described in [12, TS 38.331].

If a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with a single *TCI-State*, that can be used as an indicated TCI state*,* the UE obtains the QCL assumptions from the configured TCI state for DM-RS of PDSCH and DM-RS of PDCCH, and the CSI -RS applying the indicated TCI state.

If a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with a single *TCI-State or ul-TCI-StateList* with *a single TCI-UL-State*, that can be used as an indicated TCI state,the UE determines an UL TX spatial filter, if applicable, from the configured TCI state for dynamic-grant and configured-grant based PUSCH and PUCCH, and SRS applying the indicated TCI state.

When a UE configured with *dl-OrJointTCI-StateList* would transmit a PUCCH with positive HARQ-ACK or a PUSCH with positive HARQ-ACK corresponding to the DCI carrying the TCI State indication and without DL assignment, or corresponding to the PDSCH scheduled by the DCI carrying the TCI State indication, and if the indicated TCI State(s) is/are different from the previously indicated one*(s)*, the indicated *TCI-State(s)* and/or *TCI-UL-State(s)* should be applied starting from the first slot that is at least symbols after the last symbol of the PUCCH or the PUSCH, and if the UE receives more than one indicated TCI state for a CC/BWP to be applied starting from the first slot that is at least symbols after the last symbol of the PUCCH or the PUSCH, the indicated TCI state carried in the latest DCI in time corresponding to positive HARQ-ACK value is applied. The first slot and the symbols are both determined on the active BWP with the smallest SCS among the BWP(s) from the CCs applying the indicated *TCI-State(s)* or *TCI-UL-State(s)* that are active at the end of the PUCCH or the PUSCH carrying the positive HARQ-ACK.

When a UE is configured with *dl-OrJointTCI-StateList*, and if the UE is configured with *unifiedTCI-StateType* is set as ‘separate’, and if the UE receives a TCI codepoint mapped with either of {*TCI-State*, *TCI-UL-State}*, the UE shall update the one indicated {*TCI-State*, *TCI-UL-State}* and maintain the other {*TCI-State*, *TCI-UL-State}* that is not updated by the received TCI codepoint.

When a UE is configured with *dl-OrJointTCI-StateList* and is having two indicated *TCI-states*, if the UE receives a TCI codepoint mapped with a sub-set of first and second *TCI-State(s)* and/or a sub-set offirst and second *TCI-UL-State(s)*, the UE shall update the first/second *TCI-State(s)* and/or first/second *TCI-UL-State(s)* mapped to the TCI codepoint, when applicable, and keep the previously indicated first/second *TCI-State(s)* and/or first/second *TCI-UL-State(s)* that is/are not updated by the TCI codepoint.

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH* in which one or more rows contain multiple *SLIV*s for PDSCH on a DL BWP of a serving cell, and the UE is receiving a DCI carrying the *TCI-State* indication and without DL assignment, the UE does not expect that the number of indicated *SLIV*s in the row of the *pdsch-TimeDomainAllocationListForMultiPDSCH* by the DCI is more than one.

If the UE is configured with *SSB-MTC-AddtionalPCI* and with *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, the UE receives an activation command for CORESET associated with each *coresetPoolIndex*, as described in clause 6.1.3.14 of [10, TS 38.321] or 6.1.3.xx of [10, TS 38.321], used to map up to 8 TCI states and/or pairs of TCI states, with one TCI state for DL channels/signals and/or one TCI state for UL channels/signals to the codepoints of the DCI field *'Transmission Configuration Indication'* in one CC/DL BWP. When a set of TCI state IDs are activated for a *coresetPoolIndex*, the activated TCI states corresponding to one *coresetPoolIndex* is associated with the serving cell physical cell ID and activated TCI states corresponding to another *coresetPoolIndex* can be associated with another physical cell ID.

When a UE supports two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication'* the UE may receive an activation command, as described in clause 6.1.3.24 of [10, TS 38.321], the activation command is used to map up to 8 combinations of one or two TCI states to the codepoints of the DCI field *'Transmission Configuration Indication'*. The UE is not expected to receive more than 8 TCI states in the activation command.

When the DCI field *'Transmission Configuration Indication'* is present in DCI format 1\_2 and when the number of codepoints S in the DCI field *'Transmission Configuration Indication'* of DCI format 1\_2 is smaller than the number of TCI codepoints that are activated by the activation command, as described in clause 6.1.3.14, 6.1.3.24 and 6.1.3.47 of [10, TS38.321], only the first S activated codepoints are applied for DCI format 1\_2.

When the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the activation command, the indicated mapping between TCI states and codepoints of the DCI field *'Transmission Configuration Indication'* should be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH and is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN, and is provided by *K-Mac* or if *K-Mac* is not provided. If *tci-PresentInDCI* is set to 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET scheduling the PDSCH, and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than *timeDurationForQCL* if applicable, after a UE receives an initial higher layer configuration of TCI states and before reception of the activation command, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the SS/PBCH block determined in the initial access procedure with respect to *qcl-Type* set to 'typeA', and when applicable, also with respect to *qcl-Type* set to 'typeD'.

<unchanged parts omitted>

5.2.1.5.2 Semi-persistent CSI/Semi-persistent CSI-RS

For semi-persistent reporting on PUSCH, a set of trigger states are higher layer configured by *CSI-SemiPersistentOnPUSCH-TriggerStateList,* where the CSI request field in DCI scrambled with SP-CSI-RNTI activates one of the trigger states. For a reporting setting for which the *CSI-ReportConfig* contains a list of sub-configurations, provided by the higher layer parameter [*csi-ReportSubConfigList*], one or more trigger states can be configured with each indicating one or more of the sub-configurations. A UE is not expected to receive a DCI scrambled with SP-CSI-RNTI activating one semi-persistent CSI report with the same *CSI-ReportConfigId* as in a semi-persistent CSI report which is activated by a previously received DCI scrambled with SP-CSI-RNTI.

For semi-persistent reporting on PUCCH, the PUCCH resource used for transmitting the CSI report are configured by *reportConfigType*. Semi-persistent reporting on PUCCH is activated by an activation command as described in clause 6.1.3.16 of [10, TS 38.321], which selects one of the semi-persistent Reporting Settings for use by the UE on the PUCCH. For a selected reporting setting for which the *CSI-ReportConfig* contains a list of sub-configurations provided by the higher layer parameter [*csi-ReportSubConfigList*], [an/the] activation command can [also] select one or more sub-configurations to use by the UE as described in clause 6.1.3.X of [10, TS 38.321]. When the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the activation command, the indicated semi-persistent Reporting Setting should be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH.

For a UE configured with CSI resource setting(s) where the higher layer parameter *resourceType* set to 'semiPersistent'.

- when a UE receives an activation command, as described in clause 6.1.3.12 of [10, TS 38.321], for CSI-RS resource set(s) for channel measurement and CSI-IM/NZP CSI-RS resource set(s) for interference measurement associated with configured CSI resource setting(s), and when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the selection command, the corresponding actions in [10, TS 38.321] and the UE assumptions (including QCL assumptions provided by a list of reference to *TCI-State's,* one per activated resource) on CSI-RS/CSI-IM transmission corresponding to the configured CSI-RS/CSI-IM resource configuration(s) shall be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH and is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN, and is provided by *K-Mac* or if *K-Mac* is not provided. If a *TCI-State* referred to in the list is configured with a reference to an RS configured with *qcl-Type* set to '*typeD*', that RS can be an SS/PBCH block, periodic or semi-persistent CSI-RS located in same or different CC/DL BWP.

- when a UE receives a deactivation command, as described in clause 6.1.3.12 of [10, TS 38.321], for activated CSI-RS/CSI-IM resource set(s) associated with configured CSI resource setting(s), and when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the deactivation command, the corresponding actions in [10, TS 38.321] and UE assumption on cessation of CSI-RS/CSI-IM transmission corresponding to the deactivated CSI-RS/CSI-IM resource set(s) shall apply starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH and is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN, and is provided by *K-Mac* or if *K-Mac* is not provided.

<unchanged parts omitted>

5.2.2.5 CSI reference resource definition

The CSI reference resource for a serving cell is defined as follows:

- In the frequency domain, the CSI reference resource is defined by the group of downlink physical resource blocks corresponding to the band to which the derived CSI relates.

- In the time domain, the CSI reference resource for a CSI reporting in uplink slot *n'* is defined by a single downlink slot *,* where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN,

<unchanged parts omitted>

6.1.2.1 Resource allocation in time domain

When the UE is scheduled to transmit a transport block and no CSI report by a DCI or by a RAR UL grant or fallbackRAR UL grant, or the UE is scheduled to transmit a transport block and a CSI report(s) on PUSCH by a DCI, the '*Time domain resource assignment'* field value *m* for the scheduled PUSCH on the serving cell of the DCI or the *PUSCH time resource allocation* field value *m* of the RAR UL grant or of the fallbackRAR UL grant provides a row index *m* + 1to a resource allocation table. The determination of the used resource allocation table is defined in Clause 6.1.2.1.1. The indexed row defines the slot offset *K2*, the start and length indicator *SLIV*, or directly the start symbol *S* and the allocation length *L*, the PUSCH mapping type, the number of slots used for TBS determination (if *numberOfSlotsTBoMS* is present in the resource allocation table), and the number of repetitions (if *numberOfRepetitions* is present in the resource allocation table) to be applied in the PUSCH transmission.

When the UE is scheduled to transmit a PUSCH with no transport block and with a CSI report(s) by a '*CSI request'* field on a DCI, the '*Time domain resource assignment'* field value *m* of the DCI provides a row index *m* + 1to the allocated table as defined in Clause 6.1.2.1.1. The indexed row defines the start and length indicator SLIV, or directly the start symbol *S* and the allocation length *L*, and the PUSCH mapping type to be applied in the PUSCH transmission and the *K2* value is determined as , where  are the corresponding list entries of the higher layer parameter

- *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17*, if PUSCH is scheduled by DCI format 0\_2 and *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17* is configured;

- *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17*, if PUSCH is scheduled by DCI format 0\_1 or 0\_3 and *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17* is configured;

- *reportSlotOffsetList* or *reportSlotOffsetList-r17*, otherwise;

in *CSI-ReportConfig* for the  triggered CSI Reporting Settings and  is the *(m+1)*th entry of  including the omitted CSI Reporting Settings triggered for non-active DL BWPs, where the UE does not expect that *(m+1)* is larger than 16.

- The slot *Ks* where the UE shall transmit the PUSCH is determined by *K2* as *Ks* =, if UE is configured with *ca-SlotOffset* for at least one of the scheduled and scheduling cell, , otherwise, where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN, *n* is the slot with the scheduling DCI, K*2* is based on the numerology of PUSCH,  and  are the subcarrier spacing configurations for PUSCH and PDCCH, respectively, and the scheduling DCI is other than DCI format 0\_0 with CRC scrambled by TC-RNTI.

<unchanged parts omitted>

6.2.1 UE sounding procedure

<unchanged parts omitted>

For a UE configured with one or more SRS resource configuration(s), and when the higher layer parameter *resourceType* in *SRS-Resource* or *SRS-PosResource* is set to 'aperiodic':

<unchanged parts omitted>

*- k* is configured via higher layer parameter *slotOffset* for each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command, respectively.

*-* is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN.

*-*  and are the  and the, respectively, which are determined by higher-layer configured ca-SlotOffset for the cell receiving the PDCCH,  and  are the  and the, respectively, which are determined by higher-layer configured ca-SlotOffset for the cell transmitting the SRS, as defined in [4, TS 38.211] clause 4.5.

- An available slot is a slot satisfying there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies UE capability on the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set. From the first symbol carrying the SRS request DCI to the last symbol of the triggered SRS resource set, UE does not expect to receive SFI indication, UL cancellation indication or dynamic scheduling of DL channel/signal(s) on flexible symbol(s) that may change the determination of available slot.

*- t* is configured via higher layer parameter *availableSlotOffsetList* with up to four different valuesof *AvailableSlotOffset* for each triggered SRS resources set and it is based on the subcarrier spacing of the triggered SRS transmission. When one or more SRS resource sets across all configured BWPs in a component carrier are configured, and at least one resource set is configured with *availableSlotOffsetList* parameter of more than one values, the indicated value of *t* is indicated by SOI field in DCI scheduling PUSCH/PDSCH and DCI 0\_1/0\_2 without data and without CSI request described in [5, TS 38.212]. The UE shall apply indicated value *t* specificallyfor those sets with configured *availableSlotOffsetList* parameter. When one or more SRS resource sets across all configured BWPs in a component carrier are configured and at least one resource set is configured with *availableSlotOffsetList* parameter, and the *availableSlotOffsetList* parameter for each SRS resource set has only one value, the UE shall apply the configured value specificallyfor those sets with configured *availableSlotOffsetList* parameter. For SRS resource set configured with *availableSlotOffsetList* parameter, each of resource set is configured with *K* values of *AvailableSlotOffset*. For SRS resource set configured without *availableSlotOffsetList* parameter, *t* = 0 is applied for the resource set.

- If the UE receives the DCI triggering aperiodic SRS in slot *n* and none of the resource sets is configured with parameter *availableSlotOffsetList* across all configured BWPs in a component carrier except when SRS is configured with the higher layer parameter *SRS-PosResource*

- if the UE is configured with *ca-SlotOffset* for at least one of the triggered and triggering cell, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot *,*

- otherwise, the UE transmits aperiodic SRS in each of the triggered resource set(s) in slot , where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where

*- k* is configured via higher layer parameter *slotOffset* for each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command respectively;

*-* is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN.

- and are the and the, respectively, which are determined by higher-layer configured ca-SlotOffset for the cell receiving the PDCCH, and are the  and the , respectively, which are determined by higher-layer configured ca-SlotOffset for the cell transmitting the SRS, as defined in [4, TS 38.211] clause 4.5.

- If the UE receives the DCI triggering aperiodic SRS in slot *n* and when SRS is configured with the higher layer parameter *SRS-PosResource*, the UE transmits every aperiodic SRS resource in each of the triggered SRS resource set(s) in slot , if UE is configured with ca-SlotOffset for at least one of the triggered and triggering cell, , otherwise, where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where

*- k* is configured via higher layer parameter *slotOffset* for each aperiodic SRS resource in each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command respectively;

*-*  is the subcarrier spacing configuration for with a value of 0 for frequency range 1 and for FR2-NTN.

- and are the and the, respectively, which are determined by higher-layer configured ca-SlotOffset for the cell receiving the PDCCH, and are the  and the , respectively, which are determined by higher-layer configured ca-SlotOffset for the cell transmitting the SRS, as defined in [4, TS 38.211] clause 4.5.

<unchanged parts omitted>