3GPP TSG-RAN WG4 Meeting #110bis R4-2405291

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

**Agenda item:** 9.15.4

**Source:** Moderator (Qualcomm)

**Title:** Topic summary for [110bis][138] NR\_NTN\_Ph3\_UERF

**Document for:** Information

# Introduction

A Rel-19 WI on Non-Terrestrial Networks (NTN) for NR Phase 3 (RP-240775) has been approved with the following objectives:

Objective of SI or Core part WI or Testing part WI

The work item aims at specifying further enhancements for NG-RAN based NTN (Non-Terrestrial Networks) with the following assumptions:

* GSO (Geo Synchronous Orbit) and NGSO (Non-Geo Synchronous Orbit). NGSO includes Low Earth Orbit (LEO) and Medium Earth Orbit (MEO).
* Earth fixed tracking area. Earth fixed & Earth moving cells for NGSO
* FDD mode
* UEs with GNSS (Global Navigation Satellite Systems) capabilities
* In frequency band above 10 GHz, both Terminal Type 1 (Electronic steering antenna) and Type 2 (Mechanical steering antenna) to be considered for GSO and NGSO
* Implicit compatibility to support HAPS (High Altitude Platform Station) and ATG (Air To Ground) scenarios, where relevant

Note 1: In Rel-19 WID, “VSAT” device with external antenna on moving platform is equivalent to a device that operate on platforms in motion, and this is referred to as ESIM (Earth Station In Motion).

The objectives of the work item are the following:

1. Study and specify if beneficial downlink coverage enhancements targeting support for additional reference satellite payload parameters covering both GSO and NGSO constellations operating in FR1-NTN or FR2-NTN [RAN1, RAN2, RAN4]

* Define additional reference satellite payload parameters assuming power sharing among satellite beams or different satellite beam patterns/size (i.e. wide or narrow) across the satellite footprint, such that satellite beams may not all be simultaneously active or may be active below the nominal EIRP density per satellite beam (see section 6.1.1 in TR 38.821) due to limited power and limited feeder link bandwidth.
* Define the corresponding power sharing assumptions and necessary link level and system level evaluation methodology and relevant KPIs for evaluations of the coverage, to allow for identification of physical channels/signals and system-level aspects that need enhancements and the corresponding needed improvements.
* Study and if needed specify solutions, including link level enhancements for FR1-NTN (e.g. for PDCCH, PDSCH) and/or system level enhancements for FR1-NTN and/or FR2-NTN, allowing dynamic and flexible power sharing between satellite beams or different satellite beam patterns/size (i.e. wide or narrow) across the satellite footprint.
* Notes for this objective:
  + SSB channel enhancement is not considered
  + Antenna gain of UE shall be assumed to be -5.5dBi in case of smartphone in FR1-NTN, the UE is assumed to be a full duplex UE, and at least 2Rx are considered at the UE
  + NGSO to be considered in priority: LEO Set-1 @ 600 km
  + Rel-18 network energy saving techniques should be considered as baseline in the system level study

1. Uplink Capacity/Throughput Enhancement for FR1-NTN [RAN1, RAN2, RAN4]

* Study then specify, if beneficial, DFT-s-OFDM PUSCH enhancements via Orthogonal Cover Codes (OCC)
  + Determine the achievable capacity improvement to be targeted taking into account realistic impairments (e.g. Doppler, time variation, phase distortion, etc)
  + Specify necessary signalling, if needed
  + Update RF requirements accordingly, if needed
  + Note: The study can consider orthogonal cover codes across OFDM symbols, across slots, and/or within an OFDM symbol.
  + Note: the study phase is targeted to be completed by RAN#104
* Notes for this objective:
  + The enhancement is not targeting improvements/impacts of MU-MIMO capability
  + The enhancement is not targeted to PUSCH DMRS
  + No enhancement for initial access
  + Enhancements to PRACH are not in scope.
  + This feature may be applicable for UEs operating in terrestrial networks based on a common design

1. Specify signaling of the intended service area of a broadcast service (e.g. MBS broadcast) via NR NTN [RAN2, RAN3]

* Specify SIB signaling to indicate the intended service area in case the satellite footprint covers a larger area. [RAN2]
* Specify the necessary signaling between CN and NG-RAN. [RAN3]

1. Support of regenerative payload [RAN3, RAN2, RAN4]

* Specify the support of gNB on board in TS 38.300
* Specify, if needed, any necessary enhancements related to the intra and inter-gNB mobility, especially for Xn interface over feeder link or over ISL. [RAN3]
* Note: if any additional necessary stage-3 specifications impact for e.g. NGAP is identified, RAN3 will handle it.

1. Support of Rel-17 RedCap and Rel-18 eRedCap UEs with NR NTN operating in FR1-NTN bands [RAN4, RAN1]

* For full-duplex FDD RedCap and eRedCap UEs, define the RF and RRM requirements [RAN4]
* For HD-FDD RedCap UEs and eRedCap UEs, check whether any essential changes are needed for their support (i.e. focusing on HD collision rules) by end of Q2/2024 [RAN1]
  + Depending on feasibility assessment above, define the RF and RRM requirements [RAN4]
* Notes for this objective:
  + GNSS (Global Navigation Satellite Systems) capabilities and simultaneous GNSS and NR-NTN operation is supported in RedCap/eRedCap UE.

This summary handles the tdoc submitted for AI 9.15.1 and 9.15.2

# Topic #1: Work plan and RedCap features in scope

*Topic description:* Work plan and RedCap features in scope

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2404869 | Ericsson | Proposal-1: Network energy saving feature in Rel-18 can be starting point for RF impact analysis for NTN DL coverage enhancement objective.  Proposal-2: Wait RAN1 reach conclusions on OCC feature before RAN4 start to evaluate the RF impact  Proposal-3:No RAN RF work on the regenerative payload objective.  Proposal-4:Start the RedCap UE RF requirement work in this meeting. |
| R4-2405713 | Qualcomm Inc. | Observation 1: UE RF impact is coming from RedCap and also possibly from UL capacity enhancement. However, RAN4 needs to wait for better maturity of RAN1 design of UL capacity enhancements before working on it.  Observation 2: UE RF impact is not expected for DL coverage enhancements, broadcast service area signalling or support of regenerative payload.  Proposal 1: Start RAN4 work from FD-FDD RedCap requirements and specify both 2Rx and 1Rx requirements. |
| R4-2404253 | Sony | Proposal 1: The same UE channel bandwidth as Rel-17 Redcap and Rel-18 eRedcap should be specified for NTN Redcap and eRedcap.  Proposal 2: For NTN eRedcap, both the reduced baseband bandwidth eRedcap and NOT reduced baseband bandwidth eRedcap should be specified.  Observation 2: Based on experience in the IoT NTN work, no impact on UE RF requirements with respect to the HD collision rules is expected.  Proposal 6: RAN4 can specify the RF requirement for HD-FDD Redcap and eRedcap UEs, while RAN1 is checking whether any essential changes are needed. |
| R4-2404264 | Nokia | Proposal 2: RAN4 should evaluate the feasibility of one RX antenna RedCap and eRedCap devices in NTN scenario.  Proposal 3: Wait for RAN1 to finish HD-FDD feasibility evaluation before starting any work for HD-FDD RedCap and eRedCap UEs. |
| R4-2404670 | Vivo | Proposal 1: For RedCap or eRedCap supporting FR1-NTN, the antenna configuration 1T\*1R can be considered.  Proposal 4: For eRedCap, we need to further discuss whether to support Reduced BB for NTN. |
| R4-2405316 | Samsung | Observation 1: The Objective 1, changes in satellite payload, including beamwidth, SAN eirp, beam coverage size, may have potential impact on the Tx and Rx UE RF requirements. This potential impact should be early clarified or FFS.  Observation 2: The UE RF impact, from Objective 2, can be FFS depending on the study outcomes from RAN1.  Observation 3: We share the observation of no major impact on UE RF Tx requirements for support redcap in FR1-NTN.  Observation 4: We share the observation that the corresponding changes in Rx requirements to accommodate single port RedCap UE is needed, and this would impact diversity characteristics, refsense, etc. |
| R4-2405346 | Huawei | Observation 1: there is no need to open the RF discussion on HD-FDD (e)RedCap UE before RAN1 conclude the essential changes for supporting this feature.  Proposal 3: RAN4 can discuss whether both two kinds of Rel-18 eRedCap UE can be supported for NR NTN.   |  |  |  | | --- | --- | --- | |  | Rel-18 eRedCap UE  (20MHz + PR1) | Rel-18 eRedCap UE  (BW3/PR3 + PR1) | | UE RF channel BW | Up to 20MHz | Up to 20MHz | | PRB restriction | No PRB restriction | For 15 kHz SCS, the maximum number of RBs is 25.  For 30 kHz SCS, the maximum number of RBs is 12 | | Peak data rate reduction | Targeted to same peak data rate, i.e. 10Mbps | | |

## Open issues summary

*Open issues and candidate options before meeting:*

Issues 1-1 and 1-2 are expected to be agreeable without further discussion and can be directly considered in WF. Issues 1-3 to 1-5 would benefit from quick online check.

### Issue 1-1: Work plan for RF Core part, UE RF impact from DL coverage enhancement and regenerative payload

* Proposals
  + Option 1: No UE RF impact (Qualcomm)
  + Option 2: Potential UE RF impact from DL coverage enhancement (Samsung, Ericsson)
* Recommended WF
  + Companies to bring Tdoc in future meeting if any impact is identified

### Issue 1-2: Work plan for RF Core part, UL capacity enhancements (OCC)

* Proposals
  + Option 1: Wait for further RAN1 progress before concluding whether there is RAN4 spec impact (Samsung, Qualcomm, Ericsson)
* Recommended WF
  + Option 1

### Issue 1-3: Work plan for RF Core part, HD-FDD RedCap

Background: Related WI objective states: *For HD-FDD RedCap UEs and eRedCap UEs, check whether any essential changes are needed for their support (i.e. focusing on HD collision rules) by end of Q2/2024 [RAN1]*

* + *Depending on feasibility assessment above, define the RF and RRM requirements [RAN4]*
* Proposals
  + Option 1: Discuss RedCap HD-FDD only after RAN1 concludes study (Huawei, Nokia, Qualcomm)
  + Option 2: RAN4 can specify the RF requirement for HD-FDD Redcap and eRedcap UEs, while RAN1 is checking whether any essential changes are needed. (Sony)
* Recommended WF
  + Confirm online whether option 1 is ok

### Issue 1-4: Work plan for RF Core part, 1Rx vs. 2Rx for RedCap

* Proposals
  + Option 1: Specify both 1Rx and 2Rx requirements (Qualcomm, Sony, Vivo, Ericsson, Huawei)
  + Option 2: Further discussion and/or evaluation is needed to decide whether 1 Rx is specified (Nokia, Apple)
* Recommended WF
  + Confirm online whether option 1 is ok

### Issue 1-5: Work plan for RF Core part, eRedCap BW reduction

Background: In Rel-18, there are two kinds of Rel-18 eRedCap UE listed below.

|  |  |  |
| --- | --- | --- |
|  | **Rel-18 eRedCap UE**  **(20MHz + PR1)** | **Rel-18 eRedCap UE**  **(BW3/PR3 + PR1)** |
| **UE RF channel BW** | Up to 20MHz | Up to 20MHz |
| **PRB restriction** | No PRB restriction | For 15 kHz SCS, the maximum number of RBs is 25.  For 30 kHz SCS, the maximum number of RBs is 12 |
| **Peak data rate reduction** | Targeted to same peak data rate, i.e. 10Mbps | |

* Proposals
  + Option 1: Specify both variants, i.e. with and without bandwidth reduction (Sony)
  + Option 2: FFS (Vivo, Huawei)
* Recommended WF
  + Discuss online

# Topic #2: RedCap UE RF requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2405713 | Qualcomm Inc. | Proposal 1: Start RAN4 work from FD-FDD RedCap requirements and specify both 2Rx and 1Rx requirements. |
| R4-2404185 | Apple | Proposal 1: For RedCap and eRedCap UEs with NR NTN operating in FR1-NTN bands, it needs to be clarified whether 2Rx is mandatory for all operating bands or 1Rx can still be supported.  Observation 1: NR NTN mandatory 2Rx support is mainly for Rx diversity to improve DL coverage instead of DL MIMO support to enhance throughput and capacity.  Observation 2: For NR NTN RedCap and eRedCap UEs, using maxNumberMIMO-LayersPDSCH to indicate more than 1Rx antenna port support would be misleading.  Proposal 2: RAN4 to discuss whether to continue using maxNumberMIMO-LayersPDSCH to indicate more than 1Rx antenna port support or a new UE capability on number of Rx support which is independent of DL MIMO layer support needs to be introduced for NR NTN RedCap and eRedCap UEs. |
| R4-2404253 | Sony | Observation 1: For the NTN Redcap and eRedcap, the general transmission requirements might be reusable, but further check on the regulatory requirements is needed.  Observation 2: Based on experience in the IoT NTN work, no impact on UE RF requirements with respect to the HD collision rules is expected.  Proposal 1: The same UE channel bandwidth as Rel-17 Redcap and Rel-18 eRedcap should be specified for NTN Redcap and eRedcap.  Proposal 2: For NTN eRedcap, both the reduced baseband bandwidth eRedcap and NOT reduced baseband bandwidth eRedcap should be specified.  Proposal 3: Further check if any update is needed for NTN Redcap and eRedcap with respect to regulatory requirements with considering the feasibility of Redcap and eRedcap implementations.  Proposal 4: Reuse the NR NTN REFSENS for the NTN Redcap with 2Rx.  Proposal 5: Apply the deltaR1R as specified in Table 7.3I.2-1 of 38.101-1 for the single Rx NR Redcap.  Proposal 6: RAN4 can specify the RF requirement for HD-FDD Redcap and eRedcap UEs, while RAN1 is checking whether any essential changes are needed.  Proposal 7: It is proposed to adopt the same tightening rule as in Rel-17 Redcap to derive the REFSENS for NTN Redcap HD-FDD, which results in 0 dB tightening for n255, and 0.5 dB tightening for n254 and n256 for 5MHz, e.g., REFNSEN = -100 dBm for all three NR bands in NTN with 5MHz BW for 2Rx.  Proposal 8: NTN Redcap HD-FDD REFSENS for channel BW wider than 5 MHz can be calculated by REFSENS(5MHz) + 10log10(n x NRB/25), where NRB is the maximum transmission bandwidth configuration with n=1 for 15kHz SCS, n=2 for 30kHz SCS, and n=4 for 60kHz SCS.  Proposal 9: Reuse the same way as in Rel-18 eRedcap REFSENS (as in 7.3I.3 of 38.101-1 ) to define the NTN eRedcap REFSENS.  Proposal 10: RAN4 further checks if other reception requirements from NR NTN can be reused for NTN Redcap and eRedcap. |
| R4-2404264 | Nokia | Proposal 1: RAN4 should evaluate the existing RedCap and eRedCap RF requirements defined in TS 38.101-1 as a starting point for supporting RedCap and eRedCap UEs in NTN. |
| R4-2404437 | CATT | Proposal 1: The operating band supported by NTN RedCap / eRedCap UE should include at least band n256 and n255. RAN4 should evaluate whether the NTN RedCap / eRedCap UE supports the n254 band.  Proposal 2: The channel bandwidth supported by NTN RedCap UE should be 5MHz / 10MHz / 15 MHz / 20MHz. For NTN eRedCap UE, the supported channel bandwidth should be 5MHz, and 60 KHz SCS will not be supported.  Proposal 3: RAN4 should evaluate whether the NTN RedCap / eRedCap UE supports the enhanced channel raster.  Observation 1: Reusing the TN RedCap / eRedCap UE Tx requirements could be considered as a potential approach for determining the NTN RedCap / eRedCap UE Tx requirements.  Proposal 4: RAN4 should evaluate whether the pre-compensate function could be supported by NTN RedCap / eRedCap UE. |
| R4-2404585 | Xiaomi | Observation 1: For full-duplex FDD mode, the RF requirements for redcap and eRedcap UE in TN are band agnostic.  Proposal 1: For full-duplex FDD redcap and eRedcap UE, the current RF requirements for PC3 in TN bands could be reused for FR1 NTN bands. |
| R4-2404670 | Vivo | Proposal 1: For RedCap or eRedCap supporting FR1-NTN, the antenna configuration 1T\*1R can be considered.  Observation 1: For R17 Redcap UE and Rel-18 eRedCap UE without BB reduction supporting FR-1 NTN, the channel bandwidth can support Max 20MHz. For R18 eRedCap UE with BB reduction supporting NTN, the RF channel bandwidth can support 20MHz and the baseband can support Max 5MHz.  Proposal 2: For RedCap and eRedCap UE supporting NTN, consider PC3 as the maximum output power.  Proposal 3: For Rx, reference sensitivity of NTN full duplex Redcap UE with 2 Rx antenna ports follows the legacy NR NTN UE, reference sensitivity of NTN full duplex Redcap UE with 1 Rx antenna ports reuse the following relaxation:   |  |  |  | | --- | --- | --- | | Operating band | Channel bandwidth (MHz) | ΔR1R (dB) | | FDD band | 5 | 2.5 | | FDD band | 10, 15, 20 | 3.0 |   Proposal 4: For eRedCap, we need to further discuss whether to support Reduced BB for NTN. |
| R4-2404870 | Ericsson | Proposal-1: Adding new suffix in TS 38.101-5 for RedCap requirement.  Proposal-2: Add the same additional clause for transmit power for RedCap/eRedCap.  Proposal-3: Reuse the 1 Rx scaling factor of TN scaling factor for 1Rx REFSENS for NTN bands .  Proposal-4: Consider the at least 0.5 dB tightening for the HD-FDD NTN band in general. |
| R4-2405063 | ZTE Corporation | Proposal 1: For RedCap UE with NR NTN operating in FR1-NTN bands, maximum output power for power class 3 specified in clause 6.2.1 in TS 38.101-5 applies.  Proposal 2: REFSENS of 2.5 dB tightening for 5 MHz and 3 dB for 10, 15, 20 MHz can be reused for FD-FDD RedCap UE with NR NTN operating in FR1-NTN bands.  Proposal 3: For supporting of Rel-17 RedCap and Rel-18 eRedCap UEs with NR NTN operating in FR1-NTN bands, it should reuse the principle of defining REFSENS for NR eRedCap UEs. |
| R4-2405346 | Huawei | Proposal 1: It’s proposed to reuse the Single antenna port reference sensitivity allowance ΔR1R specified in TS 38.101-1 for NR NTN RedCap UE in FDD bands.   |  |  |  | | --- | --- | --- | | Operating band | Channel bandwidth (MHz) | ΔR1R (dB) | | FDD band | 5 | 2.5 | | FDD band | 10, 15, 20 | 3.0 |   Proposal 2: the existing NR NTN REFSENS requirements (less than or equal to 20MHz channel bandwidth) can be reused for a RedCap UE equipped with 2 Rx antenna ports |

## Open issues summary

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

Issues 2-1 to 2-3 appear non-controversial and could be confirmed in a WF with no online discussion. Issues 2-4 to 2-7 are suggested to be discussed online. The final issue 2-8 lists individual proposals which were considered less urgent or needing further homework from companies, it is suggested to de-prioritize them in this meeting but consider them for next meeting.

### Issue 2-1: Target power class

* Proposals
  + Option 1: PC3 (Vivo, ZTE)
* Recommended WF
  + PC3

### Issue 2-2: Channel bandwidts and SCS

* Proposals
  + Option 1: 5, 10, 15 and 20 MHz (Sony, CATT), 60 kHz SCS is out of scope (CATT)
* Recommended WF
  + Option 1

### Issue 2-3: Re-use of TN requirements and specification structure

* Proposals (not mutually exclusive)
  + Option 1: Use TN requirements as starting point (Nokia, ZTE, CATT)
  + Option 2: Re-use TN PC3 RF requirements (Xiaomi)
  + Option 3: Add new suffix in TS 38.101-5 for RedCap requirements (Ericsson)
  + Option 4: Reuse the same way as in Rel-18 eRedcap REFSENS (as in 7.3I.3 of 38.101-1 ) to define the NTN eRedcap REFSENS. (Sony)
* Recommended WF
  + Add RedCap NTN requirements under a new suffix into TS 38.101-5, consider TN specification structure, i.e. which clauses are under suffix I in TS 38.101-1 as starting point. For re-use of exact requirement values, confirm them under separate issues.

### Issue 2-4: Operating bands

* Proposals
  + Option 1: band n256 and n255. FFS for n254 (CATT)
* Recommended WF
  + Discuss online

### Issue 2-5: 2 Rx FD-FDD Refsens

* Proposals
  + Option 1: Re-use non-RedCap NTN UE refsens for 2Rx FD-FDD NTN (e)RedCap UE (Vivo, Sony)
* Recommended WF
  + Option 1

### Issue 2-6: 1 Rx FD-FDD Refsens

* Proposals
  + Option 1: Re-use TN (e)RedCap UE 1 Rx refsens allowance for NTN (e)RedCap UE (Vivo, Sony, Ericsson, ZTE, Huawei)

|  |  |  |
| --- | --- | --- |
| Operating band | Channel bandwidth (MHz) | ΔR1R (dB) |
| FDD band | 5 | 2.5 |
| FDD band | 10, 15, 20 | 3.0 |

* Recommended WF
  + Option 1

### Issue 2-7: HD-FDD Refsens (pending on outcome of issue 1-3)

* Proposals
  + Option 1: Adopt the same tightening rule as in Rel-17 Redcap to derive the REFSENS for NTN Redcap HD-FDD, which results in 0 dB tightening for n255, and 0.5 dB tightening for n254 and n256 for 5MHz, e.g., REFNSEN = -100 dBm for all three NR bands in NTN with 5MHz BW for 2Rx. (Sony)
    - NTN Redcap HD-FDD REFSENS for channel BW wider than 5 MHz can be calculated by REFSENS(5MHz) + 10log10(n x NRB/25), where NRB is the maximum transmission bandwidth configuration with n=1 for 15kHz SCS, n=2 for 30kHz SCS, and n=4 for 60kHz SCS. (Sony)
  + Option 2: Consider the at least 0.5 dB tightening for the HD-FDD NTN band in general. (Ericsson)
* Recommended WF
  + Discuss online pending on outcome of issue 1-3

### Issue 2-8: Further less urgent proposals to be analysed for next meeting

* Proposals (not mutually exclusive)
  + RAN4 should evaluate whether the NTN RedCap / eRedCap UE supports the enhanced channel raster. (CATT)
  + RAN4 to discuss whether to continue using maxNumberMIMO-LayersPDSCH to indicate more than 1Rx antenna port support or a new UE capability on number of Rx support which is independent of DL MIMO layer support needs to be introduced for NR NTN RedCap and eRedCap UEs. (Apple)
  + RAN4 should evaluate whether the pre-compensate function could be supported by NTN RedCap / eRedCap UE. (CATT)
  + Further check if any update is needed for NTN Redcap and eRedcap with respect to regulatory requirements with considering the feasibility of Redcap and eRedcap implementations. (Sony)
  + RAN4 further checks if other (*moderator: other than REFSENS*) reception requirements from NR NTN can be reused for NTN Redcap and eRedcap. (Sony)
* Recommend WF
  + Encourage companies to consider these in inputs to RAN4#111

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