**3GPP TSG RAN Meeting #98-e RP-223534**

**e-meeting, December 12-16, 2022** (revision of RP-222654)

**Source: Thales**

**Title: Revised WID: NR NTN (Non-Terrestrial Networks) enhancements**

**Document for: Approval**

**Agenda Item: 9.3.2.7**

3GPP™ Work Item Description

Information on Work Items can be found at <http://www.3gpp.org/Work-Items>
See also the [3GPP Working Procedures](http://www.3gpp.org/specifications-groups/working-procedures), article 39 and the TSG Working Methods in [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm)

# Title: NR NTN (Non-Terrestrial Networks) enhancements

## Acronym: NR\_NTN\_enh

## Unique identifier: 941006

NOTE: For new WIs/SIs leave the Unique identifier empty and make a proposal for an Acronym.

 For a revised WI/SI: Take Unique identifier and acronym as shown in 3GPP workplan.

 If this is a RAN WID including Core and Perf. part, then Title, Acronym and Unique identifier refer to the feature WI.

 Please tick (X) the applicable box(es) in the table below:

 Either:

|  |  |
| --- | --- |
| **This WID includes a Core part** | **X** |
| **This WID includes a Performance part** | **X** |

 or:

|  |  |
| --- | --- |
| **This WID includes a Testing part** |  |
| **and it addresses the following 3GPP work area:** | **Radio Access** |  |
| **Core Network** |  |
| **Services** |  |

Potential target Release: Rel-18

Note that this field above indicates the proposed Release at the time of submission of the WID to TSG approval. It can later be changed without a need to revise the WID. The updated target Release is indicated in the Work Plan. NOTE: In case of contradiction with the target dates of clause 5, clause 5 determines the target release.

## 1 Impacts

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Affects:** | UICC apps | ME | AN | CN | Others (specify) |
| **Yes** |  | X | X | X |  |
| **No** |  |  |  |  | X |
| **Don't know** | X |  |  |  |  |

## 2 Classification of the Work Item and linked work items

### 2.1 Primary classification

This work item is a …

|  |  |
| --- | --- |
| X | Feature |
|  | Building Block |
|  | *Work Task* |
|  | Study Item |

NOTE: Normally, Core/Perf./Testing parts in RAN WIDs are Building Blocks. Only if they are under an SA or CT umbrella, they are defined as work tasks. If you are in doubt, please contact MCC.

### 2.2 Parent Work Item

|  |
| --- |
| Parent Work / Study Items  |
| Acronym | Working Group | Unique ID | Title (as in 3GPP Work Plan) |
|  |  |  |  |

NOTE: RAN agreed some time ago, that it describes the feature WI + Core/Perf. part WI or Testing part WI in one WID. Therefore the table above should just include the feature WI data (In case the feature covers Core and Perf. part, please list under Working Group the leading WG of the Core part).

### 2.3 Other related Work Items and dependencies

|  |
| --- |
| Other related Work Items (if any) |
| Unique ID | Title | Nature of relationship |
| 750040 | Study on NR to support non-terrestrial networks (FS\_NR\_nonterr\_nw) | The present WID will make use of the channel model defined by the FS\_NR\_nonterr\_nw study  |
| 800099 | Study on solutions for NR to support non-terrestrial networks (FS\_NR\_NTN\_solutions) | The present WID will leverage solutions identified in FS\_NR\_NTN\_solutions to address some of the key issues associated to NTN |
| 890034 | Integration of satellite systems in the 5G architecture (5GSAT\_ARCH) | The present WID can consider the QoS management and Satellite NG-RAN global identities solutions identified in 5GSAT\_ARCH. |
| 860046 | Solutions for NR to support non-terrestrial networks (NR\_NTN\_solutions) | The present WID will use this WID as basis for the evolution. |
| 96XXXX | Study on requirements and use cases for network verified UE location for Non-Terrestrial-Networks (NTN) in NR (FS\_NR\_NTN\_netw\_verif\_UE\_loc) | The present WID will use SI FS\_NR\_NTN\_netw\_verif\_UE\_loc as basis for the evaluation in 4.1.3. |

NOTE: Also related or dependent WIs/SIs in other TSGs should be indicated.

## 3 Justification

In Release 17, a work item was carried out to define solutions enabling New Radio and NG-RAN to support Non-Terrestrial Networks (NTN):

* Transparent payload based GSO and NGSO network scenarios addressing at least 3GPP power class 3 UE with GNSS capability in both Earth fixed and/or moving cell configurations

As part of Release 18, a new work item is proposed to define enhancements for NG-RAN based Non-Terrestrial Networks in order to:

* Support new scenarios to cover deployments in frequency bands above 10 GHz
* Offer optimized performance especially when addressing handset terminals (including smartphones with more realistic assumptions on antenna gains instead of 0 dBi antenna gain with the specific realistic antenna gain assumption to be determined at the working group level) w.r.t. coverage considering the NTN characteristics such as large propagation delay and satellite movement.
* Provide mobility and service continuity enhancements considering the NTN characteristics such as large propagation delay and satellite movement.
* Address requirements, if needed based on the FS\_NR\_NTN\_netw\_verif\_UE\_loc study outcome, which mandate the network operator to cross check the UE location reported by the UE, which needs to be carried out in order to fulfil the regulatory requirements (e.g., Lawful intercept, emergency call, Public Warning System, …) regarding a network verified UE location i.e., to be able to check the UE reported location information (e.g. estimate UE location at the network side) and specify if needed mechanisms to fulfil the regulatory requirements.

## 4 Objective

### 4.1 Objective of SI or Core part WI or Testing part WI

The work item aims at specifying enhancements for NG-RAN based NTN (Non-Terrestrial Networks) according to the following assumptions with implicit compatibility to support HAPS (High Altitude Platform Station) and ATG (Air To Ground) scenarios:

* 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
* Both “VSAT” (Very Small Aperture Terminal) devices with directive antenna (including fixed and moving platform mounted devices and commercial handset terminals (e.g. Power class 3) are supported in FR1
* Only “VSAT” devices with directive antenna (including fixed and moving platform mounted devices) are supported in above 10 GHz bands.

Note 1: In Rel-17 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).

Note 2: The Rel-17 NTN architecture is assumed.

The detailed objectives are to specify enhancing features to Rel-15, 16 & 17’s NR radio interface & NG-RAN as follows:

4.1.1 Coverage enhancement

The Rel-18 NTN objectives are focused on the applicability of the solutions developed by general NR coverage enhancement to NTN, and identifying potential issues and enhancements if necessary, considering the NTN characteristics including large propagation delay and satellite movement. Only NTN-specific characteristics are to be included in this coverage enhancement work, otherwise it should be part of another WI (e.g., UL enhancement of coverage).

The following sentence will be revisited in RAN#99 as part of the DL enhancements discussion:

“The evaluation should also take into account any related regulatory requirements, e.g., ITU limitation of power flux density.” No work on this topic will take place in RAN WGs before the discussion on DL enhancements in RAN#99.

The following reference scenario is considered for the definition of uplink coverage enhancements for NTN: parameter set-1 for LEO-1200 satellite operating at Line of Sight (LOS) and commercial smartphones with -5.5 dBi antenna gain and 3 dB polarisation loss (per antenna port).

Note: It is understood that the enhancements defined for LEO can also apply to GEO and MEO scenarios as appropriate. No additional work is expected for MEO/GEO.

The targeted services are VoIP using AMR 4.75 kbps and data transmission services with Low data rate of 3 kbps.

 The detailed objectives are for NTN:

* To specify PUCCH enhancements for Msg4 HARQ-ACK (e.g. repetition) [RAN1, RAN4]
* To specify if necessary, enhancements to the Rel-17 procedures for DMRS bundling for PUSCH taking into account NTN-specifics (e.g. time-frequency pre-compensation) [RAN1]

4.1.2 NR-NTN deployment in above 10 GHz bands

The following assumptions are taken a baseline for this work:

* GSO and NGSO (e.g. LEO, MEO, HEO) based satellite access to be considered
	+ ESIM scenarios for NGSO in Ka band are not considered in this WI.
* Targeted UE types: fixed and mobile VSAT. VSAT UE characteristics from TR38.821 to be considered in priority but additional NTN UE classes may be considered if justified
	+ Regarding mobile VSAT, three types of terminal and scenario exist; airborne, maritime and land based ESIM. Which type(s) to be specified depends on the outcome of the regulation analysis and co-existence study.
* FDD mode is assumed for satellite operation above 10 GHz, while TDD mode is assumed for terrestrial operation in FR2
* The ITU-R harmonized Ka band will serve as reference
* Co-existence between overlapping NTN and TN band portions is out of scope of this work item. This aspect will be captured in the specification.

The following covers the objectives for NR-NTN deployment in above 10 GHz bands. This work is expected to start after June 2022.

* Study and identify NTN example band: Analysis of regulations and adjacent channel co-existence scenarios. The example band shall be identified early in the WI. Additional bands can be introduced in a release-independent manner. [RAN4]
	+ Consider the satellite harmonized Ka band as a reference, according to ITU allocation; taking into account deployment type (e.g. VSAT, ESIM), scenarios, and ITU-R/regional regulations, define an example band suitable for development of generic 3GPP minimum performance requirements (the example RAN4 band may be a portion of or the entire harmonized Ka band). [RAN4]
	+ Study implications of FDD operation in FR2 and derive requirements for the identified example band appropriately. Satellite bands introduced in 3GPP for NTN for FDD shall not impact the existing 3GPP TDD specifications for terrestrial bands adjacent to the NTN band (see note 3 of the approved way forward RP-211596 in RAN#92-e). [RAN4]
	+ Relevant coexistence scenarios and analysis to be considered in RAN4, if and where applicable, to ensure that satellite bands introduced in 3GPP for NTN shall not impact the existing specifications and shall not cause degradation (in the sense of RAN4 co-existence studies) to networks in 3GPP specified terrestrial bands adjacent to the NTN band. In that, it is assumed that the NTN-TN adjacent band coexistence will be performed at the harmonized Ka band edges. The outcome is expected to be applicable to all NTN-TN adjacent band scenarios (if any) in the whole Ka band range where applicable and regulations allow. [RAN4]
	+ For all the above, RAN4 process as agreed for NTN in FR1 should be used for coexistence analysis in above 10 GHz bands [RAN4].
	+ Definition of NTN band(s) above 10 GHz does not change the current FR1/FR2 definition, nor automatically apply to future terrestrial bands defined in this frequency region; (see proposal 2 of the approved way forward RP-211596 in RAN#92-e) [RAN4]
* Specify Rx/Tx requirements for satellite access node and different VSAT UE class (not only 60 cm aperture) as appropriate for the identified example band [RAN4]
* Identify values for physical layer parameters chosen from the existing FR1 and FR2 sets. The following set of parameters to specify, but not necessarily limited to, are listed.as follows [RAN4]:
	+ time relationship related enhancement (e.g. K\_offset)
	+ subcarrier spacing for different UL/DL signals/channels
	+ PRACH configuration index for FDD above 10 GHz.

4.1.3 Network verified UE location

Based on RAN1 conclusions of the study phase, RAN to prioritize the specification of necessary enhancements to multi-RTT to support the network verified UE location in NTN assuming a single satellite in view [RAN1, 2, 3, 4]. DL-TDoA methods for verification may be considered as lower priority and if time permits and condition in Note is satisfied.

Note 1: Enhancements assume reuse of the RAT dependent positioning framework

Note 2: The specification of DL-TDOA enhancements will be subject to the study of the impact of realistic UE clock drift onto DL-TDOA performance

Note 3: The target accuracy for position verification purposes is as documented in clause « recommendations » of the 3GPP TR 38.882 (i.e. 10 km granularity)

Note 4 : Multiple satellite in view by the UE may be considered if time allows

Note 5 : The enhancements may be subject to relevant SA WGs (e.g. SA3/SA3-LI) feedbacks on the reliability of UE reports involved

Note 6 : The enhancements should take into account the mirror-image ambiguity

4.1.4 NTN-TN and NTN-NTN mobility and service continuity enhancements

This work considers existing methods from NR TN as well as outcome of Rel-17 NR NTN WI outcome as baseline for NTN-TN mobility.

* Specify NTN-TN and NTN-NTN measurement/mobility and service continuity enhancements [RAN2,RAN3,RAN4]
	+ For NTN-NTN mobility, specify cell reselection enhancements for earth moving cell, the timing based and location-based cell reselection for quasi-earth fixed cell in Rel-17 can be considered as the starting point. [RAN2, RAN3, RAN4]
	+ Specify NTN-NTN handover enhancement for RRC\_CONNECTED UEs in the quasi-earth-fixed cell and earth-moving cell to reduce the signalling overhead. [RAN2, RAN3]
	+ Specify cell reselection enhancements for RRC\_IDLE/INACTIVE UEs to reduce UE power consumption (NTN-TN mobility is prioritized). [RAN2, RAN3, RAN4]
	+ Study and, if needed, specify enhancement to Xn[/NG] signalling to support feeder link switch-over, CHO, e.g. exchange of necessary information between gNBs. [RAN3]

### 4.2 Objective of Performance part WI

NOTE: Leave empty if the WI proposal does not contain a RAN performance part.

The performance part objectives are applicable to the NR-NTN deployment in above 10 GHz bands objective.

* Specify RRM performance requirements and test cases [RAN4]
* Specify UE demodulation and CSI reporting requirements [RAN4]
* Specify satellite access node demodulation requirements [RAN4]
* Specify satellite access node conformance tests [RAN4]

The RAN4 performance part for the remaining objectives needs to be further discussed once the scope is stabilized.

### 4.3 RAN time budget request (not applicable to RAN5 WIs/SIs)

NOTE: For all new RAN related WIs/SIs which are not led by RAN WG5 the WI/SI rapporteur has to fill out the attached Excel table to request time budgets for corresponding RAN WG meetings.
The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI.
One time unit (TU) corresponds to ~ 2 hours in the meeting.
If no TU is needed, then leave the field empty otherwise enter a number >0 in the field.

 For revisions of already approved WI/SI descriptions: Please remove the Excel table from the WID/SID's zip file. The time budgets are already recorded. If you want to modify them, then this has to be done via the status report and not via a revised WID/SID.

 If this WID is covering Core and Performance part, then please fill out one line for each part in the attached Excel table.

**additional comments to the time budget request in the attached Excel table:**

## 5 Expected Output and Time scale

|  |
| --- |
| **New specifications** *{One line per specification. Create/delete lines as needed}* |
| Type  | TS/TR number | Title | For info at TSG#  | For approval at TSG# | Remarks |

 *{Note 1: Only TSs may contain normative provisions. Study Items shall create or impact only TRs.
"Internal TR" is intended for 3GPP internal use only whereas "External TR" may be transposed by OPs.}*

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
By default a new specs can only be new for one of both parts.

| **Impacted existing TS/TR** |
| --- |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
| 38.211 | NR; Physical channels and modulationEnhancement on the PRACH sequence and/or format (in the case pre-compensation of timing and frequency offset is not done at UE side) | RAN#101 | Core part |
| 38.213 | NR; Physical layer procedures for controlEnhancements to Timing Advance, control procedures signalling | RAN#101 | Core part |
| 38.214 | NR; Physical layer procedures for dataTiming relationship enhancements, Enhancements on UL time and frequency synchronization,  | RAN#101 | Core part |
| 38.300 | NR; NR and NG-RAN Overall description; Stage-2NTN stage 2 description  | RAN#102 | Core part |
| 38.304 | NR; User Equipment (UE) procedures in idle mode and in RRC Inactive stateEnhance the idle mobility trigger conditions | RAN#102 | Core part |
| 38.305 | NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RANNTN UEs with GNSS capabilities  | RAN#102 | Core part |
| 38.306 | NR; User Equipment (UE) radio access capabilitiesSupport of NTN UE capabilities  | RAN#102 | Core part |
| 38.307 | NR; Requirements on User Equipments (UEs) supporting a release-independent frequency bandNTN release-independent frequency bands  | RAN#102 | Core part |
| 38.321 | NR; Medium Access Control (MAC) protocol specification: Enhance Random access, timing advance, DRX, Scheduling Request, HARQ  | RAN#102 | Core part |
| 38.322 | NR; Radio Link Control (RLC) protocol specificationEnhance Status reporting and Sequence Number and Window Size | RAN#102 | Core part |
| 38.323 | NR; Packet Data Convergence Protocol (PDCP) specificationEnhance Status reporting and Sequence Number and SDU discard | RAN#102 | Core part |
| 38.331 | NR; Radio Resource Control (RRC); Protocol specificationEnhance idle and connected mode mobilityNTN specific system information and RRC signalling  | RAN#102 | Core part |
| 38.401 | NG-RAN; Architecture descriptionNTN specific features | RAN#102 | Core part |
| 38.410 | NG-RAN; NG general aspects and principlesNTN specific features | RAN#102 | Core part |
| 38.413 | NG-RAN; NG Application Protocol (NGAP)NTN specific features | RAN#102 | Core part |
| 38.423 | NG-RAN; NG-RAN; Xn Application Protocol (XnAP)NTN specific features | RAN#102 | Core part |
| 38.101-5 | NR; User Equipment (UE) radio transmission and reception, part 5: Satellite Access Radio Frequency (RF) and performance requirementsNTN specific characteristics | RAN#102 | Core part |
| 38.133 | NR; Requirements for support of radio resource managementNTN specific RRM characteristics | RAN#102 | Core part |
| 38.108 | NR; Satellite Access Node radio transmission and receptionNTN specific characteristics | RAN#102 | Core part |
| 38.101-5 | NR; User Equipment (UE) radio transmission and reception, part 5: Satellite Access Radio Frequency (RF) and performance requirementsNTN specific characteristics | RAN#104 | Perf part |
| 38.133 | NR; Requirements for support of radio resource managementNTN specific RRM characteristics | RAN#104 | Perf part |
| 38.181 | NR; Satellite Access Node conformance testingNTN specific characteristics | RAN#104 | Perf part |
| 38.863 | NR; Solutions for NR to support non-terrestrial networks (NTN):Non-terrestrial networks (NTN) related RF and co-existence aspects | RAN#101 | Core part |

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
If an existing spec is affected by both (Core part and Perf. part), then it has to be listed twice with appropriate approval dates.

## 6 Work item Rapporteur(s)

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## 7 Work item leadership

Leading working group: RAN2

Secondary working groups: RAN1, RAN3, RAN4

## 8 Aspects that involve other WGs

Possible cooperation/alignment with:

SA2, SA3 and SA3-LI with respect to ‘Network verified UE location’ and the possible impact on regulatory requirements (e.g. LI, PWS,…).

* SA2 & SA4 with respect to ‘coverage enhancement’ and in particular the potential low-rate codecs performance enhancements for in link budget limited context.

NOTE: For RAN WIs: Section 8 applies only to WGs outside of TSG RAN because RAN WG aspects have to be covered in section 4.

## 9 Supporting Individual Members

*{At least 4 supporting Individual Members are needed. There is an expectation that these companies will provide resources to progress the work. Note that having 4 supporting companies is a necessary but not sufficient condition: the usual TSG approval process by consensus is needed for the WID approval.}*

|  |
| --- |
| Supporting IM name |
| Thales |
| NTT DOCOMO |
| Transsion Holdings |
| Futurewei |
| Panasonic Corporation |
| NEC |
| Continental Automotive |
| Xiaomi |
| MediaTek Inc. |
| Interdigital, Inc. |
| SoftBank |
| SONY |
| Sequans |
| OPPO |
| Turkcell |
| CATT |
| Ligado Networks |
| Deutsche Telekom |
| LG Electronics |
| vivo |
| Apple |
| ITRI |
| Spreadtrum communications |
| Samsung |
| ITL |
| CMCC |
| KT Corp. |
| Sateliot |
| Fraunhofer IIS |
| Fraunhofer HHI |
| China Unicom |
| Qualcomm |
| Nokia |
| Nokia Shanghai Bell |
| Novamint |
| FirstNet |
| Baicells |
| ESA |
| Lockheed Martin |
| CEWIT |
| Omnispace |
| ST Engineering iDirect Ireland Limited |
| ZTE Corporation |
| Sanechips |
| GateHouse SatCom |
| Inmarsat |
| Lenovo |
| Motorola Mobility |
| Avanti |
| Magister Solutions Ltd. |
| Intelsat |
| Hughes Network Systems Ltd |
| Airbus |
| Huawei |
| HiSilicon |
| LEONARDO |
| Viasat |
| Intel |
| Reliance Jio |
| III |