**3GPP TSG RAN meeting #90-e RP-20XXXX**

**e-meeting, December 7 - 11th, 2020** *revision from RP-201256, 200600 & 193234*

**Source: Thales**

**Title: Solutions for NR to support non-terrestrial networks (NTN)**

**Type: WID revised**

**Document for: Approval**

**Agenda Item: 9.8.6 Solutions for NR to support non-terrestrial networks (NTN) [RAN2 WI: NR\_NTN\_solutions]**

**Release Rel-17**

3GPP™ Work Item Description

For guidance, see [3GPP Working Procedures](http://www.3gpp.org/About/WP.htm), article 39; and [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm).
Comprehensive instructions can be found at <http://www.3gpp.org/Work-Items>

# Title: Solutions for NR to support non-terrestrial networks (NTN)

## Acronym: [NR\_NTN\_solutions](https://www.3gpp.org/DynaReport/WiSpec--860046.htm%22%20%5Ct%20%22_blank)

## Unique identifier: [860046](https://www.3gpp.org/DynaReport/GanttChart-Level-2.htm%22%20%5Cl%20%22bm860046%22%20%5Ct%20%22_blank)

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

 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** |  |

## 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 |

including some study activities.

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

### 2.2 Parent and child Work Items

|  |
| --- |
| Parent and child Work Items  |
| Unique ID | Title | Nature of relationship |
|  |  | *{mandatory text: "parent WID" or "child WID"}*  |

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 Unique ID and title and Nature of relationship is "parent WID".

### 2.3 Other related Work Items and dependencies

|  |
| --- |
| Other related Work Items (if any) |
| Unique ID | Title | Nature of relationship |
|  | Preceding Rel-15 & Rel WI | The proposed WID will leverage the NR and NG-RAN specifications |
| 750040 | Study on NR to support non-terrestrial networks (FS\_NR\_nonterr\_nw) | The proposed 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 proposed WID will leverage solutions identified in *FS\_NR\_NTN\_solutions* to address the key issues associated to NTN |
| 800026  | Study on architecture aspects for using satellite access in 5G (FS\_5GSAT\_ARCH) | The proposed WID can take into account for instance the QoS management and Satellite NG-RAN global identities solutions identified in *FS\_5GSAT\_ARCH*.  |

NOTE: Classical examples: List a preceding SI or a preceding WI (e.g. if you further enhance a topic). Also related or dependent WIs in other TSGs should be indicated.

**Dependency on non-3GPP (draft) specification**: -

## 3 Justification

Non-terrestrial networks refer to networks, or segments of networks, using an airborne or spaceborne vehicle for transmission:

* Spaceborne vehicles: Satellites (including Low Earth Orbiting (LEO) satellites, Medium Earth Orbiting (MEO) satellites, Geostationary Earth Orbiting (GEO) satellites as well as Highly Elliptical Orbiting (HEO) satellites)
* Airborne vehicles: High Altitude Platforms (HAPs) encompassing Unmanned Aircraft Systems (UAS) including Lighter than Air UAS (LTA), Heavier than Air UAS (HTA), all operating in altitudes typically between 8 and 50 km, quasi-stationary.

In 3GPP TS 22.261 approved at SA#82, use cases for 5G Satellite integration and the corresponding service requirements have been identified as result of the work item “5GSAT”. This will address mobile broadband needs in unserved/underserved areas as well as public safety needs, maritime (3GPP TS 22.119 “Maritime communication services over 3GPP system”) , airplane connectivity and railway communication service requirements applicable to satellite access.

Since RAN#76, two activities on NR to support Non-Terrestrial Networks have been successively carried out

* A first activity, FS\_NR\_nonterr\_nw (see RP-171450) studied the channel model for the non-terrestrial networks, to define deployment scenarios, parameters and identify the key potential impacts on NR. The work led by RAN started at RAN#76 and has been completed at RAN#80. The results are reflected in TR 38.811.
* A second activity, FS\_NR\_NTN\_solutions (see RP-190710), define and evaluate solutions for the identified key impacts from the first activity. The work led by RAN3 started at RAN#80 and is planned to be completed at RAN#86. The results are reflected in TR 38.821 (RP-193062).

Furthermore an email discussion took place between RAN#85 and #86 on the scoping of a REl-17 WI on non-terrestrial network. The report of this email discussion is available in RP-192500. It concluded that the Rel-17 NR-NTN NWI should include two activities:

* Normative activity on NR-NTN to develop specifications to support the following scenarios:
	+ Transparent payload based LEO scenario addressing at least 3GPP class 3 UE with and without GNSS capability and both Earth fixed &/or moving cell scenario (as per SI outcome).
		- *Note 1: Addressing LEO will provide the flexibility to also support transparent payload based HAPS based scenarios.*
	+ Transparent payload based GEO scenario addressing UE with GNSS capability.
		- *Note 2: Addressing LEO and GEO scenarios will enable NR to support all NGSO scenarios with circular orbit at altitude greater than or equal to 600 km.*
* Study activity on NTN scenarios addressing
	+ Transparent payload based HAPS scenarios: Study of enablers for Spectrum coexistence with cellular (additional Coresets, PCI confusion mitigation, ..)
	+ IoT-NTN based scenarios
	+ NTN-network based location of UE (for regulatory services): identify possible solutions

Based on the above points, a new work item is proposed to carry the conclusion of the FS\_NR\_NTN\_solutions study item and specify the solutions enabling NR to support non-terrestrial networks.

Addressing LEO and GEO scenarios will enable to support all NGSO scenarios with circular orbit at altitude greater than or equal to 600 km.

As per TR 38.821, it shall be assumed that handheld devices in FR1 and “VSAT” devices with external antenna (including fixed and moving platform mounted devices) can be considered for NTN for the RAN1-3 specifications.

In the context of this work item, HAPS refers to a high altitude platform system for which at least the service link (HAPS – UE) operates a 3GPP specified NR mobile service in allocated spectrum which regulation allows. If needed, the terminology “HAPS” may be revisited.

## 4 Objective

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

The work item aims to specify the enhancements identified for NR NTN (non-terrestrial networks) especially LEO and GEO with implicit compatibility to support HAPS (high altitude platform station) and ATG (air to ground) scenarios according to the following principles:

* FDD is assumed for core specification work for NR-NTN.
	+ NOTE: This does not imply that TDD cannot be used for relevant scenarios e.g. HAPS, ATG
* Earth fixed Tracking area is assumed with Earth fixed and moving cells
* UEs with GNSS capabilities are assumed.
* Transparent payload is assumed
* Handheld devices in FR1 are supported (e.g. Power class 3)
* “VSAT” devices with external antenna (including fixed and moving platform mounted devices) at least in FR2 are supported for the RAN1-3 specifications. “VSAT” characteristics in TR 38.821 can be assumed for the RAN1-3 specifications.

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

### 4.1.1 RAN1

Enhancing features to address the identified issues due to long propagation delays, large Doppler effects, and moving cells in NTN, the following should be specified (see TR 38.821):

* Timing relationship enhancements[RAN1,RAN2]
* Enhancements on UL time and frequency synchronization [RAN1,RAN2]
* HARQ
	+ Number of HARQ process [RAN1]
	+ Enabling / disabling of HARQ feedback as described in the TR 38.821 [RAN1&2]

In addition, the following topics should be specified if beneficial and needed

* Enhancement on the PRACH sequence and/or format and extension of the ra-ResponseWindow duration (in the case of UE with GNSS capability but without pre-compensation of timing and frequency offset capabilities) [RAN1/2].
* Feeder link switch [RAN2,RAN1]
* Beam management and Bandwidth Parts (BWP) operation for NTN with frequency reuse [RAN1/2]
	+ Including signalling of polarization mode

### 4.1.2 RAN2

NOTE: offset based solutions for timer adaptations are assumed.

The following user plane procedures enhancements should be specified (see TR 38.821)

* MAC
	+ Random access:
		- Definition of an offset for the start of the ra-ResponseWindow for NTN.
		- Introduction of an offset for the start of the ra-ContentionResolutionTimer to resolve Random access contention
		- Solutions for resolving preamble ambiguity and extension of RAR window.
		- Adaptation for Msg-3 scheduling
			* Only for the case with pre-compensation of timing and frequency offset at UE side)
	+ Enhancement on UL scheduling to reduce scheduling latency.
	+ DRX:
		- If HARQ feedback is enabled, introduction of offset for *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL*.
		- If HARQ is turned off per HARQ process, adaptions in HARQ procedure
	+ Scheduling Request: Extension of the value range of *sr-ProhibitTimer*
* RLC
	+ Status reporting: Extension of the value range of *t-Reassembly*
	+ Sequence Numbers: extension of the SN space only for GEO scenarios
* PDCP
	+ SDU discard: Extension of the value range of *discardTimer*.
	+ Sequence Numbers: extension of the SN space for GEO scenarios.

The following control plane procedures enhancements should be specified (see TR 38.821)

* Idle mode:
	+ Definition of additional assistance information for cell selection/reselection (e.g. using UE location information, satellite Ephemeris information)
	+ Definition of NTN (satellite/HAPS) cell specific information in SIB
* Connected mode
	+ Enhancement necessary to take into account location information (UE & Satellite/HAPS) and/or ephemeris in determining when to perform hand-over, in order to have a high degree of hand-over control for hand-over robustness and coverage management.
	+ Enhancement to existing measurement configurations to address absolute propagation delay difference between satellites (e.g. SMTC measurement gap adaptation to the SSB/CSI-RS measurement window) [RAN2/4].
* Service continuity for mobility from TN to NTN and from NTN to TN systems (to be addressed when connected mode mobility has sufficiently progressed)
* Identify potential issues associated to the use of the existing Location Services (LCS) application protocols to locate UE in the context of NTN and specify adaptations if any [RAN2/3]

Furthermore the following can be considered with 2nd priority

* Verify the applicability of existing Rel-16 ANR techniques to solve PCI confusion in order to support co-channel operation between HAPS & terrestrial networks and develop enhancements if needed [RAN2/3]

### 4.1.3 RAN3

The following NG-RAN architecture enhancements should be specified (see TR 38.821)

* to support feeder link switch over in Transparent payload architecture based LEO scenarios
* network identities handling
* registration update and paging handling
* cell relation handling and related features e.g. neighbours, ANR, RAN paging …

### 4.1.4 RAN4

Study the framework how NTN core requirements are defined.

Specify the following requirements [RAN4] (Note 1)

* + UE RRM core requirements
* Study and identify which bands may be potentially relevant to NTN including:
	+ Analysis of regulations in the spectrum considered
	+ Adjacent channel co-existence
* Considering the potential bands to be used as example for the WID:
* Specify needed generic RF core requirements for the network and the UE such that adjacent channel co-existence scenarios are met and performance of other RF parameters (RX performance, TX signal quality etc.) are subject to acceptable minimum requirements
* Investigate and specify UE timing & frequency pre compensation accuracy requirements as needed [RAN4].

*Note 1: It is assumed that this work item will be frequency agnostic and therefore we can consider that NTN can operate in FR1 or FR2 ranges. Defining NR bands for NTN should be included as part of dedicated Rel-17 RAN4 led work items including an analysis of regulations in spectrum considered, which bands 3GPP should specify, as well as potential co-existence between NR terrestrial and satellite*

*Note 2: The scope and work load associated to adjacent channel co-existence study(ies) between HAPS and TN in existing 3GPP band(s) allowed by regulation for HAPS as IMT BS operation shall be clarified before being discussed to be part of the Rel-17 NR-NTN-solutions WI.*

### 4.2 Objective of Performance part WI

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

Specify necessary UE and network performance requirements for the specified enhancements [RAN4].

Specify RRM test and network conformance tests [RAN4].

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

NOTE: For all 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 leave the field empty otherwise enter a number 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 of them in the attached Excel table.

See attached Excel table.

## 5 Expected Output and Time scale

|  |
| --- |
| **New specifications** *{One line per specification. Create/delete lines as needed}* |
| Proposed Spec no. or series | Type (see note 1)  | 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 WID 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 |
|  |  |  |  |
| TS 38.211 | **NR; Physical channels and modulation**Enhancement on the PRACH sequence and/or format (in the case pre-compensation of timing and frequency offset is not done at UE side) | TSG#90 | Core part |
| TS 38.213 | **NR; Physical layer procedures for control**Enhancements to Timing Advance, control procedures signalling | TSG#90 | Core part |
| TS 38.214 | **NR; Physical layer procedures for data**Timing relationship enhancements, Enhancements on UL time and frequency synchronization,  | TSG#90 | Core part |
| TS 38.300 | **NR; Overall description; Stage-2:** NTN stage 2 description  | TSG#92 | Core part |
| TS 38.304 | **NR; User Equipment (UE) procedures in idle mode and in RRC Inactive state**Enhance the idle mobility trigger conditions | TSG#92 | Core part |
| TS 38.305 | **NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN**NTN UEs with GNSS capabilities  | TSG#92 | Core part |
| TS 38.306 | **NR; User Equipment (UE) radio access capabilities**Support of NTN UE capabilities  | TSG#92 | Core part |
| TS 38.307 | **NR; Requirements on User Equipments (UEs) supporting a release-independent frequency band**NTN release-independent frequency bands  | TSG#92 | Core part |
| TS 38.321 | **NR; Medium Access Control (MAC) protocol specification**: Enhance Random access, timing advance, DRX, Scheduling Request, HARQ  | TSG#92 | Core part |
| TS 38.322 | **NR; Radio Link Control (RLC) protocol specification**Enhance Status reporting and Sequence Number and Window Size | TSG#92 | Core part |
| TS 38.323 | **NR; Packet Data Convergence Protocol (PDCP) specification**Enhance Status reporting and Sequence Number and SDU discard | TSG#92 | Core part |
| TS 38.331 | **NR; Radio Resource Control (RRC); Protocol specification**Enhance idle and connected mode mobility, NTN specific system information and RRC signalling  | TSG#92 | Core part |
| TS 38.401 | **NG-RAN; Architecture description**NTN specific features | TSG#91 | Core part |
| TS 38.410 | **NG-RAN; NG general aspects and principles**NTN specific features | TSG#91 | Core part |
| TS 38.413 | **NG-RAN; NG Application Protocol (NGAP)**NTN specific features | TSG#91 | Core part |
| TS 38.423 | **NG-RAN; NG-RAN; Xn Application Protocol (XnAP)**NTN specific features | TSG#91 | Core part |
| TS 38.133 | **NR; Requirements for support of radio resource management**NTN specific RRM features | TSG#92 | Core part |
| TS 38.104 | **NR; Base Station (BS) radio transmission and reception**NTN specific characteristics | TSG#92 | Core part |
| TS 38.101-1 | **NR; User Equipment (UE) radio transmission and reception, part 1: Range 1 standalone**NTN specific characteristics | TSG#92 | Core part |
| TS 38.101-2 | **NR; User Equipment (UE) radio transmission and reception, part 2: Range 2 standalone**NTN specific characteristics | TSG#92 | Core part |
| TS 38.133 | **NR; Requirements for support of radio resource management**NTN specific RRM features | TSG#94 | Perf part |
| TS 38.101-4 | **NR; User Equipment (UE) radio transmission and reception, part 4: performance requirements**NTN specific characteristics | TSG#94 | Perf part |
| TS 38.104 | **NR; Base Station (BS) radio transmission and reception**NTN specific characteristics | TSG#94 | Perf part |
| TS 38.141-1 | **NR; Base Station (BS) conformance testing part 1**NTN specific characteristics | TSG#94 | Perf part |
| TS 38.141-2 | **NR; Base Station (BS) conformance testing part 2**NTN specific characteristics | TSG#94 | Perf part |

NOTE: If this is a RAN WID 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)

Rapporteur

Company: Thales

Email: nicolas.chuberre@thalesaleniaspace.com

## 7 Work item leadership

Leading working group: RAN2

Secondary working group: RAN1, 3, 4

## 8 Aspects that involve other WGs

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

## 9 Supporting Individual Members

|  |
| --- |
| Supporting IM name |
| Thales |
| Airbus,  |
| Asia Pacific Telecom |
| Avanti communications Ltd.,  |
| CATT |
| CEWiT,  |
| CITICSAT,  |
| CMCC |
| CNES,  |
| CTTC,  |
| Dish Network, |
| DLR,  |
| Erillisverkot,  |
| Ericsson |
| ESA,  |
| ETRI |
| Eutelsat |
| Firstnet |
| Fraunhofer IIS,  |
| Fraunhofer HHI,  |
| Futurewei Technologies |
| Gemalto N. V.,  |
| Gilat,  |
| Globalstar Inc.,  |
| Google Inc., |
| HiSilicon, |
| Huawei, |
| HUGHES Network Systems Ltd,  |
| ICS,  |
| III, |
| Indian Institute of Tech (H),  |
| Indian Institute of Tech (M),  |
| Inmarsat,  |
| Intelsat,  |
| Interdigital, |
| ITRI |
| Kymeta Corporation,  |
| KT Corp.,  |
| KT SAT,  |
| Leonardo SpA,  |
| LG Electronics |
| Lenovo |
| Ligado |
| Loon LLC,  |
| Mediatek |
| Ministère de l‘intérieur,  |
| Mitsubishi Electric |
| Motorola Mobility |
| NEC |
| Nokia |
| Nokia Shanghai Bell |
| Nomor research GmbH,  |
| Novamint,  |
| NTPU |
| Omnispace |
| Oppo |
| Panasonic Corporation |
| Pivotal Commware,  |
| Qualcomm |
| Rakuten Mobile |
| Reliance Jio,  |
| Saankhya Labs,  |
| Sanechips |
| Sateliot,  |
| Siemens,  |
| Sierra Wireless |
| Softbank |
| Sony |
| SyncTechno Inc.,  |
| STMicroelectronics,  |
| TNO,  |
| Xilinx Ireland |
| VT iDirect solutions ltd,  |
| VTT  |
| ZTE Corporation |

***END***