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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on Management Aspects of NTN Phase 2  (Release 19) | |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document studies the management aspects of NTN in R19. It mainly investigates use cases, potential requirements and potential solutions of NTN management.

# 2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Technical Specification Group Services and System Aspects; Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.423: "Technical Specification Group Radio Access Network; NG-RAN; Xn application protocol (XnAP)".

[3] 3GPP TS 38.300: "Technical Specification Group Radio Access Network; NR; NR and NG-RAN Overall Description; Stage 2".

[4] 3GPP TR 38.821: "Technical Specification Group Radio Access Network; Solutions for NR to support non-terrestrial networks (NTN)".

[5] 3GPP TR 22.865: "Technical Specification Group Services and System Aspects; Study on satellite access Phase 3".

[6] 3GPP TS 23.501: " Technical Specification Group Services and System Aspects; System architecture for the 5G System (5GS) ); Stage 2".

[7] 3GPP TS 23.401: "Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[8] 3GPP TS 23.682: "Technical Specification Group Services and System Aspects; Architecture enhancements to facilitate communications with packet data networks and applications".

[9] 3GPP TS 28.530: "Technical Specification Group Services and System Aspects; Management and orchestration; Concepts, use cases and requirements".

[10] 3GPP TS 38.331: "Technical Specification Group Radio Access Network; NR; Radio Resource Control (RRC) protocol specification".

[11] 3GPP TS 22.261: " Technical Specification Group Services and System Aspects; Service requirements for the 5G system; Stage 1".

[12] 3GPP TR 23.700-29: "Technical Specification Group Services and System Aspects; Study on integration of satellite components in the 5G architecture; Phase 3".

[13] 3GPP TS 28.541: "Technical Specification Group Services and System Aspects; Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

[14] 3GPP TS 38.413: " Technical Specification Group Radio Access Network; NG-RAN; NG Application Protocol (NGAP)".

[15] 3GPP TS 33.501: "Technical Specification Group Services and System Aspects; Security architecture and procedures for 5G system".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1], TS 22.261 [11] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Feeder link:** wireless link between the NTN Gateway and the NTN payload

NOTE: This definition is taken from TS 38.300 [3].

**Service link:** wireless link between the NTN payload and UE

NOTE: This definition is taken from TS 38.300 [3].

**Regenerative payload:** payload that transforms and amplifies an uplink RF signal before transmitting it on the downlink. The transformation of the signal refers to digital processing that may include demodulation, decoding, re-encoding, re-modulation and/or filtering

**Serving satellite:** satellite providing the satellite access to a UE (e.g. providing the serving cell(s)). Depending on the orbit, the serving satellite may cover a given geographic area for a limited period of time

**S&F Satellite operation:** operation mode providing communication service (in storing and forwarding information) to a UE in periods of time and/or geographical areas in which the serving satellite is not simultaneously connected to the ground network via feeder link or ISL. For the case of UL, "store" refers to on-board storage of UL information from UE and "forward" refers to forwarding of stored UL information to the ground network. For the case of DL, "store" refers to on-board storage of DL information from the ground network and "forward" refers to forwarding of stored DL information to the UE

**UE-Satellite-UE Communication:** refers to a communication between UEs under the coverage of one or more serving satellites, using satellite access without the user traffic transiting through the ground segment

**NTN Gateway**: earth station located at the surface of the earth, providing connectivity to the NTN payload using the feeder link. An NTN Gateway is a TNL node

NOTE: this definition is taken from TS 38.300 [3].

**NTN payload**: network node, embarked on board a satellite or high altitude platform station, providing connectivity functions, between the service link and the feeder link. In the current version of the present document, the NTN payload is a TNL node

NOTE: This definition is taken from TS 38.300 [3].

**On board NTN gNB:** gNB implemented in the regenerative payload on board a satellite

**On ground NTN gNB:** gNB of a transparent satellite payload implemented on ground

## 3.2 Symbols

Void.

## 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].

AMF Access and Mobility Management Function

5GC 5G Core Network

GEO Geostationary Orbit

HEO Highly Elliptical Orbit

ISL Inter-Satellite Link

LEO Low Earth Orbit

MME Mobility Management Entity

NTN Non-Terrestrial Network

S&F Store and Forward

SMF Session Management Function

TNL Transport Network Layer

UPF User Plane Function

# 4 Concepts and background

## 4.1 Overview

The following management architecture assumptions of NTN are applied to the study:

- The 5GC architecture for satellite access for NR as defined in TS 23.501 [6] is used as a baseline.

- The EPC architecture for satellite access for IoT as defined in TS 23.401 [7] and the architecture enhancements to facilitate communications with packet data networks and applications as defined in TS 23.682 [8] are used as a baseline.

- The reference management scenario for NTN as defined in TS 28.530 [9] is used as a baseline.

- The management architecture will support Store and Forward (S&F) satellite operation.

- The management architecture will support UE-Satellite-UE communication, when UPF is present onboard of the satellites.

The benefit of management enhancement to support new NTN features can be summarized as follows:

Configuration supporting regenerative mode

- identify whether a network element/ network function is onboarded or not and configure it, maintain its association with onboarded satellite

- configure the connection between entity on board and entity on ground to support smooth feeder link switchover

Configuration supporting Store and Forward

- configure the rules (e.g., storage quota allocation, forwarding priority, etc.) of S&F and enable S&F the communication service under satellite coverage with intermittent/temporary satellite connectivity (e.g. when the satellite is not connected via a feeder link or via ISL to the ground network).

Configuration supporting UE-Satellite-UE

- identify whether the UPF is onboarded or not and configure it.

- configure the connection between UPF on board and SMF on ground to support smooth feeder link switchover

Table 4.1-1 gives a quick summary of relation between NTN features and NTN management use cases.

Table 4.1-1: NTN features supported by existing NTN management use cases/capability

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Use case in R19 /capability defined in R18** | **Regenerative mode** | **Transparent mode** | **Store and Forward** | **UE-Satellite-UE** | **Mobility coordination** | **Backhaul** |
| 5.1.1 Connections between RAN node on-board satellite and CN (regenerative mode) | X |  |  |  |  |  |
| 5.1.2 Associations between SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground (transparent mode) |  | X |  |  |  |  |
| 5.1.3 Support of non-terrestrial network architecture with 5G system functions on board the NTN | X |  |  |  |  |  |
| 5.1.4 NRM extension to support re-generative mode of operations | X |  |  |  |  |  |
| 5.2.1 NTN neighbour cell management |  |  |  |  | X |  |
| 5.2.2 NTN Tracking area management |  |  |  |  | X |  |
| 5.2.3 MBS broadcast service management |  |  |  |  | X |  |
| 5.3.1 Store and Forward | X |  | X |  |  |  |
| 5.3.2 Distinguish which network elements support Store and Forward Satellite operation | X |  | X |  |  |  |
| 5.4.1 UE-Satellite-UE Communication via UPFs on-board the satellites | X |  |  | X |  |  |
| 5.4.2 MEC deployed on the satellite | X |  |  | X |  |  |
| 5.5.1 Connectivity between non-terrestrial network node and security gateway | X | X | X | X |  |  |
| NRM enhancement in TS 28.541 (Rel-18) |  | X |  |  |  | X |

## 4.2 Management relationship between 3GPP management system and regenerative satellite components

The management relationship between 3GPP management system and regenerative-based satellite components is depicted in figure 4.2-1. It describes satellites with gNB/eNB on board, core network functions on board or on the ground. The 3GPP Management system manages one or multiple moving regenerative satellite component(s), including gNB/eNB on-board satellite, core network function on-board satellite, Xn interface over inter-satellite link, and feeder link switchover.



Figure 4.2-1: Management relationship between 3GPP management system, regenerative satellite components and core network functions

# 5 Use cases, potential requirements and solutions

## 5.1 Management of connections and associations between satellite and ground systems (gNB/eNB/CN/management system)

### 5.1.1 Use case #1: Connections between RAN node on-board satellite and CN (regenerative mode)

#### 5.1.1.1 Description

When non-geo synchronized objects like LEO and MEO satellites are used for the NTN system, the satellites will not always be at the same position relative the earth's surface, and the coverage area on the earth surface for one satellite varies over time.

One consequence of non-geosynchronous satellites is that the associations between the entities on ground segment and entities in space segment are changing frequently, typically with a period of one to several minutes.



Figure 5.1.1.1-1 Non-geosynchronous satellites in NTN with regenerative gNB processed satellite payload

Fig. 5.1.1.1-1 illustrates this association change in an NTN system with regenerative gNB satellite payload. In this case, the ground segment Core Network (CN) will serve the same spotbeams all the time, while the space segment gNB on different satellites (satellite 1, 2 and 3) will serve the spotbeam in different time period as the satellites are approaching and leaving the coverage of the spotbeam over time. From management point of view, it will e.g. impact the association between GNBCUCPFunction and AMFFunction, and in case of regenerative payload with gNB onboard and quasi-earth fixed cell is applied, it will impact the cell configuration of NRCellCU in GNBCUCPFunction and cell configuration of NRCellDU in GNBDUFunction.

Another issue is the topology between space segment Managed Element (MnS producer) and the ground based Management System (MnS consumer): With long distances in between, disturbances (e.g. bad weather conditions), and partial reachability issues (when satellites fly over oceans with no gateway coverage), the latency, availability and reliability of the interface between them (feeder link + Inter-satellite link) are impacted.

Summary:

For the deployment scenario of RAN nodes on-board satellites, this would result in the following scenario: a LEO or MEO satellite with an onboard RAN node leaves the coverage area of a CN and then returns to the coverage area of that CN after cycling around the Earth.

From the operator's perspective, it is necessary to investigate how to efficiently manage the connections between RAN nodes and CN to avoid errors in CN due to stale connections, e.g. AMF/MME sending paging requests or AMF configuration updates to an unavailable RAN node. For example, 3GPP management system configures AMF/MME and/or gNB/eNB to add necessary information to support their awareness of when connectivity between a RAN node and a CN NF is available or unavailable.

#### 5.1.1.2 Potential requirements

**REQ-NTN-REGCON-1：**3GPP MnS producer should have the capability to configure the connections between RAN nodes on-board satellite and 5GC on an unreliable management interface.

**REQ-NTN-REGCON-2：**3GPP MnS producer should provide the capability to configure the continuously changing NRCellCU and NRCellDU configurations on RAN nodes on-board satellite due to NTN (quasi-earth-fixed) cells,on an unreliable management interface.

#### 5.1.1.3 Potential solutions

##### 5.1.1.3.1 Potential solution #<1>: Batch pre-configuration of the eNB/MME gNB/AMF associations

For NTN with regenerative eNB/gNB processed satellite payload, it is assumed that the sector equipment and eNB/gNB are located at the satellites, while MME/AMF and ProvMnS consumer are located on ground according to figure below.

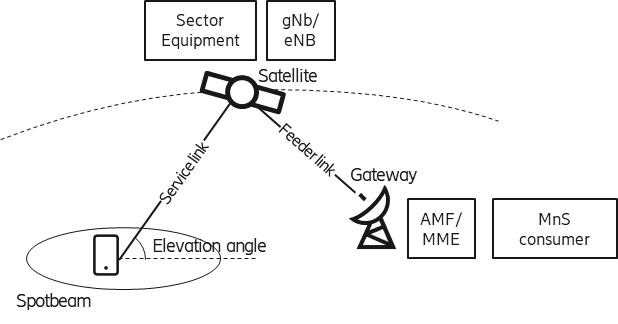


Figure 5.1.1.3.1-1 Location of NTN functions for regenerative eNB/gNB processed satellite payload.

As mentioned in the Use case #1 description, the interface between functions in the ground segment and space segment is unreliable, and the relationship between the eNB/gNB and MME/AMF is changing all the time, therefore there is a need to pre-configure the relation (association) between eNB/gNB and MME/AMF end points as a batch in advance.

For LTE/EPC, in order to realize batch configuration of the association, one possible solution is to modify the EP\_RP\_EPS (on eNB side) and EP\_RP\_EPS (on MME side) instances.

Attribute farEndNeIpAddr, which consists of an IP address of the remote MME/eNB, is complemented by a new optional attribute farEndNeIpAddrList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and IP address(es) of the remote MME/eNB. Further, the FarEndEntity attribute (inherited from EP\_RP) also needs to be complemented by an optional list where each list element consists of a FarEndEntity and a timeWindow.

For NR/5GC, in order to realize batch configuration of the association, one possible solution is to modify the EP\_NgC (on gNB side) and EP\_N2 (on AMF side) instances.

Attribute remoteAddress, which consists of an IP address of the remote AMF/gNB, is complemented by a new optional attribute remoteAddressList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and IP address of the remote AMF/gNB. Further, the FarEndEntity attribute (inherited from EP\_RP) also needs to be complemented by an optional list where each list element consists of a FarEndEntity and a timeWindow.

An example on modification of EP\_NgC and EP\_N2 is illustrated below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Attribute name** | **S** | **isReadable** | **isWritable** | **isInvariant** | **isNotifyable** |
| localAddress | O | T | T | F | T |
| remoteAddress | O | T | T | F | T |
| remoteAddressList | O | T | T | F | T |

Note *(to be placed in the IOC description of EP\_NgC and EP\_N2)*: If remoteAddressList is present, then the values (if present) of remoteAddress and FarEndEntity are not valid.

| **Attribute Name** | **Documentation and Allowed Values** | **Properties** |
| --- | --- | --- |
| remoteAddressList | A list of Remote address including timestamps and IP address used for initialization/release of the underlying transport.  IP address can be an IPv4 address (See RFC 791 [37]) or an IPv6 address (See RFC 2373 [38]). | type: AddrListWithTimestamp  multiplicity: \*  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| AddrListWithTimeStamp.timeWindow | Indicates the start time and stop time when the remote address is valid for this endpoint | type: TimeWindow  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| AddrListWithTimeStamp.remoteAddress | Address including IP address used for initialization/release of the underlying transport.  IP address can be an IPv4 address (See RFC 791 [37]) or an IPv6 address (See RFC 2373 [38]). | type: String  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| AddrListWithTimeStamp.FarEndEntity | The value of this attribute shall be the Distinguished Name of the far end network entity to which the reference point is related.  As an example, with EP\_Iucs, if the instance of EP\_Iucs is contained by one RncFunction instance, the farEndEntity is the Distinguished Name of the MscServerFunction instance to which this Iucs reference point is related.    allowedValues: N/A | type: DN  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration for NR/5GC, is shown below.



Figure 5.1.1.3.1-2 Sequence diagram: Configuration of gNB/AMF endpoint as a batch (for NR/5GC)

0. For each gNB in space, the ProvMnS consumer requests the ProvMnS producer to create a number of EP\_NgC instances for the CUCPFunction through ProvMnS. The number of EP\_NgC instances shall be equal to the max number of simultaneous AMFs that the gNB will connect to during its movement in the satellite orbit.  
  
For each AMF on ground, the ProvMnS consumer requests the ProvMnS producer to create a number of EP\_N2 instances for the AMFFunction through ProvMnS. The number of EP\_N2 instances shall be equal to the max number of simultaneous gNBs that the AMF will connect to.

1. The ProvMnS consumer receives, from an external entity, a list of the associations between all the gNBs in space and the AMFs on ground over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. position of the ground gateways, and possibility for the AMFs to connected to these ground gateways, the expected orbit position of the space gNBs over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite gNB, ground gateways, ground AMF, transport over the time period, etc. Observe that the MnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.

2. The ProvMnS consumer sends, to each gNB in space, a batch of its associations to all AMFs during the time period by the ProvMnS service ModifyMOIAttributes() with the remoteAddressList for all the EP\_NgC instances in the gNB. FarEndEntity attribute (inherited from EP\_RP) also needs to be replaced by a list where each list element consists of a FarEndEntity and a timeWindow.

3. The ProvMnS consumer sends, to each AMF on ground, a batch of its associations to all gNBs during the time period by the ProvMnS service ModifyMOIAttributes() with the remoteAddressList for all the EP\_N2 in the AMFs. FarEndEntity attribute (inherited from EP\_RP) also needs to be replaced by a list where each list element consists of a FarEndEntity and a timeWindow.

4. The actual changes of all EP\_NgC associations to AMFs for all gNBs over the time period are continuously and timely executed by the gNBs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notification service.

5. The actual changes of all EP\_N2 associations to gNB for all AMF over the time period are continuously and timely executed by the AMFs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notification service.

##### 5.1.1.3.2 Potential solution #<2>: Pre-configuration of the gNB/eNB and AMF/MME before connections between them are established or lost

This is a candidate solution for Use case #1: Connections between RAN node on-board satellite and CN (regenerative mode).

As described in Use case #1, the connections between gNB/eNB on-board satellite and AMF/MME on the ground changes frequently, typically because the periodic connecting/disconnecting of the gNB/eNB on-board satellite to the gateways. Therefore, this solution proposes to take the connecting/disconnecting of the gNB/eNB on-board satellite to the gateways as an event or to periodically trigger the 3GPP management system to perform configuration operations on the gNB/eNB and AMF/MME based on pre-received information about the connection and disconnection time of satellites and gateways.

For example, an external entity (e.g. satellite management system) may provide the information on the connection and disconnection time of satellites and gateways over a period of time in the future. Then the 3GPP management system can determine when to trigger create/modify/delete operations on which interface instances, effectively avoiding delays in operations.

The solution addresses the scenario where the gNB/eNB on-board satellite is connected to one or more gateways simultaneously during a given period, and the AMF/MME on the ground associated with the gateway can be different or the same. Figure 5.1.1.3.2-1 shows an example deployment scenario.

- Case I: gNB/eNB connects to the same AMF/MME via a different gateway (e.g. gNB/eNB connects AMF/MME 3 via Gateway 2 or Gateway 3).

- Case II: gNB/eNB connects to a different AMF/MME via a different gateway (e.g. gNB/eNB connects AMF/MME 2 via Gateway 2).

The attribute localAddress in EP\_NgC/EP\_RP\_EPS instances will have the different value if the connection between gNB/eNB and AMF/MME is via the different gateway.



Figure 5.1.1.3.2-1 Example scenario of connections between RAN node on-board satellite and CN.

The 3GPP management system creates multiple EP\_NgC (on gNB side)/EP\_RP\_EPS (on the eNB side) and EP\_N2 (on AMF side)/ EP\_RP\_EPS (on MME side) instances to handle the multiple connectivity links between gNB/eNB on-board satellite and AMF/MME on the ground, and adds new attributes representing the connection availability duration information in EP\_NgC, EP\_N2 and EP\_RP\_EPS IOC.

Before the connection between gNB/eNB on-board satellite and gateway is lost or based on the information on satellite and gateway connection status, the 3GPP management system may create/remove/modify the EP\_NgC /EP\_RP\_EPS and EP\_N2/ EP\_RP\_EPS instances and removes/modifies the relevant connection availability duration information.

The connection availability duration information is a list that provides the time when the gNB/eNB has a connection to an AMF/MME and the time when the connection is disconnected.

Take the impacts on EP\_NgC as an example, the new attributes may be as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| localAddress | O | T | T | F | T |
| remoteAddress | O | T | T | F | T |
| AvaDurWindow | O | T | T | F | T |

| Attribute Name | Documentation and Allowed Values | Properties |
| --- | --- | --- |
| EP\_NgC.avaDurWindow | This provides the connection availability durations of the EP\_NgC | type: TimeWindow  multiplicity: \*  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |

##### 5.1.1.3.3 Potential solution #<3.1>: Batch pre-configuration of NRCellCU/NRCellDU over time in GNBCUCPFunction/GNBDUFunction

As mentioned in the problem description, the interface between functions in the ground segment and space segment is unreliable, and the relationships between the gNB and the NTN quasi-earth-fixed cells which the gNB is serving are changing all the time, therefore there is also (in addition to Potential solution #<1>) a need to pre-configure the relation (association) between gNB and NTN Cells as a batch in advance.

In order to realize batch configuration of the association, one possible solution is to create maximum number of NRCellCU instances and NRCellDU instances that the satellite gNB can handle simultaneously at the same time, and change the configuration of the NRCellCU and NRCellDU instance according to a list, where each list entry consist of information on time window when it is valid, and the valid configuration attribute for serving the NTN quasi-earth-fixed Cell during the time window.

The NRCellCU is modified so that the current attributes in NRCellCU are complemented by a new optional attribute NRCellCUInfoList, which is a list with entries consisting of a timeWindow, and NRCellCUInfo with the same attributes as the current attributes in NRCellCU.

The NRCellDU is also modified in a similar way, i.e. the current attributes in NRCellDU are complemented by a new optional attribute NRCellDUInfoList, which is a list with entries consists of a timeWindow, and NRCellDUInfo with the same attributes as the current attributes in NRCellDU.

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration, is shown below (the operations, e.g. CreateMOI and ModifyMOIAttributes), are defined in 3GPP TS 28.532).



Figure 5.1.1.3.3-1 Sequence diagram of potential solution 3.1

0. For each gNB in space, ProvMnS consumer request each ProvMnS producer (gNB) in space to create a number of Managed Object (MO) NRCellCU instances for the GNBCUCPFunction, and a number of Managed Object (MO) NRCellDU instances for the GNBDUFunction through NR NRM MnS The number of NRCellCU and NRCellDU instances shall be at least equal to the max number of NTN quasi-earth-fixed Cell that the gNB can serve simultaneously.

1. ProvMnS consumer receives, from an external entity, a list of the associations between all the gNBs in space and the NTN quasi-earth-fixed cells over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. minimum elevation angle between the NTN quasi-earth-fixed cell and space gNB, the expected orbit position of the space gNBs over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite gNB, ground gateways, ground AMF, transport over the time period, etc. Observe that the ProvMnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.

2. ProvMnS consumer sends, to each ProvMnS producer (gNB) in space, a batch of its associations to all NTN quasi-earth-fixed cells (NTN cell configuration for the gNB-CU-CP part) during the time period by the NR NRM MnS service ModifyMOIAttributes() with the NRCellCUInfoList for all the NRCellCUInfo entries in the gNB. All remaining batch associations from the previous modification will be discarded when the new modification is received.

3. ProvMnS consumer sends, to each ProvMnS producer (gNB) in space, a batch of its associations to all NTN quasi-earth-fixed cells (NTN cell configuration for the gNB-DU part) during the time period by the NR NRM MnS service ModifyMOIAttributes() with the NRCellDUInfoList for all the NRCellDUInfo entries in the gNB. All remaining batch associations from the previous modification will be discarded when the new modification is received.

4. The actual changes of all NTN quasi-earth-fixed cells (gNB-CU-CP part) associations for all gNBs over the time period are continuously and timely executed by the gNBs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notification service.

5. The actual changes of all NTN quasi-earth-fixed cells (gNB-DU part) associations for all gNBs over the time period are continuously and timely executed by the gNBs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notification service.

##### 5.1.1.3.4 Potential solution #<3.2>: Batch pre-configuration of NRCellCU/NRCellDU over time in GNBCUCPFunction/GNBDUFunction (with multiple instances)

As mentioned in the problem description, the interface between functions in the ground segment and space segment is unreliable, and the relationships between the gNB and the NTN quasi-earth-fixed cells which the gNB is serving are changing all the time, therefore there is also (in addition to Potential solution #<1>) a need to pre-configure the relation (association) between gNB and NTN Cells as a batch in advance.

For realizing batch configuration of the association, one possible solution is to create NRCellCU instances and NRCellDU instances for all the ground fix NTN cells that the satellite gNB can serve, and provide validity of the NRCellCU and NRCellDU instances by a new attribute NRCellValidTimeWindowList, where each list entry consist of time window which indicates if the NRCellCU/NRCellDU instance is valid.

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration is shown below.



Figure 5.1.1.3.4-1 Sequence diagram of potential solution 3.2

0. For each gNB in space, ProvMnS consumer requests each ProvMnS producer (gNB) in space to create a number of Managed Object (MO) NRCellCU instances for the GNBCUCPFunction, and a number of Managed Object (MO) NRCellDU instances for the GNBDUFunction through NR NRM MnS The number of NRCellCU and NRCellDU instances shall be equal to the all the NTN quasi-earth-fixed Cells that the gNB can serve.

1. ProvMnS consumer receives, from an external entity, a list of the associations between all the gNBs in space and the NTN quasi-earth-fixed cells over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. minimum elevation angle between the NTN quasi-earth-fixed cell and space gNB, the expected orbit position of the space gNBs over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite gNB, ground gateways, ground AMF, transport over the time period, etc. Observe that the ProvMnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.

2. ProvMnS consumer updates all the NRCellCU instances in each ProvMnS producer (gNB) in space, the list indicating in which time periods the NRCellCU (configured to associated to a NTN quasi-earth-fixed Cell gNB-CU-CP part) instance wis valid. by the NR NRM MnS service ModifyMOIAttributes() with the NRCellValidTimeWindowList for all the TimeWindow entries in the gNB. All remaining timeWindow list from the previous modification will be discarded when the new modification is received.

3. ProvMnS consumer updates all the NRCellDU instance in each ProvMnS producer (gNB) in space, the list indicating in which time periods the NRCellDU (configured to associated to a NTN quasi-earth-fixed Cell gNB-DU part) instance wis valid. by the NR NRM MnS service ModifyMOIAttributes() with the NRCellValidTimeWindowList for all the TimeWindow entries in the gNB. All remaining timeWindow list from the previous modification will be discarded when the new modification is received.

4. The actual changes of all NRCellCU validity for all gNBs over the time period are continuously and timely executed by the gNBs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notification service.

5. The actual changes of all NRCellDU validity for all gNBs over the time period are continuously and timely executed by the gNBs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notification service.

##### 5.1.1.3.5 Potential solution #<4>: Pre-configuration based on single time window

To avoid adding time window for each IOC (e.g., EP\_NgC, EP\_N2, EP\_RP\_EPS, NRCellCU, NRCellDU), the pre-configuration can be done based on singletime window which covers all MOIs that are valid/activated during this time window.

Following is one example to illustrate valid instances for different time windows.

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Figure 5.1.1.3.5-1: Example to illustrate valid instances for different time windows.

In this use case, instances of EP\_NgC, EP\_N2, EP\_RP\_EPS, NRCellCU, NRCellDU can be configured into different time windows. A new IOC may be introduced to capture relation of a certain time window and corresponding activated instances in NTN scenarios.

The relationship diagram between the new IOC (named NTNTimeBasedConfig) and NTNFunction that is defined in TS 28.541 is shown in Figure 5.1.1.3.5-2.

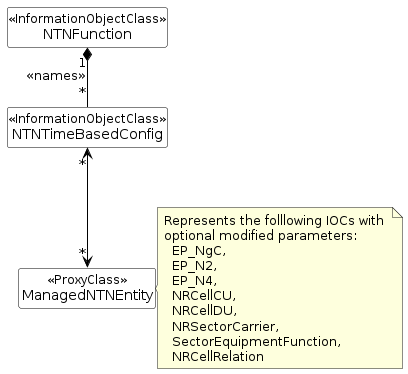


Figure 5.1.1.3.5-2: NRM fragment for NTNTimeBasedConfig

The NTNTimeBasedConfig IOC includes attributes defined in the Table 5.1.1.3.5-1 and 5.1.1.3.5-2.

Table 5.1.1.3.5-1: attributes for NTNTimeBasedConfig IOC

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| ntnTimeWindow | O | T | T | F | T |
| Attribute related to role |  |  |  |  |  |
| managedNTNEntityRefList | O | T | T | F | T |

Table 5.1.1.3.5-2: attributes properties for NTNTimeBasedConfig IOC

| Attribute Name | Documentation and allowedValues | Properties |
| --- | --- | --- |
| ntnTimeWindow | It provides the time windows (including start time and end time) within which the configuration for NTN is valid. | type: TimeWindow  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| managedNTNEntityRefList | It contains the list of MOIs that are activated/valid for NTN scenario under certain time duration, including possible modification of attributes. | type: managedNTNEntityInfo  multiplicity: \*  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: True |
| managedNTNEntityInfo.entityRef | It contains the reference to MOI that is activated/valid for NTN scenario under certain time duration. The class of MOIs includes one or more of following IOCs:  EP\_NgC,  EP\_N2,  NRCellCU,  NRCellDU,  NRSectorCarrier,  SectorEquipmentFunction,  NRCellRelation | type: DN  multiplicity: 1  isOrdered: N/A  isUnique: True  defaultValue: None  isNullable: False |
| managedNTNEntityInfo.*XXX* | In case the reference MOI in the entityRef is of type … *(copy each attribute in the reference MOI for modification)* | type: *XXX*  multiplicity: 0..1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: True |

To fill the managedNTNEntityRefList in NTNTimeBasedConfig IOC, instances of EP\_NgC, EP\_N2, NRCellCU, NRCellDU, etc., are previously created by Provisioning MnS producer for NTN scenarios with assigned DN respectively. DNs that are valid within same time window are grouped to a managedNTNEntityRefList which is used for NTNTimeBasedConfig IOC instantiation.

NOTE: The detail of attributes for NTNTimeBasedConfig IOC needs further investigation in normative phase.

#### 5.1.1.4 Evaluation of potential solutions

There are 2 potential solutions support the REQ-NTN-REGCON-1. It is proposed to evaluate them based on the following principles.

**Principle 1**: When regenerative mode is considered, the potential solution supports gNB/eNB and ground nodes to know in advance when the connections will be lost and need to be reconnected, without dependence of a working management interface. So that the N2/S1 connection setup/resume and disconnect/suspend can be triggered.

Both of the potential Solution #<1> and the potential Solution #<2> can support **Principle 1.** Moreover, both of them can be configured based on the pre-obtained information about the connection between the satellite and the gateway. Therefore, neither of them has the risk of N2/S1 connection update failure due to the configuration delay.

**Principle 2**: Less configuration complexity.

Solution #<1> proposes to change the attribute of the existing EP\_RP IOC. It requires that the existing standard definition of the FarEndEntity attribute changes from a DN type attribute allowing only one value, to the FarEndEntityList attribute which is a list attribute and each list element of this attribute consists of a FarEndEntity and a timeWindow describing the valid time of the connection.

Because of this change, the associations represented by EP\_RP IOC may need to change from one-to-one association to one-to-many association. Considering that many IOCs inherit from the EP\_RP IOC, such change may lead to impact on other IOCs.

Solution #<2> adds a new attribute or IOC in the existing interface instances. The new attribute or IOC is a list describing the available time window for the instance.

Potential solution#<1>:

- Pros:

o Supports gNB/eNB and ground nodes to know in advance when the connections will be lost and need to be reconnected, without dependence of a working management interface. So that the N2/S1 connection setup/resume and disconnect/suspend can be triggered.

o Since the association between the local address and the remote address is changed, the complexity and overhead when configuring all association time windows is reduced, as only one instance per association needs to be updated.

o No changes to EP\_RP and not modifying any existing attributes, minimizing the impact on inheritance relationships and reducing unexpected backward compatibility issues.

o In case of large satellite constellation, the number of EP instances will be the same as in terrestrial network case.

- Cons:

o Each MOI can represent different logical entities in different time windows which can potentially increase the complexity.

Potential solution#<2>:

- Pros:

o Supports gNB/eNB and ground nodes to know in advance when the connections will be lost and need to be reconnected, without dependence of a working management interface. So that the N2/S1 connection setup/resume and disconnect/suspend can be triggered.

o No changes to EP\_RP, minimizing the impact on inheritance relationships and reducing unexpected backward compatibility issues.

- Cons:

o When the satellite constellation is large, many instances need to be created and updated, resulting in more overhead cost and potential misalignment needs to be handled.

Potential solution #<3.1>

- Pros:

o Minimizes the complexity and overhead when configuring all association time windows, as only one instance per association needs to be updated. Also minimizes feeder link load as well as satellite CPU load and memory usage.

o No backward compatibility issues as there are no modifications of any existing attributes.

- Cons:

o Each MOI can represent different logical entities in different time windows which can potentially increase the complexity.

Potential solution #<3.2>

- Pros:

o No backward compatibility issues.

- Cons:

o As in gNB in space are non-geo synchronized, each space gNB needs to serve all the quasi-earth fixed cells on the entire earth, and the association updates need to be made with a period of approximately every minute, this solution has the drawback of managing a huge number of instances for all the connections (hundreds or even thousands) with the high system load for creation and updates, and related risk of delays and inconsistency in the creation/updates due to loss of feeder link between the management system and satellites, or alternatively a huge overhead and memory cost if all instances should be created in advance. In the latter case there is also a risk for inconsistent configuration in case some of all the sub-operations cannot be successfully executed for various reasons, causing a "PARTIALLY\_FAILED" response.

Potential solution #<4>

- Pros:

o No backward compatibility issues.

o Minimizes the configuration complexity and brings an overall pre-configuration to have a global view of all valid MOIs within a single instance for a time window, which can avoid the modification on all existing NRMs that are related to NTN scenario.

o Satisfy both requirements (i.e., REQ-NTN-REGCON-1 and REQ-NTN-REGCON-2) while other potential solutions only satisfy one of them.

- Cons:

o Some cons mentioned in Potential solution #<2> and Potential solution #<3.2> remain, e.g.:

 When the satellite constellation is large, many instances need to be created, resulting in more overhead cost.

 As in gNB in space are non-geo synchronized, each space gNB needs to serve all the quasi-earth fixed cells on the entire earth, this solution a huge overhead and memory cost if all instances should be created in advance.

It is recommended to take potential solution #<4> as baseline for normative work. The detail of attributes for NTNTimeBasedConfig IOC needs further investigation in normative phase.

### 5.1.2 Use case #2: Associations between SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground (transparent mode)

#### 5.1.2.1 Description

When non-geo synchronized objects like LEO and MEO satellites are used for the NTN system, the satellites will not always be at the same position relative the earth's surface, and the coverage area on the earth surface for one satellite varies over time.

One consequence of non-geosynchronous satellites is that the associations between the entities on ground segment and entities in space segment are changing frequently, typically with a period of one to several minutes.



Figure 5.1.2.1-1 Non-geosynchronous satellites in NTN system with transparent satellite payload

Fig. 5.1.2.1-1 illustrates this association change in an NTN system with transparent satellite payload. In this case, the ground segment gNB will serve the same spotbeams all the time, while different satellites (satellite 1, 2 and 3) in the space segment will serve the same spotbeam in different time periods as the satellites are approaching and leaving the coverage to the spotbeam over time. From management point of view, it will e.g. impact the association between NRSectorCarrier in the gNB and SectorEquipmentFunction in the satellite.

Another issue is the topology between space segment Managed Element (MnS producer) and the ground based Management System (MnS consumer): With long distances in between, disturbances (e.g. bad weather conditions), and partial reachability issues (when satellites fly over oceans with no gateway coverage), the latency, availability and reliability of the interface between them (feeder link + Inter-satellite link) are impacted.

Summary:

For the deployment scenario of SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground, this would result in the following scenario: a LEO or MEO satellite with an onboard SectorEquipmentFunction leaves the coverage area of a RAN node (gNB/eNB) on ground and then returns to the coverage area of that RAN node (gNB/eNB) after cycling around the Earth.

From the operator's perspective, it is necessary to investigate how to efficiently manage the connections between SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground due to stale connections. For example, 3GPP management system configures association between NRSectorCarrier in the gNB and SectorEquipmentFunction in the satellite, adding necessary information to support their awareness of when connectivity between the satellite and the RAN nodes (gNB/eNB) on ground is available or unavailable.

#### 5.1.2.2 Potential requirements

**REQ-NTN-TRANSCON-1：**3GPP MnS producer should have the capability to configure the associations between SectorEquipmentFunction on-board satellite and NRSectorCarrier in the RAN nodes (gNB/eNB) on ground on an unreliable management interface.

#### 5.1.2.3 Potential solutions

##### 5.1.2.3.1 Potential solution #<1>: Batch pre-configuration of the NRSectorCarrier/ sectorEquipmentFunction associations

For NTN with transparent satellite payload, it is assumed that the sector equipment is located at the satellites, while eNB/gNB, MME/AMF (not shown in the figure) and the ProvMnS consumer are located on ground according to figure below.

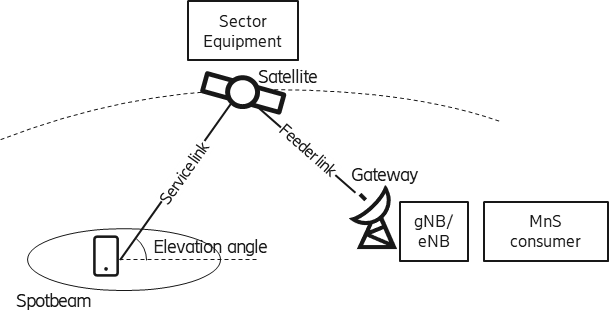


Figure 5.1.2.3.1-1 Location of NTN functions for transparent satellite payload according to 3GPP architecture

As mentioned in the Use case #2 description, the interface between functions in the ground segment and space segment is unreliable, and the relationships between the eNB/gNB and SectorEquipment are changing all the time, therefore there is a need to pre-configure the relation (association)between eNB/gNB and SectorEquipment end points as a batch in advance.

In order to realize batch configuration of the association, one possible solution is to modify EUtranGenericCell/NRSectorCarrier (on eNB/gNB side) and SectorEquipmentFunction (on sector Equipment side) instances.

For EUtranGenericCell on eNB side, attribute relatedSector, which consists of Distinguished Name (DN) of the remote Sector Equipment, is complemented by a new optional attribute relatedSectorList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and DN of the remote Sector Equipment.

For NRSectorCarrier on gNB side, attribute sectorEquipmentFunctionRef, which consists of Distinguished Name (DN) of the remote Sector Equipment, is complemented by a new optional attribute sectorEquipmentFunctionRefList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and DN of the remote Sector Equipment.

For SectorEquipmentFunction on Sector Equipment side, in case of LTE, attribute theCellList, which consists of Distinguished Name (DN) of a list of remote eNB E-UTRAN cell, is complemented by a new optional attribute theCellListList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and a list of DN of remote eNB E-UTRAN cell.

For SectorEquipmentFunction on Sector Equipment side, in case of NR, attribute theNRSectorCarrierList, which consists of Distinguished Name (DN) of a list of remote gNB sector carrier, is replaced by attribute theNRSectorCarrierListList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and a list of DN of remote gNB sector carrier.

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration for NR is shown below.



Figure 5.1.2.3.1-2 Sequence diagram: Configuration of Sector Carrier / Sector Equipment function associations as a batch (for NR)

0. For each Sector Equipment in space, the ProvMnS consumer requests the ProvMnS producer to create SectorEquipmentFunction instances through the ProvMnS.  
  
For each gNB on ground, the ProvMnS consumer requests the ProvMnS producer to create a number of NRSectorCarrier instances for the GNBDUFunction through the ProvMnS. The number of NRSectorCarrier instances shall be equal to the max number of sector Carriers that the gNB will handle.

1. The ProvMnS consumer receives, from an external entity, a list of the associations between all the sector equipments in space and the gNBs on ground over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. position of the ground gateways, and possibility for the gNBs to connected to these ground gateways, the expected orbit position of the space sector equipment over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite sector equipment, ground gateways, ground gNB, transport over the time period, etc. Observe that the MnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.

2. The ProvMnS consumer sends, to each sector equipment in space, a batch of its associations to all sector carriers in one or several specific gNBs during the time period through the ProvMnS ModifyMOIAttributes() with the theNRSectorCarrierListList for all the sectorEquipmentFunctions.

3. The ProvMnS consumer sends, to each gNB on ground, a batch of its associations to all sector equipment in space for all sector carriers in all gNBs during the time period through the ProvMnS service ModifyMOIAttributes() with the sectorEquipmentFunctionRefList for all the NRSectorCarrier in the gNBs.

4. The actual changes of the associations to all sector carriers in different gNBs over the time period are continuously and timely executed by the sector equipment according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notificationservice.

5. The actual changes of the associations to all sector equipment for all sector carriers in all gNBs over the time period are continuously and timely executed by the gNB according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notificationservice.

##### 5.1.2.3.2 Potential solution #<2>: Batch pre-configuration of the NRSectorCarrier/ SectorEquipmentFunction associations (with multiple instances)

An alternative potential solution may also be considered, where each gNBDUFunction for each NRCellDU creates individual NRSectorCarrier associated to sectorEquipmentFunction on each satellite in the constellation, and for each SectorEquipmentFunction located in space, attribute theNRSectorCarrierList consists of reference of NRCSectorCarrier for all NTN cells in all GNBDUFunction.

For NRSectorCarrier, a new attribute, validTimeWindows, as a list of TimeWindow datatype, indicates when the NRSectorCarrier (and it associated SectorEquipmentFunction) is active.

For SectorEquipmentFunction, a new attribute ValidTimeWindowsList is added, consisting of a list where each list item maps to the elements in theNRSectorCarrierList, and the item in ValidTimeWindowsList consist of a list of TimeWindow datatype, indicating when the associated NRSectorCarrier is active.

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration for NR is shown below.



Figure 5.1.2.3.2-1 Sequence diagram: Batch configuration of Sector Carrier / Sector Equipment function associations with multiple instances

0. For each Sector Equipment in space, the ProvMnS consumer requests the ProvMnS producer to create SectorEquipmentFunction instances through the ProvMnS, with attribute theNRSectorCarrierList consists of reference of NRCSectorCarrier for all NTN cells in all GNBDUFunction.   
  
For each gNB on ground, the ProvMnS consumer requests the ProvMnS producer to create a number of NRSectorCarrier instances for the GNBDUFunction through the ProvMnS. Each NRSectorCarrier instances is associated to one sectorEquipmentFunction on one satellite, and the total number of NRSectorCarrier shall cover associated to sectorEquipmentFunction on each satellite in the constellation.

1. The ProvMnS consumer receives, from an external entity, a list of the associations between all the sector equipments in space and the gNBs on ground over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. position of the ground gateways, and possibility for the gNBs to connected to these ground gateways, the expected orbit position of the space sector equipment over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite sector equipment, ground gateways, ground gNB, transport over the time period, etc. Observe that the MnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.

2. The ProvMnS consumer sends, to each sector equipment in space, a batch of its associations to all sector carriers in one or several specific gNBs during the time period through the ProvMnS ModifyMOIAttributes() with the theNRSectorCarrierValidtimeListList for all the sectorEquipmentFunctions.

3. The ProvMnS consumer sends, to each gNB on ground, a batch of its associations to all sector equipment in space for all sector carriers in all gNBs during the time period through the ProvMnS service ModifyMOIAttributes() with the validTimeList for all the NRSectorCarrier in the gNBs.

##### 5.1.2.3.3 Potential solution #<3>: Pre-configuration based on single time window

The solution for NTN pre-configuration based on single time window can refer to description in clause 5.1.1.3.5.

In this use case, different instances of NRSectorCarrier and SectorEquipmentFunction can be associated to different time windows which reflects to their valid duration.

#### 5.1.2.4 Evaluation of potential solutions

Potential solution #<1>

- Pros:

o Minimizes the complexity and overhead when configuring all association time windows, as only one attribute per association needs to be updated. Also minimizes feeder link load as well as satellite CPU load and memory usage.

o No backward compatibility issues as there are no modifications of any existing attributes.

- Cons:

o Each MOI can represent different logical entities in different time windows which can potentially increase the complexity.

Potential solution #<2>

- Pros:

o No backward compatibility issues as there are no modifications of any existing attributes.

- Cons:

o As the association updates need to be made with a period of approximately every minute, this solution has the drawback of managing a huge number of instances for all the connections (hundreds or even thousands) with the high system load to create and update them frequently, and related risk of delays and inconsistency in the creation/updates due to loss of feeder link between the management system and satellites, or alternatively a huge overhead and memory cost if all instances should be created in advance. In the latter case there is also a risk for inconsistent configuration in case some of all the sub-operations cannot be successfully executed for various reasons, causing a "PARTIALLY\_FAILED" response.

Potential solution #<3>

- Pros:

o No backward compatibility issues.

o Minimizes the configuration complexity and brings an overall pre-configuration to have a global view of all valid MOIs within a single instance for a time window, which can avoid the modification on all existing NRMs that are related to NTN scenario.

It is recommended to take potential solution #<3> as baseline for normative work.

### 5.1.3 Use case #3: Support of non-terrestrial network architecture with 5G system functions on board the NTN

#### 5.1.3.1 Description

Support of non-terrestrial network architecture with 5G system functions on board the NTN (i.e. regenerative payloads) provides new architecture option(s) besides the transparent payload as specified in Rel-17 and Rel-18, which makes the deployment of non-terrestrial network more flexible. TR 38.821 [4] gives an overview about the typical scenario based on regenerative payload is depicted below:



Figure 5.1.3.1-1: Non-terrestrial network typical scenario based on regenerative payload

Satellite regenerative payload is effectively equivalent to having all or part of base station functions (e.g. gNB, CU, or DU) and/or CN functions on board the satellite. Support of regenerative payload brings some benefits on radio resource handling in Uu, and radio resource coordination between the gNBs/eNBs via the ISL. But it also introduces system complexity due to moving RAN node, different LEO/MEO deployment and feeder link switchover, etc. Thus, the 3GPP management systems should provide means for an MnS consumer to manage and control different NTN configurations in the following scenarios:

- Feeder link switchover, due to e.g. maintenance, traffic offloading, or (for LEO) due to the satellite and eNB/gNB moving out of visibility with respect to the current NTN GW.

- Configuration enhancement on the interface management between the RAN and the 5GC, e.g. N2/S1 management.

#### 5.1.3.2 Potential requirements

**REQ-NTN-FUN-01:** The 3GPP management system shall have the capability to manage feeder link switchover.

#### 5.1.3.3 Potential solutions

##### 5.1.3.3.1 Potential solution #<1>: Pre-configure provisioning data for NTN related NF

A feeder link switchover is the procedure where the feeder link is changed from a source NTN Gateway to a target NTN Gateway for a specific NTN payload. The feeder link switchover is a Transport Network Layer procedure.

Following are the proposed solutions to support above enhancements based on existing NRM fragment in TS 28.541 [13].

- To support feeder link switchover:

a) If the satellite remains in the coverage area of current AMF. Considering that NTN-GW is transport network node and how to configure gNB/AMF to associate with NTN-GW is out of scope of 3GPP, in this case, the switch is transparent to the UEs and network, the NG interface remains unaffected after the satellite/gNB connects to current AMF via the new NTN Gateway.

b) If satellite moves into a coverage of a new AMF. Considering the switchover may be predictable (e.g. based on the LEO satellite ephemeris information and NTN GWs location) or event-triggered (e.g. for maintenance), an gNB can be configured to associate with multiple AMFs as well as with predicted time windows, solutions under 5.1.1.3 are proposed to reuse to address the issues.

NOTE: This solution needs to align with RAN WG3 and SA WG2.

- To support configuration enhancement for gNB and/or CN functions on board the satellite:

a) New attribute called "isOnBoard" can be defined in the corresponding IOCs (e.g. GNBCUCPFunction IOC, AMFFunction IOC, etc.) to indicate whether these functions are on board the satellite.

Existed attribute "nRSatelliteRATtype" defines the RAT Type for NR satellite access (e.g. GEO, MEO, LEO etc) in TS 28.541 [13] can be reused in corresponding function IOCs (e.g. GNBCUCPFunction IOC, AMFFunction IOC, etc.).

#### 5.1.3.4 Evaluation of potential solutions

The possible solution described in clause 5.1.3.3.1 adopts the NRM-based approach, which enhances the existing NRM fragment with new optional attributes indicating whether these functions are on board the satellite and related NTN RAT type, the change is lightweight and it is backward compatible, therefore it is a feasible solution.

### 5.1.4 Use case #4: NRM extension to support re-generative mode of operations.

#### 5.1.4.1 Description

The current NR-NRM definitions do not support NTN function in regenerative mode. It only support transparent mode of operation. In case of regenerative mode of operation the attribute nTNpLMNInfoList (in NTNFunction IOC) will overlap with the attribute pLMNId (in GNBCUCPFunction IOC).

#### 5.1.4.2 Potential requirements

**REQ-NTN-FUN-01:** The MnS Producer should have the capability to manage re-generative mode of satellite operation.

#### 5.1.4.3 Potential solutions

##### 5.1.4.3.1 Potential solution #1: Basic NRM extensions to support re-generative mode of operations.

This solution proposes the following options to update NTNFunction NRM fragment to support re-generative mode of satellite operations.

1. Option 1

The GNBCUCPFunction should have direct association (represented by an attribute nTNFunctionRef) with the NTNFunction with 1..0..1 relation. That imply that a gNB will have a single NTNFunction configuration available to it. In other words, it will show that a particular gNB is supporting NR NTN. The attribute nTNpLMNInfoList attribute in NTNFunction IOC is to be made CM (condition mandatory) with the condition of "transparent mode of satellite communication is used." That would imply that the attribute nTNpLMNInfoList shall only be present in case of transparent mode. In this case the attribute pLMNId (in GNBCUCPFunction IOC) will indicate non-NTN PLMN and the attribute nTNpLMNInfoList attribute (in NTNFunction IOC) will indicate NTN PLMN. This is due to the fact that in case of regenerative mode of operation the NTN specific PLMN information provided by the attribute pLMNId in GNBCUCPFunction IOC applies.

A new IOC (SatelliteInfo) is to be introduced to contain all the satellite related configuration. This IOC will be in composition relation with NTNFunction IOC with 1…\* relation. The existing EphemerisInfos attribute (part of SatelliteInfo information related with generic configuration for the satellite IOC) is added directly to the SatelliteInfo IOC making the existing EphemerisInfoSet IOC obsolete.



Figure 5.1.4.3.1-1: NRM fragment for Option1

2. Option 2

The GNBCUCPFunction should have direct association (represented by an attribute nTNFunctionRef) with the NTNFunction with 1..0..1 relation. That imply that a gNB will have a single NTNFunction configuration available to it. In other words, it will show that a particular gNB is supporting NR NTN. The attribute nTNpLMNInfoList attribute in NTNFunction IOC is to be made CM (condition mandatory) with the condition of "transparent mode of satellite communication is used." In other words the attribute nTNpLMNInfoList shall only be present in case of transparent mode. In this case the attribute pLMNId (in GNBCUCPFunction IOC) will indicate non-NTN PLMN and the attribute nTNpLMNInfoList attribute (in NTNFunction IOC) will indicate NTN PLMN. This is due to the fact that in case of regenerative mode of operation the NTN specific PLMN information provided by the attribute pLMNId in GNBCUCPFunction IOC applies.

The existing EphemerisInfoSet IOC stays and will have direct association with SatelliteInfo IOC. A new IOC (SatelliteInfo) is to be introduced to contain all the satellite related configuration except Ephemeris information. This IOC will be in composition relation with NTNFunction IOC with 1…\* relation.



Figure 5.1.4.3.1-2: NRM fragment for Option2

3. Option 3

The attribute nTNpLMNInfoList attribute in NTNFunction IOC is to be made CM (condition mandatory) with the condition of "transparent mode of satellite communication is used." In other words the attribute nTNpLMNInfoList shall only be present in case of transparent mode. In this case the attribute pLMNId (in GNBCUCPFunction IOC) will indicate non-NTN PLMN and the attribute nTNpLMNInfoList attribute (in NTNFunction IOC) will indicate NTN PLMN. This is due to the fact that in case of regenerative mode of operation the NTN specific PLMN information provided by the attribute pLMNId in GNBCUCPFunction IOC applies.

The GNBCUCPFunction should also have direct association (represented by an attribute satelliteInfoRef) with the SatelliteInfo with 1..1 relation.

A new IOC (SatelliteInfo) is to be introduced to contain all the satellite related configuration except Ephemeris information. This IOC will be in composition relation with NTNFunction IOC with 1…\* relation. The solution proposes new S&FConfigInfo to contain information related with generic configuration for the satellite.



Figure 5.1.4.3.1-3: NRM fragment for Option3

#### 5.1.4.4 Evaluation of potential solutions

The solution proposed in 5.1.4.3 provides 3 potential NRM update options to support re-generative mode of operations. Option-1 is considered best as it support re-generative mode of operations and also enable any further satellite related configurations to be done in a consistent way.

The Option-1 may result in the GNBCUCPFunction malfunction in case of an error in NFNFunction. This need to be addressed in the normative phase.

## 5.2 Management for mobility coordination

### 5.2.1 Use case #1: NTN neighbour cell management

#### 5.2.1.1 Description

As defined in TS 38.423 [2] clause 9.2.2.13, the maximum number of neighbour cells associated to a served cell is 1024. In TN scenario the limitation on the number of neighbour cells is acceptable, but in NTN scenario the number of neighbour cells may overwhelm for two reasons:

** NTN cell footprint is larger than a TN cell**

The typical beam footprint size of an NTN cell ranges from 100 km to 3500 km according to TR 38.821 [4], while for a TN cell the size is generally less than 10 km.

 NTN neighbour cell changes as NTN cell moving.



Figure 5.2.1-1: NTN neighbour cell changes in LEO earth-moving scenario

There are three types of service links described in TS 38.300 [3], one of the types is Earth-moving, which means the coverage area of earth-moving beam(s) slides over the Earth surface. In this scenario, NTN neighbour cell changes as NTN cell moving. Figure 5.2.1-2 shows the NTN neighbour cell changes in LEO earth-moving scenario. The NTN cell coverage is geographical area #1 at 10:00. At that moment, the neighbour cells are NTN cells and TN cells whose coverage are overlapping with geographical area #1. When the satellite moves to geographical area #2 at 10:15, the TN cells that overlap with an NTN cell change, which means the neighbour cells of an NTN cell are not the ones in geographical area #1 at 10:00. In this case, if the cell recognized as neighbour cell in geographical area #1 still remains as neighbour cell at geographical area #2 and the information of the cell is sent to UE for handover, the performance of mobility could be worse since this cell is invalid at geographical area #2.

Overall, simply enlarging the limit of maximum number of neighbour cells leads two drawbacks in NTN:

1. As satellite moving, the number of neighbour cells passed by could be extremely large resulting in high storage demand in RAN.

2. As satellite moving, plenty of neighbour cells lose validity.

Therefore, to provide better mobility coordination and service continuity, how to configure NTN neighbour cells becomes a problem to be solved.

#### 5.2.1.2 Potential requirements

**REQ-NTN-FUN-01:** The 3GPP management system shall have the capability to configure NTN neighbour cells considering the satellite movement.

#### 5.2.1.3 Potential solutions

##### 5.2.1.3.1 Potential solution #<1>: Add valid duration for NRCellRelation

The valid neighbour cells of an NTN cell keep changing as the satellite is moving. To provide better mobility coordination and service continuity, the valid duration of the NTN neighbour cell can be configured. This solution proposes to add a new attribute for NRCellRelation IOC (defined in TS 28.541 [13] clause 4.3.32) which indicates the valid duration of neighbour cell relation between a source cell (i.e. an NTN cell) and a target cell (i.e. a neighbour NTN cell of this NTN cell). The valid duration is a time window which represents the start time and end time when the target cell is a valid neighbour cell towards the source cell.

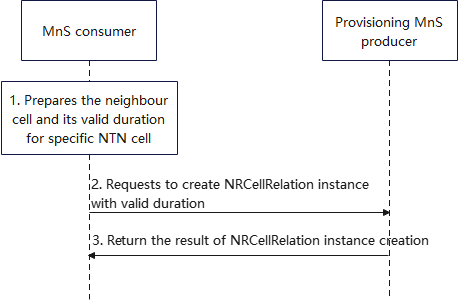


Figure 5.2.1.3.1-1: procedure of NTN neighbour cells relation configuration

1. According to the satellite ephemeris information, such as the orbital trajectory information or coordinates for the NTN vehicles, MnS consumer (e.g. operators) can obtain a neighbour NTN cell list of an NTN cell, which contains one or more neighbour NTN cells. For each neighbor cell in the list, there is a corresponding valid duration.

2. When MnS consumer requests to create NRCellRelation instance for each neighbour cell relation between the NTN cell and its neighbour cell, the valid duration is added as one attribute of this NRCellRelation instance. Since the valid duration is only useful for NTN scenario, one attribute constraint for it is that the source and target cell are NTN cells.

3. Provisioning MnS producer sends NRCellRelation instance creation result to MnS consumer, which contains the neighbour NTN cell and its valid duration for the source NTN cell.

NOTE: This solution is most useful for earth-moving scenario, and not applicable for earth-fix scenario.

##### 5.2.1.3.2 Potential solution #<2>: Pre-configuration based on single time window

The solution for NTN pre-configuration based on single time window can refer to description in clause 5.1.1.3.5.

In this use case, different instances of NRCellRelation can be associated to different time windows which reflects to their valid duration.

#### 5.2.1.4 Evaluation of potential solutions

Potential solution #<1>

- Pros:

o Avoids potential backward compatibility issue

- Cons:

o Increases configuration complexity since the time window is configured within each single MOI

Potential solution #<2>

- Pros:

o No backward compatibility issues.

o Minimizes the configuration complexity and brings an overall pre-configuration to catch a global view of all valid MOIs within a single instance for a time window, which can avoid the modification on all existing NRMs that are related to NTN scenario.

It is recommended to take potential solution #<2> as baseline for normative work.

### 5.2.2 Use case #2: NTN Tracking area management

#### 5.2.2.1 Description

Tracking areas (TAs) and cell identities (cell IDs) represents a fixed geographic area within the network where a mobile device can move without requiring an update of its location information. The respective mapping is generally assigned and planned in advance by the operator and configured in the RAN and CN by 3GPP management system. The typical beam footprint size of an NTN cell is much larger compared to usual TN cell, therefore, the coverage of one cell in NTN may cover multiple TAs, the relationship between Cell and TA in NT and NTN is illustrated by Figure 5.2.2.1-1.



Figure 5.2.2.1-1: Cell-TA relationship in TN and NTN

The NTN can support Earth-fixed cell, quasi-Earth-fixed cell or Earth-moving cell. To avoid Tracking Area Codes (TAC) fluctuations in the NTN earth-moving cells case, the network may broadcast multiple Tracking Area Codes per PLMN ID in an NR NTN cell (see TS 38.300 [3] clause 16.14.3.1). As illustrated in Figure 5.2.2.1-2, the tracking area is designed to be fixed on ground, when cells sweep on the ground, the tracking area code (i.e. TAC) broadcasted is changed when the cell arrives to the area of next planned earth fixed tracking area location. This implies that the TAC or a list of TACs configuration on gNB needs to be frequently updates by 3GPP management system.



Figure 5.2.2.1-2: An example of updating TACs in LEO earth-moving scenario

Another issue in NTN tracking area management is that how does AMF capture the information of NTN gNB supported TAIs which will change as the satellite moving. One way to solve it is that management system configures the AMF with TAIs supported by NTN gNB.

#### 5.2.2.2 Potential requirements

**REQ-NTN-FUN-01:** The 3GPP management system shall have the capability to configure/update TACs for NTN earth-moving cells.

**REQ-NTN-FUN-02:** The 3GPP management system shall have the capability to configure AMF with TAIs supported by NTN gNB which may change as the satellite moving.

#### 5.2.2.3 Potential solutions

##### 5.2.2.3.1 Potential solution #<1>: Timing window based TAList update

In Rel-17, RAN has defined that NTN cell should broadcast multiple TAIs per PLMN ID, trackingAreaList has been introduced in PLMN-IdentityInfoList information element (see TS 38.331 [10]). It also requires that the field is only present in an NTN cell, network does not configure trackingAreaCode if this field is present.

For non-terrestrial network, RAN has also introduced SIB19 (System Information Block 19) which contains NTN-specific parameters (e.g. ephemeris information) for serving cell and optionally NTN-specific parameters for neighbour cells.

Considering the related TAIs broadcast in each cell change frequently with a foot print moving on earth, may be predictable, e.g. based on the satellite ephemeris information, position of the ground gateways, NTN beam information etc., time windows per TAList, which define the specific period during that the satellite coverage will be available for this location, can be derived and configured when NTN cell sweep over earth.

Following are the proposed solutions to support above requirements for Earth-moving cell scenario based on existing NRM fragment in TS 28.541 [13].

- Attribute "nTNTAClist" per PLMN ID can be defined under NRCellDU IOC (currently only configure gNB level TAClist for NTN), to indicate multiple tracking areas per each NTN cell covers. Moreover, ephemeris information for each satellite should also be referred to the cell when sending SIB19.

- Attribute "availableTimeWindows" as a list of "TimeWindow<<datatype>> " per nTNTAClist can be defined to indicator which time period the coverage will be available for the location.

- NTN neighbour cell might also be configured for each cell, solution under clause 5.2.1.3 could be reused.

##### 5.2.2.3.2 Potential solution #<2>: Pre-configuration based on single time window

The solution for NTN pre-configuration based on single time window can refer to description in clause 5.1.1.3.5.

In this use case, different instances of NRCellDU which includes nTNTAClist introduced in clause 5.2.2.3.1 can be associated to different time windows which reflects to their valid duration.

To support REQ-NTN-FUN-02, new IOC NTNgNBCapability is introduced which is name contained by AMFFunction IOC. Different instances of NTNgNBCapability can be associated to time windows which reflects to their valid durations.

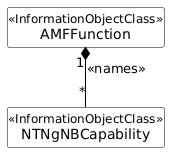


Figure 5.2.2.3.2-1: NRM fragment for NTNgNBCapability

The NTNgNBCapability IOC includes attributes defined in the Table 5.2.2.3.2-1 and 5.2.2.3.2-2.

Table 5.2.2.3.2-1: attributes for NTNgNBCapability IOC

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
| nTNgNBId | M | T | T | F | T |
| supportedTAIList | M | T | T | F | T |

Table 5.2.2.3.2-2: attributes properties for NTNgNBCapability IOC

| Attribute Name | Documentation and allowedValues | Properties |
| --- | --- | --- |
| nTNgNBId | It identifies a gNB within a PLMN. The gNB ID is part of the NR Cell Identifier (NCI) of the gNB cells.  See "gNB Identifier (gNB ID)" of subclause 8.2 of TS 38.300 [3]. See "Global gNB ID" in subclause 9.3.1.6 of TS 38.413 [14].  allowedValues: 0..4294967295 | type: Integer  multiplicity: 1  isOrdered: N/A  isUnique: N/A  defaultValue: None  isNullable: False |
| supportedTAIList | It contains the list of TAIs that are supported by NTN gNB | type: TAI  multiplicity: 1…\*  isOrdered: False  isUnique: True  defaultValue: None  isNullable: False |

#### 5.2.2.4 Evaluation of potential solutions

The possible solution #<1> for Earth-moving cell scenario described in clause 5.2.2.3.1 adopts the NRM-based approach, which enhances the existing NRM fragment with attributes indicating multiple tracking areas per each NTN cell covers and which time period the coverage will be available for the location, the change is lightweight and it is backward compatible, therefore it is a feasible solution.

Potential solution #<2>

- Pros:

o No backward compatibility issues.

o Minimizes the configuration complexity and brings an overall pre-configuration to catch a global view of all valid MOIs within a single instance for a time window, which can avoid the modification on all existing NRMs that are related to NTN scenario.

It is recommended to take potential solution #<2> as baseline for normative work.

### 5.2.3 Use case #3: MBS broadcast service management

#### 5.2.3.1 Description

The NTN can support Earth-fixed cell, quasi-Earth-fixed cell or Earth-moving cell. Signaling enhancements for the MBS Broadcast in NR NTN have been discussed on Earth-moving cells [3]. MBS Broadcast for intended service, since the coverage of NTN Uu Cells are large, which are not fixed to a geographical location and moves with the satellite movement, the MBS broadcast may not be intended for such a large area. MBS broadcast may be intended for a specific geo location which may not map to Uu Cell or Mapped Cell, it would be flexible to provision an Area of interest similar to Warning message, which can indicate a specific geo location.

Therefore, to provide better service of mobility management, area IDs can be configured via OAM and based on the ID, gNB can understand to which geolocation within NTN cell coverage it needs to broadcast the MBS service.

#### 5.2.3.2 Potential requirements

**REQ-NTN-MBS-1:** The 3GPP management system shall have the capability to configure NTN area IDs considering MBS services.

#### 5.2.3.3 Potential solutions

##### 5.2.3.3.1 Potential solution #<1>: Configuring small MBS service area in NTN

RAN has discussed the MBS broadcast service for NR NTN system. RAN assumes that the MBS Service Area Information defined by a list of NR-CGI or a list of TAI could also be applied for NTN system. Besides that, for the case the intended service area is small than a cell. Following are the proposed solutions to support above requirements based on existing NRM fragment in TS 28.541 [13].

- Attribute "MbsSmallArealist" can be defined under MbsServiceArea IOC (currently only configure a list of NR-CGI or a list of TAI for NTN and TN), to indicate a geographical area represented by a (set of) referenceLocation and radius or by a polygon.

NOTE The new geographical area description could be considered for intended MBS service area, the detailed format can be aligned with the area broadcast in the Uu link, which is pending to RAN.

#### 5.2.3.4 Evaluation of potential solutions

The possible solutions described in clause 5.2.3.3.1 adopt an NRM-based approach, enhancing the existing NRM fragment with new attributes that define a specific geographical area for MBS services within NTN coverage. This approach is lightweight and backward compatible, making it a feasible solution for supporting NTN-based MBS services.

## 5.3 Management support of Store and Forward Satellite operation

### 5.3.1 Use case #1: Store and Forward

#### 5.3.1.1 Description

The use case and requirements of store and forward functionality in defined in [5]. The Store and Forward Satellite (S&F) operation in a 5G system with satellite access is intended to provide some level of communication service for UEs under satellite coverage with intermittent/temporary satellite connectivity (e.g. when the satellite is not connected via a feeder link or via ISL to the ground network) for delay-tolerant communication service. The concept of "S&F" service is widely used in the fields of delay-tolerant networking and disruption-tolerant networking.

The management of the S&F functionality need to be defined. The limitations on the size/amount of data that can be sent from the UE to the AF (Application Function, e.g. IoT devices) and vice versa need to be configured. Forwarding priority for the stored data to the ground station or to the UE and data retention period for the exchanged data should be configured. The acknowledgment can be provided for the received messages. The acknowledge policy may dictate that the acknowledgment should not be provided. Whether to acknowledgement of the received data by the satellite could be issued possibly with the additional information about the store and forward including (not limited to) estimated time to deliver the messages need to be configured.

The S&F functionality requires to store the messages, in case of MT (mobile terminatedmessage), until the satellite coverage is available and the UE is connected to the network. This is when the stored messages are sent to the UE. Same goes for MO [12] (mobile originated) messages where UE messages are stored until the connection is established with the ground network (gateway) and messages can be delivered to the appropriate AF. Since the stored messages have to be read by the network entity at run time the format and the composition, needed to enforce the S&F delivery policies, of the stored message need to be defined.

#### 5.3.1.2 Potential requirements

**REQ-SNF-REQ-01:** The 3GPP management system should enable an authorized MnS consumer to configure the limitations to the size/amount of data that can be sent from the UE to the ground station.

**REQ-SNF-REQ-02:** The 3GPP management system should enable an authorized MnS consumer to the size/amount of data that can be sent from the ground station to the UE.

NOTE: The above requirement is not for a specific UE but for all the connected UE to the satellite.

**REQ-SNF-REQ-03:** The 3GPP management system should enable an authorized MnS consumer to configure the forwarding priority for the stored data to the ground station.

**REQ-SNF-REQ-04:** The 3GPP management system should enable an authorized MnS consumer to configure the forwarding priority for the stored data to the UE.

NOTE: The above requirement is not for a specific UE but for all the connected UE to the satellite.

**REQ-SNF-REQ-05:** The 3GPP management system should enable an authorized MnS consumer to configure the data retention period.

**REQ-SNF-REQ-06:** The 3GPP management system should enable an authorized MnS consumer to configure the acknowledgement policy for both MO and MT messages.

**REQ-SNF-REQ-07:** The 3GPP management system should enable an authorized MnS consumer to configure the estimated time to deliver the messages to the UE.

NOTE: The above requirement is not for a specific UE but for all the connected UE to the satellite.

**REQ-SNF-REQ-08:** The 3GPP management system should enable an authorized MnS consumer to configure the estimated time to deliver the messages to the ground station.

**REQ-SNF-REQ-09:** The 3GPP management system should enable an authorized MnS consumer to configure the elements of network on the ground to support the S&F functionality of a satellite.

#### 5.3.1.3 Potential solutions

##### 5.3.1.3.1 Potential solution #<1>: Store and Forward configuration and storage

Define a new IOC (S&FConfigInfo) containing information related with generic S&F configuration for the satellite. This will include the following:

 Date retention period: duration for which the data should be stored before it gets discarded.

 Storage quota:

o Per UE (MO): This will define the total storage quota assigned to a single UE.

o Per AF (MT): This will define the total storage quota assigned to a single AF.

 Estimated delivery time:

o MO delivery time to AF

o MT delivery time to UE

 Acknowledgement available:

o MO acknowledgement: Yes/No – If the value is YES, Onboard-NF will provide acknowledgement to UE after receiving the MO message.

o MT acknowledgement: Yes/No - If the value is YES, Onboard-NF will provide acknowledgement to AF after receiving the MT message.

 Forwarding priorities (to UE and AF):

o First come first forwarded: This will imply that the messages received first will be delivered first to UE and AF in MT and MO respectively.

o AF (MO) based priority: Various AF can be provided with the priorities. This will imply that the messages received for a higher priority AF will be delivered first. This can be implemented with a list of AF's FQDN in the chronological order of their priorities.

o UE (MT) based priority: Various UE can be provided with the priorities. This will imply that the messages received for a higher priority UE will be delivered first. This can be implemented with a list of UE identifier (IMSI, IMEI, Anonymous id e.g. C-RNTI, etc.) in the chronological order of their priorities.

**Procedure flow (S&F Configuration)**



Figure 5.3.1.3.1-1 S&F Configuration

1. Operator decides for a Onboard-NF to support S&F mode of operation based on some local policies and service contracts.

2. Consumer send a createMOI request for SatelliteInfo IOC. The SatelliteInfo IOC will contain information related with ephemeris, S&F mode of operation.

3. The producer configures the information. Since the GNBCUCPFunciton has a direct association with NTNFunciton, it will have the information contained in all the child MOI i.e. SatelliteInfo.

4. The producer send the response indicating the successful configuration

Define a new IOC (e.g. S&FStorageInfo) containing information related with generic S&F storage management for the satellite. This will include the following:

 StoreMessages: Total number of stored messages.

 StoredMesssageRecord

o Message Name: Standardized message name as defined in 5GS.

o Provided parameters: Name (standardized parameters name as defined in S5S) value pair for each provided parameter.

o Originator: Destination for the stored message (UE or AF).

o Destination: Destination for the stored message (UE or AF).

o Received Time: Time stamp indication the time at which the message was received.

o Message Size: Total size of the message in bits.

 StoreAndForwardInfoRef: Reference to the S&F configuration that should apply to the delivery of this message.

**Procedure flow (S&F Storage Configuration)**



Figure 5.3.1.3.1-2: S&F Storage Configuration

1-4. The NTN configuration is done.

5. At some future point of time, UE successful gets connected to the Onboard-NF configured with the S&F mode of operation.

6. The UE send some messages destined for a particular AF.

7. The Onboard-NF will enforce all polices and restriction as per the S&FConfigInfo instantiated before.

8. As per the acknowledgement policy, Onboard-NF may provide acknowledgement for the received message.

9. As per the S&F mode of operation, all the messages received get stored in a S&D DB. The message will be stored according to the information created as part of S&FStorageInfo.

10. Satellite establishes connection with ground station

11. Based on the forwarding policies, Onboard-NF forward messages to the appropriate AF.

Alternate to MO message handling (step 5-11), for MT message handling the following steps are taken

12. At some future point of time, AF successful gets connected to the Onboard-NF configured with the S&F mode of operation.

13. The AF send some messages destined for a particular UE.

14. The Onboard-NF will enforce all polices and restriction as per the S&F ConfigInfo instantiated before.

15. As per the acknowledgement policy, Onboard-NF may provide acknowledgement for the received message.

16. As per the S&F mode of operation, all the messages received get stored in a S&F DB. The message will be stored according to the information created as part of S&F StorageInfo.

17. Satellite establishes connection with UE

18. Based on the forwarding policies, Onboard-NF forward messages to the appropriate UE.

NOTE: Although the solution proposes Onboard-NF to store the messages, the actual entity storing the SnF messages need to be further confirmed as per the discussions in other working groups.

#### 5.3.1.4 Evaluation of potential solutions

Only one solution is proposed. The solution fulfils all requirements. It is recommended to normatively define the solution as part of normative work. The solution assume that the configurations, done as part of Step 3, are always successfully. The normative work shall consider defining the behaviour when the configuration are not successful.

### 5.3.2 Use case #2: Distinguish which network elements support Store and Forward Satellite operation

#### 5.3.2.1 Description

The Store and Forward Satellite (S&F) operation aims to offer communication service to UEs within satellite coverage experiencing intermittent or temporary satellite connectivity. Satellites that support S&F operation may not have both available feeder link and service link connections simultaneously, which has a significant impact on the existing attach procedure, and the services that can be provided in this mode are very limited.

From the operator's perspective, it is necessary to enhance the configuration of the network elements on-board satellite to indicate whether S&F operation can be supported or not. For example, 3GPP management configures an additional parameter, e.g. an S&F indication, in the eNB to indicate whether this eNB supports S&F operation or not.

#### 5.3.2.2 Potential requirements

**REQ-SNF-REQ-1:** The 3GPP management system should be able to configure the RAN node or CN node to indicate whether it supports S&F operation.

#### 5.3.2.3 Potential solution

##### 5.3.2.3.1 Potential solution #<1>: Configuration of the eNB to indicates whether it support S&F operation or not

This is a candidate solution to address the REQ-SNF-REQ-1.

This solution proposes to add new attributes or IOCs that required to be presented when the eNB supports S&F operation. It may contain the following attributes:

- New attribute called "snFSuportInd " can be defined in the ENBFunction IOC to indicate whether this function supports S&F operation or not.

- New attribute called "snFInfoSet" can be defined in the ENBFunction IOC or EUtranGenericCell IOC to describe the specific information that needs to be broadcast by eNB supported S&F operation, e.g. snFSuportInd may be an attribute in the data type of this new attribute.

NOTE: This solution needs to align with RAN WG3 and SA WG2.

##### 5.3.2.3.2 Potential solution #<2>: Configuration of the MME to indicates whether it support S&F operation or not

This is a candidate solution to address the REQ-SNF-REQ-1.

This solution proposes to add new attributes or IOCs that required to be presented when the MME supports S&F operation. It may contain the following attributes:

- New attribute called "snFSupportInd " can be defined in the MMEFunction IOC to indicate whether this function supports S&F operation or not.

- New attribute called "snFEphemerisInfo" may be defined in the MMEFunction IOC to support MME determining the wait-timer and list of satellite ID to be provided to UE. The data type of this new attribute represents the S&F satellite ephemeris related information, e.g. snFSatelliteId which represents the identification of the satellite that supports S&F operation and locationInfo which represents the coverage information for a satellite that support S&F operation as defined in TS 28.541 [13] clause 5.3.188.

NOTE: This solution needs to align with RAN WG3 and SA WG2.



Figure 5.3.2.3.2-1: procedure of S&F operation related configuration

1. Operator decides for a MME to support S&F operation based on some local policies and service contracts.

2. MnS consumer requests to create or modify the MOI to support the S&F operation.

#### 5.3.2.4 Evaluation of potential solutions

The possible solutions described in clause 5.3.2.3 adopt the NRM-based approach, which enhance the existing NRM fragment with new conditional attributes indicating whether these functions support S&F operation or not, and the information needed by eNB supported S&F operation to broadcast, and the information needed by MME supported S&F operation to determine specific information for UE, the change is lightweight and it is backward compatible, therefore it is a feasible solution.

## 5.4 UE-Satellite-UE communication

### 5.4.1 Use case #1: UPFs on-board the satellites

#### 5.4.1.1 Description

SA2 R19 work has specified the requirement for architectural enhancements, including core network functions on-board satellite, to support new communication mode or service, such as UE-Satellite-UE. This introduces new management requirements, for example, when UPF on-board satellite and SMF on the ground, the N4 associations change frequently. So, the UPF and/or SMF need to know when to establish and release the N4 associations with which SMF and/or UPF. Another example, to support UE-satellite-UE communication, 3GPP management system configures indication information (i.e. indicates whether UPF is on-board satellite or not) enabling the SMF to know which UPF is on-board satellite. Thus, the UPF on-board satellite is selected to keep user plane traffic remain in the satellites.

#### 5.4.1.2 Potential requirements

**REQ-UE-SAT-UE-1：**3GPP management service producer should have the capability to configure the associations between UPF on-board satellite and SMF on the ground.

**REQ- UE-SAT-UE-2：**3GPP management service producer should have the capability to configure the UPF or SMF enabling the SMF to know which UPF is on-board satellite.

#### 5.4.1.3 Potential solutions

##### 5.4.1.3.1 Potential solution #<1>: Configuration of the UPF indicates whether the UPF is on-board satellite or on the ground

This is a candidate solution to address the REQ-UE-SAT-UE-1.

This solution proposes to add new attributes or IOCs that required to be presented when the UPF is on-board satellite. It may contain the following attributes:

- Explicitly Indication whether the UPF is on-board satellite or on the ground.

- Deployment information representing the satellite identification of the UPF deployed.

##### 5.4.1.3.2 Potential solution #<2>: Pre-configuration of the N4 interface between SMF and UPF before connections between them are established or lost

This is a candidate solution to address the REQ-UE-SAT-UE-2.

As described in Use case #1, the connections between UPF on-board satellite and SMF on the ground changes frequently, typically because the periodic connecting/disconnecting of the UPF on-board satellite to the gateways. Therefore, this solution proposes to take the connecting/disconnecting of the UPF on-board satellite to the gateways as an event that triggers the 3GPP management to perform configuration operations on the N4 interface.

The solution addresses the scenario where the UPF on-board satellite is connected to one or more gateways simultaneously during a given period, and the SMF on the ground associated with the gateway can be different or the same. Figure 5.4.1.3.2-1 shows an example deployment scenario.

- Case I: UPF connects to the same SMF via a different gateway (e.g. UPF connects SMF 3 via Gateway 2 or Gateway 3).

- Case II: UPF connects to a different SMF via a different gateway (e.g. UPF connects SMF 2 via Gateway 2).

The attribute in the EP\_N4 indicating the UPF address will have different values if the connection between UPF and SMF is via the different gateway.



Figure 5.4.1.3.2-1 Example scenario of connections between UPF on-board satellite and SMF.

The 3GPP management system creates multiple EP\_N4 instances to handle the multiple connectivity links between UPF on-board satellite and SMF on the ground, and adds new attributes representing the connection availability duration information in EP\_N4 IOC.

Before the connection between UPF on-board satellite and gateway is lost, the 3GPP management system may removes/modifies the EP\_N4 instances and removes/modifies the relevant connection availability duration information.

The connection availability duration information is a list that provides the time when the UPF has a connection to a SMF and the time when the connection is disconnected.

##### 5.4.1.3.3 Potential solution #<3>: Pre-configuration based on single time window

The solution for NTN pre-configuration based on single time window can refer to description in clause 5.1.1.3.5.

In this use case, different instances of EP\_N4 can be associated to different time windows which reflects to their valid duration.

#### 5.4.1.4 Evaluation of potential solutions

For REQ-UE-SAT-UE-1, the Potential solution #<1> described in clause 5.4.1.3.1 adopts the NRM-based approach, which enhances the existing NRM fragment with new conditional attributes indicating whether this functions are on board the satellite and related deployment information, the change is lightweight and it is backward compatible, therefore it is a feasible solution.

For REQ-UE-SAT-UE-2, the Potential solution #<2> described in clause 5.4.1.3.2 adopts the NRM-based approach, which enhances the existing NRM fragment with new conditional attributes timewindow indicating the availability duration information of N4 connection.

Potential solution #<3>:

- Pros:

o No backward compatibility issues.

o Minimizes the configuration complexity and brings an overall pre-configuration to catch a global view of all valid MOIs within a single instance for a time window, which can avoid the modification on all existing NRMs that are related to NTN scenario.

It is recommended to take potential solution #<3> as baseline for normative work.

### 5.4.2 Use case #2: MEC deployed on the satellite

#### 5.4.2.1 Description

Mobile Edge Computing (MEC) migrates computing, storage, and service capabilities to the mobile network edge, enabling 5G networks to meet edge application service requirements such as high bandwidth, low latency, and high reliability.

In order to solve the problems of satellite link transmission delay and reduce the backhaul bandwidth, MEC server can be deployed on the satellite, so that the satellite has the capabilities of calculation and content distribution, and can process the service requests from the ground mobile users, which can not only effectively reduce service transmission delay of the satellite-to-earth link, but also effectively save the service data transmission bandwidth of the satellite-to-earth link. MEC deployment in the satellite is suitable for services with low mobility requirements but high latency requirements, in addition, for remote users without the support of ground network communication facilities can directly offload data to the satellite for processing.

The scenarios about edge computing via UPF deployed on the satellite is described in clauses 5.43 of TS 23.501 [1]. When the UE is accessing gNB deployed in satellite, the AMF selects special SMF which supports specific DNAI, the SMF can select the UPF deployed on the GEO satellite and enable PDU Session Establishment with PSA UPF on the satellite during the PDU Session Establishment procedure as described in TS 23.502 [2].

The 3GPP management system should manage the MEC deployed on the satellite, e.g. the deployment of the edge components and provisioning of the edge components, and also need to configure necessary flow diversion policy and user plane selection information, e.g. specific DNAI related with the UPF deployed on the satellite for the 5GC elements, e.g. AMF, SMF, which is used to find and select the UPF deployed on the satellite to complete the PDU session establishment.

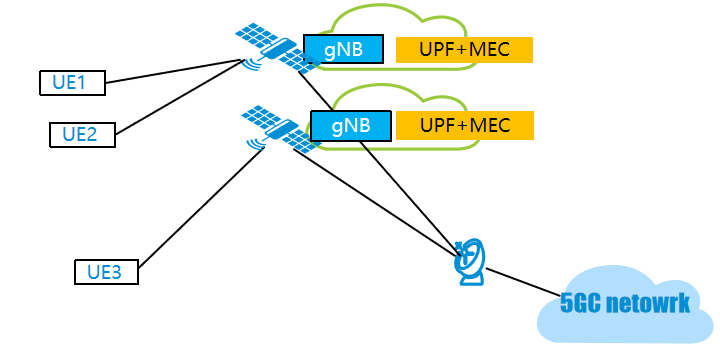


Figure 5.4.2.1-1: MEC deployed on the satellite

#### 5.4.2.2 Potential requirements

**REQ \_MECOS\_CON-1** The 3GPP management system should be able to manage the MEC deployed on the satellite, e.g. the deployment and provisioning of the edge components.

**REQ \_MECOS\_CON-2** The 3GPP management system should be able to configure the user plane selection information and flow diversion policy for the 5GC elements, e.g. SMF to support PDU session establishment procedure using the UPF deployed on the satellite.

#### 5.4.2.3 Potential solutions

##### 5.4.2.3.1 Potential solution #<1>: Configuration of UPF and EASDF to indicate deployment on satellite

For REQ \_MECOS\_CON-1，this solution proposes to add new attributes or IOCs that required to be presented when the UPF is on-board satellite. It may contain the following attributes:

- Explicit indication of whether the UPF or EASDF is deployed on a satellite or on the ground.

- Satellite identification information representing the satellite on which the UPF or EASDF is deployed.

For REQ \_MECOS\_CON-2，the existing UPF selection solution for deployment on the satellite can be reused.

#### 5.4.2.4 Evaluation of potential solutions

For REQ \_MECOS\_CON-1, the potential solution described in clause 5.4.2.3 adopts the NRM-based approach, which enhances the existing NRM fragment with new conditional attributes indicating whether this functions are on board the satellite and related deployment information, the change is lightweight and it is backward compatible, therefore it is a feasible solution.

For REQ \_MECOS\_CON-2，the existing NRM approach can be reused.

## 5.5 Management of secure connections in a non-terrestrial network

### 5.5.1 Use case #1: Connectivity between non-terrestrial network node and security gateway

#### 5.5.1.1 Description

In a 3GPP network Radio Access Network (RAN) nodes such as eNodeB and gNodeB are deployed in cell sites which are typically part of an untrusted network domain. By contrast, core network (CN) nodes are deployed in a trusted domain. These two network domains are logically and physically separated by means of Security Gateways (SEG) as defined in 3GPP TS 33.501 [15]. The communication between the domains, including the network management traffic, should be secured and is carried over a logical connection referred to as the 'backhaul'.

In ground based terrestrial networks the connectivity between RAN nodes and SEG is based on physical connectivity. As a result the underlying IP network design seldom changes, and the logical connectivity between the RAN nodes and SEG remains relatively stable.

However, in airborne Non-Terrestrial Networks (NTN) the connectivity between RAN nodes and SEG is not stable since the RAN nodes are moving. E.g. a satellite in LEO, MEO or GEO orbit. A non-terrestrial node provides a service link and relies on a feeder link to communicate with other nodes comprising the NTN, including the SEG.

As NTN nodes move the availability of terrestrial connectivity is subject to change. This has potential impact to the security associations between the NTN node, SEG and CN.

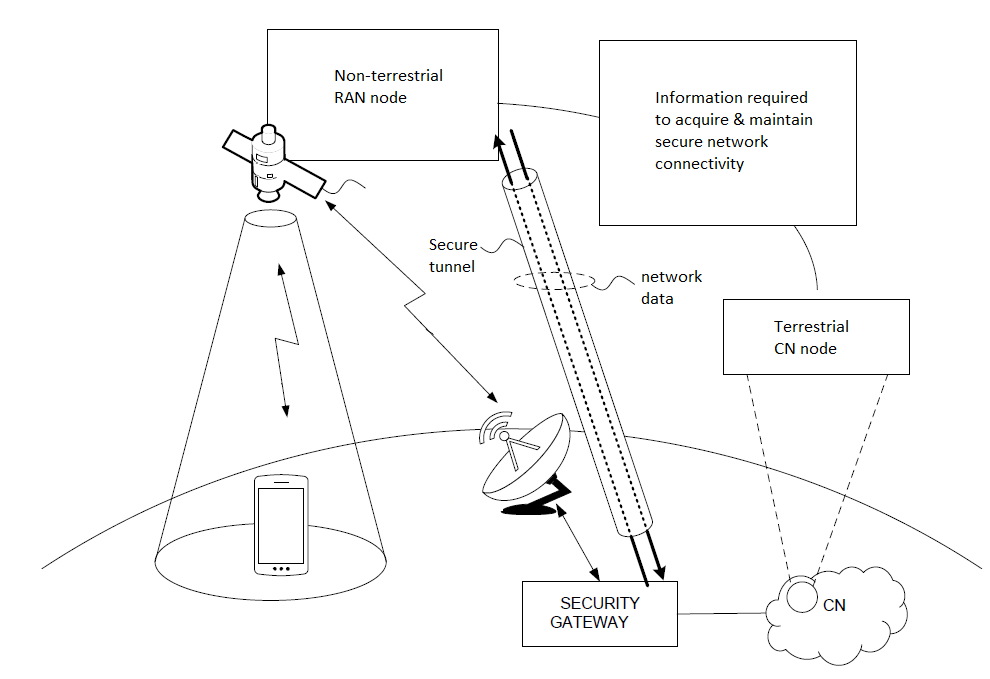


Figure 5.5.1.1-1 Secure connectivity between non-terrestrial RAN node and terrestrial CN node(s)

As NTN nodes move their security associations should be updated subject to the availability of new terrestrial connectivity to a new SEG. In some cases, such SEG transitions may be able to be performed in anticipation of the upcoming feeder link update (i.e. "make then break") whereas in others the new connectivity may not be available in advance (i.e. "break then make"). Both scenarios should be supported, and different information may be required to setup and maintain the secure associations subject to which security protocols and features are configured.

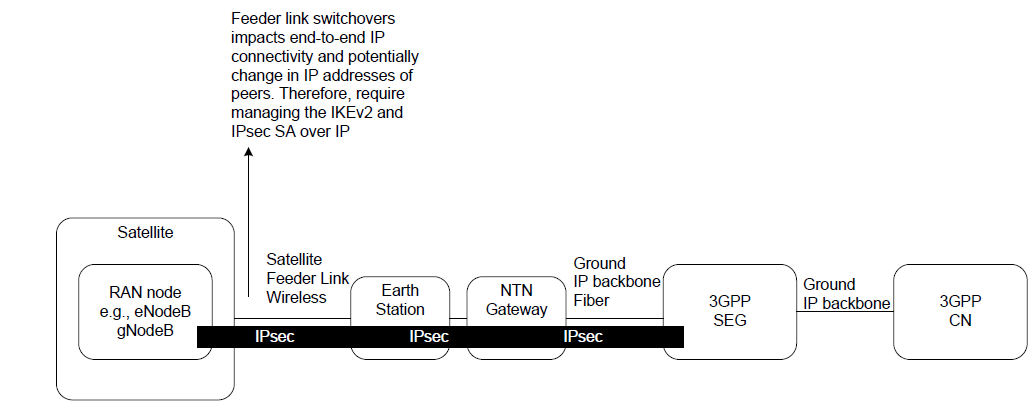


Figure 5.5.1.1-2 Impact of feeder link switchover between NTN node, SEG and CN

The IP configuration requires correlation with the state of connect/disconnect of the IP link itself. For example, for satellite based NTN node the following may need to be considered:

o satellite may only ever connect to ground stations allowed by policy. As a result, when the satellite moves out of ground station's catchment location, it loses the ground connectivity via the feeder link and the IP transport during such period, and then reestablishes the IP connectivity.

o when the satellite orbit is passing over the earth surface (e.g. oceans, mountains, deserts, forests etc.) where there is no ground station and supporting infrastructure, the satellite may by-design route data over to Inter Satellite Link (ISL) to other satellites that may have connectivity with the ground infrastructure over a feeder link, but the ground infrastructure may reside in jurisdiction not permitted by regulations.

To further ensure the security associations are maintained, additional information should also be made available to the NTN node about the anticipated terrestrial connectivity based on criteria such as flight path and/or time windows.

Summary: Movement of the NTN nodes means the backhaul connection should traverse multiple feeder links and its security associations should be maintained throughout lifecycle phases of IP connectivity. As a result, NTN nodes require information not only to setup the initial secure communications channel, but to maintain such communications as the NTN moves.

#### 5.5.1.2 Potential requirements

**REQ-NTN-PnC-1：**IP configuration data shall be configured for the secure communications channel association between RAN nodes on-board satellite and SEG.

**REQ-NTN-PnC-2：**IP configuration data shall be updated when transitioning between terrestrial networks, to ensure the secure association between NTN node and SEG.

**REQ-NTN-PnC-3：**IP configuration data shall be maintained at NTN node independent of feeder link availability.

#### 5.5.1.3 Potential solutions

##### 5.5.1.3.1 Potential solution #<1>: Pre-configure security association data in NTN satellite node

Pre-configure the anticipated feeder link switchovers and satellite handovers in advance based on the 'flight path'.

Flight path information can be used as input to the network management system to create configuration data for the RAN nodes hosted on-board satellites. Specifically, time windows can be derived that provide the anticipated connectivity between each NTN node and ground infrastructure via feeder link(s).

Each time window includes start time, end time, and the configuration required to establish/maintain secure communications with SEG during that period. Time windows may overlap in the event multiple connectivity options exist for a given period. Such overlaps can be leveraged to help ensure seamless connectivity.

At least 1 entry needs to be provided to allow each NTN node to perform initial connection to terrestrial network.

Once configured, the appropriate data is applied to its respective NTN node.

Within each NTN node the information is used to define triggers to automate the setup and maintenance of the secure connectivity, including:

- time window start: trigger for IP configuration each time IP connection is available.

- time window end: trigger to anticipate when the IP connection is about to disconnect.

- time window overlaps: trigger to allow configuring the new IP configuration in advance of losing the current connection.

- time window gaps: trigger to adjust secure IP connection configuration before potential disruption to IP connectivity.

Changes to terrestrial network may require the NTN data also be updated. Periodic checks for such changes could also occur as triggered events based on the NTN data, however it may be better to perform such maintenance from the network management system to minimize disruptions to terrestrial connectivity.

##### 5.5.1.3.2 Potential solution #<2>: Pre-configuration based on single time window

The solution for NTN pre-configuration based on single time window can refer to description in clause 5.1.1.3.5.

In this use case, different IP configuration data can be associated to different time windows which reflects to their valid duration.

#### 5.5.1.4 Evaluation of potential solutions

The potential solution #<1> described in clause 5.5.1.3.1 adopts pre-configure the anticipated feeder link switchovers and satellite handovers in advance and related time window information is used to define triggers to automate the setup and maintenance of the secure connectivity, the change is lightweight and it is backward compatible.

Potential solution #<2>

- Pros:

o No backward compatibility issues.

o Minimizes the configuration complexity and brings an overall pre-configuration to catch a global view of all valid MOIs within a single instance for a time window, which can avoid the modification on all existing NRMs that are related to NTN scenario.

It is recommended to take potential solution #<2> as baseline for normative work.

# 6 Conclusions and recommendations

The present technical report has identified use cases, requirements, and solutions for 3GPP management system to support the integration of satellite into 3GPP network (including the 5GC/EPC and NG-RAN/E-UTRAN). Clause 4 described concepts, backgroud, overview and management relationship between 3GPP management system and regenerative satellite components. Corresponding management capabilities were identified for satellite access by considering a wide range of relevant use cases along with corresponding potential requirements and possible solutions as documented in clause 5. In clause 5, around 12 use cases, along with their corresponding potential requirements and possible solutions have thus far been documented.

Moving on towards the normative specification development phase, it is recommended to consider the following aspects for normative work:

- Specify management requirement, use case and solution to support connections and associations between satellite and ground systems

- Specifying management requirement, use case and solution to support enhancement for NTN-TN and NTN-NTN mobility coordination

- Specifying management requirement, use case and solution to support Store and Forward (S&F) satellite operation

- Specifying management requirement, use case and solution to support UE-Satellite-UE communication

- Specifying management requirement, use case and solution to support secure connections in a non-terrestrial network

Annex A (informative):  
Example on satellite constellations and Quasi-Earth fixed cell planning

According to 3GPP RAN TS 38.304, clause 3.1, the following NTN cell types are defined.

***Earth-fixed cell:*** *An NTN cell fixed with respect to a certain geographic area on the earth all the time. It can be provisioned by beam(s) continuously covering the same geographical areas all the time (e.g., the case of GSO satellites).*

***Quasi-Earth fixed cell:*** *An NTN cell fixed with respect to a certain geographic area on the earth during a certain time duration. It can be provisioned by beam(s) covering one geographic area for a limited period and a different geographic area during another period (e.g., the case of NGSO satellites generating steerable beams).*

***Earth-moving cell:*** *An NTN cell moving on the ground. It can be provisioned by beam(s) whose coverage area slides over the Earth surface (e.g., the case of NGSO satellites generating fixed or non-steerable beams).*

The O&M requirements for Non-Terrestrial Network are stated in 3GPP TS 38.300 clause 16.14.7:

*The following NTN related parameters shall be provided by O&M to the gNB providing NTN access:*

*- …*

*- Additional information to enable gNB operation for feeder/service link switch overs.*

*NOTE 2: The NTN related parameters provided by O&M to the gNB may depend on the type of supported service links, i.e., Earth-fixed, quasi-Earth-fixed, or Earth-moving.*

For LEO satellite constellations, a OneWeb/Iridium like model with 720 satellites is shown according to the left figure below with inclination equals to 89.7 degrees, number of orbital planes equals to 18 and satellite per orbital plane equals to 40, according to research paper:

<https://www.researchgate.net/publication/336447729_Fault-Free_Integrity_Analysis_of_Mega-Constellation-Augmented_GNSS>

NOTE: For a satellite orbiting the Earth, orbital inclination measures the tilt of the satellite's orbit around the earth. It is expressed as the angle between Equator plane and the orbital plane of the satellite..

Figure A-1 (left) Example on satellite constellation   
(middle) Example on satellite constellation coverage and their orbits   
(right) Example on earth-fixed-footprint using a Goldberg polyhedron for cell planning

An insight that can be found with such constellation is that the density of satellite differs between different part of the earth surface. E.g. in Oneweb case, the satellite density at the polar area is much higher than at the area around equator. It is illustrated in the middle figure above, originated from Iridium video published on YouTube:

<https://www.youtube.com/watch?v=Xjig4NBAPZQ&t=20s>

The right figure above illustrates a Goldberg polyhedron with 7292 faces generated through:

<https://levskaya.github.io/polyhedronisme/?recipe=tdtdtdtdtdtI&palette=%23ffffff>

This polyhedron can be used for simple quasi-earth fixed cell planning, where each polyhedron face corresponds to one earth-fixed footprint. During the planning process, the following aspects needs to be taken into consideration:

- PCI code of the neighboring cells

- Tracking area planning over the earth surface

- Optional: Multiple cell layers on the same footprint used for conditional handover

- Time when each quasi-earth fixed cell is active

- Which gNB-in-space is serving which quasi-earth fixed cell in different time.

Due to NGSO properties and satellite density variation of the satellite constellation, the consequence is that the set of quasi-earth-fixed cells which each satellite gNB is responsible for will differ over time in terms of amount of cells as well as cell shape/size and configuration.

Annex B (informative):

## B.1 NTNTimeBasedConfig diagram

@startuml

hide empty members

skinparam ClassStereotypeFontStyle normal

hide circle

skinparam class {

BackgroundColor White

ArrowColor Black

BorderColor Black

}

skinparam linetype ortho

'skinparam BoxPadding 40

skinparam nodesep 2

class NTNFunction <<InformationObjectClass>>

class NTNTimeBasedConfig <<InformationObjectClass>>

class ManagedNTNEntity <<ProxyClass>>

NTNFunction "1" \*-- "\*" NTNTimeBasedConfig: <<names>>

NTNTimeBasedConfig "\*" <--> "\*" ManagedNTNEntity

note right of ManagedNTNEntity

Represents the folllowing IOCs:

EP\_NgC,

EP\_N2,

EP\_N4,

NRCellCU,

NRCellDU,

NRSectorCarrier,

SectorEquipmentFunction,

NRCellRelation

end note

@enduml

Annex C (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2024-04 | SA5#154 | N/A | - | - | - | Initial skeleton | 0.0.0 |
| 2024-04 | SA5#154 | S5‑242105 |  |  |  | pCR TR 28.874 Add Structure | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242106 |  |  |  | pCR TR 28.874 Add scope | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242107 |  |  |  | pCR TR 28.874 Add concepts and background of assumptions | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242108 |  |  |  | pCR TR 28.874 Add concepts and background | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242109 |  |  |  | Rel-19 pCR 28.874 Store and forward | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242111 |  |  |  | Rel-19 pCR TR 28.874 Add use case on 5G system functions on board the NTN | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242112 |  |  |  | Rel-19 pCR TR 28.874 New NTN study issue and use cases | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242113 |  |  |  | pCR TR 28.874 Add use case to support management of Core Network Function(s) on-board satellite(s) | 0.1.0 |
| 2024-04 | SA5#154 | S5‑242114 |  |  |  | pCR TR 28.874 New Use Case on NTN neighbour cell management | 0.1.0 |
| 2024-06 | SA5#155 | S5‑242846 |  |  |  | pCR TR 28.874 Add references | 0.2.0 |
| 2024-06 | SA5#155 | S5‑242847 |  |  |  | pCR TR 28.874 Update concepts and background | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243290 |  |  |  | pCR TR 28.874 Use case on MEC deployed on the satellite | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243291 |  |  |  | pCR 28.874 Add potential solutions for Management of connections and associations between satellite and ground systems | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243292 |  |  |  | pCR TR 28.874 Add use case on NTN Tracking area management | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243293 |  |  |  | pCR TR 28.874 Add definitions and terms | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243294 |  |  |  | pCR TR 28.874 Add use case of MBS broadcast service management | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243295 |  |  |  | pCR 28.874 Add potential solution for Management of connections between RAN node on-board satellite and AMF (regenerative mode) | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243296 |  |  |  | pCR TR 28.874 Add use case, requirements and solution for secure backhaul | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243297 |  |  |  | pCR 28.874 Add potential solution for Management of connections between UPF on-board satellite and SMF | 0.2.0 |
| 2024-06 | SA5#155 | S5‑243298 |  |  |  | pCR 28.874 Add new use case and requirement for S&F | 0.2.0 |
| 2024-08 | SA5#156 | S5‑243703 |  |  |  | pCR TR 28.874 Definitions | 0.3.0 |
| 2024-08 | SA5#156 | S5‑243704 |  |  |  | pCR TR 28.874 Clarifications | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244789 |  |  |  | pCR TR 28.874 Solution for NTN neighbour cell management | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244791 |  |  |  | pCR TR 28.874 Add abbreviations | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244792 |  |  |  | pCR TR 28.874 Add potential solution for MBS broadcast service management | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244793 |  |  |  | Rel-19 pCR 28.874 SnF Solution | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244794 |  |  |  | Rel-19 pCR 28.874 NRM to support regenerative mode | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244795 |  |  |  | Rel-19 pCR TR 28.874 Add solution on support 5G system functions on board the NTN | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244796 |  |  |  | Rel-19 pCR TR 28.874 Add conclusion for support 5G system functions on board the NTN | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244797 |  |  |  | Rel-19 pCR TR 28.874 Add solution on NTN Tracking area management | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244798 |  |  |  | Rel-19 pCR TR 28.874 Add conclusion for NTN Tracking area management | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244341 |  |  |  | Rel-19 pCR TR 28.874 Update potential solution#2 for addressing the Editor's note | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244799 |  |  |  | Rel-19 pCR TR 28.874 Add evaluation and conclusion for Use Case#1 | 0.3.0 |
| 2024-08 | SA5#156 | S5‑244800 |  |  |  | pCR 28.874-020 Complement potential solutions for Management of connections and associations | 0.3.0 |
| 2024-09 | SA#105 | SP-241134 |  |  |  | Presented at SA#105 for Information | 1.0.0 |
| 2024-09 |  |  |  |  |  | After editHelp cleanup | 1.0.1 |
| 2024-10 | SA5#157 | S5-245331 |  |  |  | pCR TR 28.874 Overview of management enhancement supporting new NTN features | 1.1.0 |
| 2024-10 | SA5#157 | S5-245425 |  |  |  | pCR TR 28.874 Update the Use Case#1 of UE-Satellite-UE communication | 1.1.0 |
| 2024-10 | SA5#157 | S5-246096 |  |  |  | pCR TR 28.874 Add potential solutions on configuration of the NFs supported S&F operation | 1.1.0 |
| 2024-10 | SA5#157 | S5-246092 |  |  |  | Rel-19 pCR TR 28.874 Rapportuer cleanup | 1.1.0 |
| 2024-10 | SA5#157 | S5-246093 |  |  |  | pCR TR 28.874 Add plan management solution for NTN scenarios | 1.1.0 |
| 2024-10 | SA5#157 | S5-246094 |  |  |  | pCR TR 28.874 Evaluation for NTN neighbour cell management | 1.1.0 |
| 2024-10 | SA5#157 | S5-246095 |  |  |  | pCR 28.874-101 Complement potential solutions for Management of connections and associations | 1.1.0 |
| 2024-10 | SA5#157 | S5-246097 |  |  |  | pCR 28874-101 Update evaluations | 1.1.0 |
| 2024-11 | SA5#158 | S5‑247151 |  |  |  | Rel-19 pCR 28.874 Solution Evaluations re-generative mode support NRMS | 1.2.0 |
| 2024-11 | SA5#158 | S5‑247152 |  |  |  | Rel-19 pCR 28.874 Solution Evaluations SnF | 1.2.0 |
| 2024-11 | SA5#158 | S5‑247153 |  |  |  | pCR TR 28.874 Update generic solution of time based configuration for NTN scenarios | 1.2.0 |
| 2024-11 | SA5#158 | S5‑247154 |  |  |  | pCR TR 28.874 Add evaluation for generic solution of time based configuration | 1.2.0 |
| 2024-11 | SA5#158 | S5‑247155 |  |  |  | pCR TR 28.874 Providing NTN gNB supported TAIs to AMF | 1.2.0 |
| 2024-11 | SA5#158 | S5‑246627 |  |  |  | pCR TR 28.874 Correct the description of MO and MT | 1.2.0 |
| 2024-11 | SA5#158 | S5‑246633 |  |  |  | pCR TR 28.874 Add evaluation of potential solution for MBS broadcast service management | 1.2.0 |
| 2024-11 | SA5#158 | S5‑246726 |  |  |  | Rel-19 pCR TR28.874 add potential solution for MEC deployed on the satellite | 1.2.0 |
| 2024-11 | SA5#158 | S5‑247156 |  |  |  | Rel-19 pCR TR 28.874 Update S&F potential solution#2 for addressing the Editor's note | 1.2.0 |
| 2024-11 | SA5#158 | S5‑247157 |  |  |  | Rel-19 pCR TR 28.874 add conclusion and recommendations  Rapp: Change 1 was not implemented due to a clash with Tdoc S5-247154 | 1.2.0 |
| 2024-12 | SA#106 | SP-241614 |  |  |  | Presentation of to SA for Approval | 2.0.0 |
| 2024-12 | SA#106 |  |  |  |  | Upgrade to change control version | 19.0.0 |
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