3GPP TSG RAN WG2 Meeting #123bis R2-230xxxx

**Xiamen, China, October 09-13, 2023**

**Agenda item:** 7.x.x

**Source:** Intel Corporation

**Title:** Outcome of email discussion [Post123bis][310][NR-NTN Enh] UE caps running CR (Intel)

**Document for:** Discussion and decision

# Introduction

This document aims to review the running CRs on UE capabilities for Rel-18 NR NTN Enhancement and to also discuss the open topics, if any.

* [Post123bis][310][NR-NTN Enh] UE caps running CR (Intel)

Scope: running CR update and list of open issues

Intended outcome:

* + - * + Endorsed running CRs
        + List of open issues to be addressed by company Tdocs

Deadline: Long

For reference, two annex sections are included: Annex A (RAN2#123bis agreements) and Annex B (RAN1 feature list on Rel-18 NR NTN Enh). Note that new Discussion point 4) and Discussion point 5) are added based on a company inputs on a new possible UE capabilities to be considered.

Please provide your new/additional inputs **before/by Thursday October 26th 3pm UCT (8am PST)** to have time to update the running CRs and further review/discuss the report and updated CRs (as official email discussion deadline is Friday Oct. 27th 1000 UTC, 2023).

# Companies’ point of contact (PoC)

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| **Company’s name** | **PoC’s name** | **PoC’s email address** |
| Ericsson | Ignacio Pascual | Ignacio.pascual.pelayo@ericsson.com |
| vivo | Yitao Mo (Stephen) | yitao.mo@vivo.com |
| Huawei, HiSilicon | Lili Zheng | zhenglili4@huawei.com |
| Xiaomi | Xiaolong Li | Lixiaolong1@xiaomi.com |
| Intel | Marta Martinez Tarradell | m.m.tarradell@intel.com |
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# Discussion

The following was agreed in last RAN2#123bis meeting “*Combination of RACH-less HO with time-based CHO is supported in Rel-18 NTN for both Configured and Dynamic Grant.*”. RAN2 should discuss whether related UE capabilities are desirable.

1. Do you support defining a new UE capability to indicate UE’s support of RACH-less HO with time-based CHO?

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| Ericsson | No | Existing capabilities, CHO and RACH-less, should be enough. |
| vivo | No | We don’t have specific UE behavior when CHI is configured with RACH-less. So we agree with Ericsson that reusing the CHO and RACH-less capabilities are sufficient. |
| Huawei, HiSilicon | No | We think the UE implementation of RACH-less HO and time-based CHO are quite independent features, the combination is more of a NW configuration issue. If we introduce a separate capability for this, RAN2 may end up introducing a separate capability for every combination of CHO event with RACH-less or other feature with RACH-less if agreed in the future. |
| Qualcomm |  | For now ok the time-based CHO + Rel-18 band specific RACH-less HO UE capabilities could be sufficient. |
| ZTE | No |  |
| Xiaomi | No | If UE supports both RACH-less HO and time based CHO, the UE should support RACH-less HO with time-based CHO. |

**[Summary report] [Rapp(v2)]** All companies do not see the need to defining a new UE capability to indicate UE’s support of RACH-less HO with time-based CHO understanding that this could be indicated via the UE’s capabilities for time-based CHO + Rel-18 band specific RACH-less HO UE.

1. If your response to previous Discussion point 1) is yes, do you support having two new UE capabilities to indicate UE’s support differently with CG and DG for the combination of RACH-less HO with time-based CHO?

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| **Company’s name** | **Yes/No** | **Comments, if any** |
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1. Please indicate if you have any suggested change on the TPs provided on UE capability running draftCRs to TS 38.306 and 38.331.

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| **Company’s name** | **TS #** | **Section** | **Comments, if any** |
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1. Do you support defining a new UE capability to indicate UE’s support of location-based CHO for moving cell which involves the calculation of the present reference location from ephemeris and one reference location at epoch time?

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| **Company’s name** | **Yes/No** | **Comments, if any** |
| vivo | Yes | In our understanding, the UE needs to indicated whether the candidate target cell is earth-moving and thus starting to derive the location distance. So the NW needs to know whether the UE supports this feature or not. |
| Ericsson | Yes |  |
| Huawei, HiSilicon | Yes | Since an optional capability is introduced for Idle UEs on location-based measurement initiation in moving cells, we think a similar capability is needed for Connected UEs on location-based CHO.  One thing to note is that, in R17 location-based CHO, there is no agreement or spec clarification saying it cannot be used for moving cells, however there was no UE capability on predicting reference location then. We think the only understanding is that R17 location-based CHO relies on NW reconfiguration to update the reference location. |
| Qualcomm | Yes |  |
| ZTE | Yes |  |
| Xiaomi | Yes |  |

**[Summary report] [Rapp(v2)]** All companies support defining a new optional signaling UE capability to indicate UE’s support of location-based CHO for moving cell which involves the calculation of the present reference location from ephemeris and one reference location at epoch time. One company clarified that this UE capability is needed by the network as UE needs to indicate whether the candidate target cell is earth-moving and thus starting to derive the location distance. Another one pointed that in Rel-17 location-based CHO there was no mention that it cannot be used for moving cell.

1. To define a new UE capability, e.g., *locationBasedCondHandoverNTN-r18*, to indicate whether the UE supports location-based conditional handover for moving cell in NTN bands (which involves the calculation of the present reference location from ephemeris and one reference location at epoch time, as specified in TS 38.331).
   1. This *locationBasedCondHandoverNTN-r18* capability is defined per Band, optional with signaling capability, and N/A for FDD/TDD DIFF and FR1/FR2 Diff. This is defined as part of §4.2.7.2 BandNR parameters in TS 38.306.
   2. An editor’s note is added to *locationBasedCondHandoverNTN-r18* to capture “FFS whether any change or update is needed considering how *locationBasedCondHandover-r17* is defined”*.*
2. Do you support defining a new UE capability to indicate UE’s support of unchanged PCI? If so, do you prefer having separate or same UE radio capabilities for hard and soft switch?

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| **Company’s name** | **Yes**  **/No** | **Separate**  **/Same** | **Comments, if any** |
| vivo | Yes | Slightly prefer one capability | As L3 HO is supported, then unchanged PCI should be optional to UE for simplicity. Capability signaling is needed so that the NW can trigger L3 for the non-capable UE. |
| Ericsson | Yes | Separate | Hard and soft switch require different implementations (e.g., SMTC handling). Thus, network should be informed to configure HO accordingly for those UEs not supporting the specific scenario. |
| Huawei, HiSilicon | Yes | Postpone | On whether separate capabilities are required for soft and hard switching, we think it can be postponed until more details on UE behaviors under soft switching are settled down (to check whether there is a big discrepancy). |
| Qualcomm | Yes | Separate | Network needs to know whether the UE in connected mode needs interruption or not at t-Service. |
| ZTE | Yes | Postpone | Can discuss after having a clear view on UE procedures for both soft and hard switch. |
| Xiaomi | Yes | Separate | The UE behavior is different for the hard switch and soft switch. |

**[Summary report] [Rapp(v2)]** All companies support defining a new optional signaling UE capability to indicate UE’s support of unchanged PCI. 3 companies prefer having separate UE radio capabilities for hard and soft switch, one company prefers single capability for both, and two companies prefers postponing the decision. The suggestion is to define two different UE capabilities and add an FFS on whether this may not be needed when UE’s procedures as further clarified for both soft and hard switch.

1. To define a two new UE capability, e.g., *unchangedPCI-NTN-SoftSwitch-r18 and unchangedPCI-NTN-HardSwitch-r18*, to indicate whether UE support unchanged PCI with soft or hard switch, as specified in TS 38.331.
   1. *unchangedPCI-NTN-SoftSwitch-r18 and unchangedPCI-NTN-HardSwitch-r18* capabilities are defined per UE, optional with signaling capability, and No for FDD/TDD DIFF and FR1/FR2 Diff. This is defined as part of §4.2.2 General parameters in TS 38.306.
   2. An editor’s note is added to *unchangedPCI-NTN-SoftSwitch-r18* and *unchangedPCI-NTN-HardSwitch-r18* to capture “FFS whether further changes may be needed after further progressing on the design to support unchanged PCI with soft and hard switch”*.*
2. Please indicate if there are any other UE capabilities that needs to be discussed/defined by RAN2 for Rel-18 NR NTN Enhancements.

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| **Company’s name** | **Comments, if any** |
| Ericsson | * In moving cells, location-based CHO involves the calculation of the present reference location from ephemeris and one reference location at epoch time. Thus, a new capability is needed. * Unchanged PCI. Separate capabilities for hard and soft switch.   **[Rapp(v1)]** Added new discussion points (4 and 5) covering these two new points. |
| vivo | Perhaps an optional capability without signaling is needed for the support of common LCID solution  **[Rapp(v2)]** It might be valid question for discussion but suggest waiting on this topic until further progresses on the joint session as well as NTN specific session. |
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# Conclusion

The proposals captured are the following:

**Proposal 1.** To define a new UE capability, e.g., *locationBasedCondHandoverNTN-r18*, to indicate whether the UE supports location-based conditional handover for moving cell in NTN bands (which involves the calculation of the present reference location from ephemeris and one reference location at epoch time, as specified in TS 38.331).

**Proposal 1.1.** This *locationBasedCondHandoverNTN-r18* capability is defined per Band, optional with signaling capability, and N/A for FDD/TDD DIFF and FR1/FR2 Diff. This is defined as part of §4.2.7.2 BandNR parameters in TS 38.306.

**Proposal 1.2.** An editor’s note is added to *locationBasedCondHandoverNTN-r18* to capture “FFS whether any change or update is needed considering how *locationBasedCondHandover-r17* is defined”*.*

**Proposal 2.** To define a two new UE capability, e.g., *unchangedPCI-NTN-SoftSwitch-r18 and unchangedPCI-NTN-HardSwitch-r18*, to indicate whether UE support unchanged PCI with soft or hard switch, as specified in TS 38.331.

**Proposal 2.1.** *unchangedPCI-NTN-SoftSwitch-r18 and unchangedPCI-NTN-HardSwitch-r18* capabilities are defined per UE, optional with signaling capability, and N/A for FDD/TDD DIFF and FR1/FR2 Diff. This is defined as part of §4.2.2 General parameters in TS 38.306.

**Proposal 2.2.** An editor’s note is added to *unchangedPCI-NTN-SoftSwitch-r18* and *unchangedPCI-NTN-HardSwitch-r18* to capture “FFS whether further changes may be needed after further progressing on the design to support unchanged PCI with soft and hard switch”*.*

# Annex A (RAN2#123bis agreements)

## Coverage Enhancements

1. RAN2 continues to focus on a solution to address PUCCH repetition for Msg4 HARQ-ACK in Msg3 only for random access procedure triggered by RRC connection establishment, RRC connection re-establishment or RRC connection resume, i.e. to CCCH/CCCH1 (in the future we can consider random access during RRC connected, depending on RAN1)
2. No explicit NW indication to enable/disable PUCCH repetition for Msg4 HARQ-ACK besides the needed signalling for number of repetition, RSRP configuration in SIB (meaning that if these parameters are signalled, PUCCH repetition for Msg4 HARQ-ACK is enabled)

## Network verified UE location

1. Add in NR-Multi-RTT-SignalMeasurementInformation the measurements relevant to RAN1 agreed offset (e.g., the actual index difference between subframe j and subframe i and the DL timing drift due to Doppler over the service link associated with the UE RX-TX time difference measurement period) with detailed definition referred to RAN1 agreements.
2. Ephemeris and corresponding time information (e.g., epochTime) is not provided by the UE. How this is provided to the LMF is up to RAN3 (can come back to see whether the problem that the UE could use a different ephemeris – and then should report it back to the gNB – is a valid case to consider)
3. RAN2 assumes that FG 44-3 should be an LPP capability to be reported to the LMF (no need for other capabilities)
4. RAN2 understands that to solve the mirror point issue, the measurements reported by RAN should include the information of the cells on the opposite side

## NTN-TN enhancements

1. The maximum number of TN coverage area information is 32 (5 bits)
2. RAN2 will not specify restrictions on TN coverage description (i.e., description of TN coverage is left to NW implementation). The signalled TN coverage can describe areas not currently covered by the satellite cell footprint (FFS how to reflect this in the specification)
3. TN coverage information can be broadcast by both (quasi)earth-fixed and earth-moving cells
4. The working assumption “We do not introduce new triggers making the UE reacquire the TN coverage information from SI” in Rel-18 is confirmed
5. The new SIB including the TN coverage information is not an essential SIB for NTN. An NTN-capable UE does not need to consider the cell barred if it is unable to acquire the SIB when scheduled.
6. Legacy SI update procedure will be used when the network updates the TN coverage information (can further check for moving cell case)

## Handover enhancements

1. For location-based CHO for earth-moving cells, re-use the procedure from cell reselection as baseline to derive the candidate cell’s reference location as the cell moves (FFS on how to signal the needed parameters, e.g. ephemeris and Epoch time)
2. Upon T304 expiry, the UE does not fallback to RACH-based HO.
3. Preallocated UL grant must be configured with an associated RSRP threshold.
4. UE relies on T304 and RRC Re-establishment procedure to address RACH-less HO failure in Rel-18 NTN (as in LTE). No new NTN-specific enhancements are introduced. If TAT expires, the UE follows the legacy procedures, regardless of the RACH-less HO configuration. RAN2 understands that the NW can ensure a proper configuration for TAT and T304 values (up to NW implementation, no need to capture this in the specs).
5. As for RACH-less LTM, for RACH-less NTN, the UE determines successful reception of its first UL data based on receiving a PDCCH addressing the UE’s C-RNTI in the target cell scheduling a new transmission as first UL transmission. Can be either DL assignment or UL grant addressed to same HARQ process for the “new transmission”. RAN understands this does not exclude the possibility to use a Contention Resolution MAC CE but this will not be used as a determination of the RACH less HO completion
6. We follow the LTE baseline for when UE starts the PTAG timeAlignmentTimer in NTN RACH-less HO (option 1 in R2-2311318)
7. Combination of RACH-less HO with time-based CHO is supported in Rel-18 NTN for both Configured and Dynamic Grant. For the Dynamic Grant case this should be configured by the NW only when the is no risk of confusion about which beam to use (up to NW implementation).
8. We don’t consider the impact on Rel-17 UEs behavior (or Rel-18 UEs not supporting unchanged PCI) when defining the Rel-18 unchanged PCI solution
9. Network provides the sync information of target satellite in advance to UE before satellite switching, via broadcast signalling
10. RAN2 confirms satellite switching with unchanged PCI is only applicable on quasi-earth fixed system
11. Only 1 target satellite information (i.e. NTN-config) of serving cell is provided in SIB19. FFS on exact signalling
12. SMTC configuration of target satellite needs further discussion:

      FFS on whether and how to provide the SMTC configuration of target satellite.

      FFS on how to handle the SMTC adjustment.

1. We support soft satellite switching in Rel-18
2. There will be an indication (FFS if explicit or implicit) whether hard switch or soft switch is used.
3. At least soft satellite switching, network provides SSB information of target satellite to UE. FFS on the details: options include e.g. indicating a time offset/information or indicating a different SSB index for the target satellite (FFS for Hard satellite switch)
4. In soft satellite switching, UE can start synchronizing with target satellite before T-service of source satellite.
5. We introduce a T-start which indicates the earliest occasion when the UE can start synchronizing with target satellite (actual signalling is FFS). In soft switch scenario, T-start of target satellite is earlier than T-service of source satellite (FFS if T-start is also used for hard satellite switch)
6. For soft satellite switching, the exact time when the UE starts synchronizing with target satellite (between T-start and T-service) is up to UE implementation
7. UE is not required to connect to source satellite when the UE switches to target satellite.
8. Common signalling (e.g. using servingCellConfigCommon) for the purpose of (C)HO in NTN is not supported in Rel-18.

# Annex B (RAN1 feature list [R1-2310635] on Rel-18 NR NTN Enh)

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| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (Sidelink WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
| 44. NR\_NTN\_enh | 44-1 | PUCCH repetition on common PUCCH resource | 1. Support repetition transmission of PUCCH for Msg4 HARQ-ACK on common PUCCH resource (i.e., PUCCH resource before dedicated configuration is provided)  2. Support receiving repetition factor in system information  3. Support receiving repetition factor in DCI format 1\_0 with CRC scrambled by TC-RNTI scheduling Msg4 PDSCH  4. Support Msg3 to transmit information for PUCCH Msg4 HARQ-ACK repetition  5. Extension of the repetition transmission of PUCCH before dedicated PUCCH resource configuration  6. Support of RSRP threshold for Msg4 HARQ-ACK repetition on common PUCCH resources |  | Yes | No | UE does not support PUCCH repetition for common PUCCH resources | Per Band | N/A | N/A | N/A | A UE that includes [RAN2 parameter name] in [RRC Setup Request] must support FG 44-1  [Note: This UE feature group is applicable only for bands in Table 5.2.2-1 in TS 38.101-5 [and HAPS operation bands in Clause 5.2 of TS 38.104] | Optional without capability signaling |
| 44. NR\_NTN\_enh | 44-2 | NTN DMRS bundling enhancement for PUSCH | 1. Support of DM-RS bundling for PUSCH over consecutive slots  2. Support of pre-compensation to keep phase rotation due to timing drift within the phase difference limit  [3. Support not to perform TA pre-compensation update within an actual TDW if it causes phase discontinuity that may violate the phase difference limit.] | At least one of {30-4a/b/c}, 26-1 | Yes | No | UE does not support DM-RS bundling enhancement for PUSCH in NTN | Per Band | N/A | N/A | N/A | Note: This UE feature group is applicable only for bands in Table 5.2.2-1 in TS 38.101-5 and HAPS operation bands in Clause 5.2 of TS 38.104 | Optional with capability signaling |
| 44. NR\_NTN\_enh | 44-3 | UE Rx-Tx Measurement and Report for Multi-RTT with single satellite in NTN | 1. Support UE Rx-Tx time difference and UE Rx-Tx time difference offset measurement and report for Multi-RTT positioning with single satellite in NTN  2. Support of reporting DL timing drift due to Doppler over the service link associated with the UE Rx-Tx time difference measurement period | 13-4, 13-8 | Yes | No | UE does not support Multi-RTT positioning with single satellite in NTN | Per Band | N/A | N/A | N/A | Note: This UE feature group is applicable only for bands in Table 5.2.2-1 in TS 38.101-5 [and HAPS operation bands in Clause 5.2 of TS 38.104] | Optional with capability signaling |