**3GPP TSG-SA5 Meeting #156 *S5-244405rev1***

Maastricht, The Netherlands, 19 – 23 August 2024

**Source: Ericsson**

**Title: pCR 28.874-020 Complement potential solutions for Management of connections and associations**

**Document for: Approval**

**Agenda Item: 6.19.15**

# 1 Decision/action requested

***Approve the pCR.***

# 2 References

[1] 3GPP TR 28.874-020 Study on management aspects of NTN – Phase 2

# 3 Rationale

The requirements and potential solution for use case #1 and #2 in clause 5.1 are complemented with one more requirement and more potential solutions, particularly for additional dynamic association between gNB and the NTN quasi-earth-fixed cells over time, including replacements of (some of) the Editor’s notes. An Evaluation of potential solutions is also provided.

Additional comment: We suggest to consider renumbering the Use Case numbering from 5.2 onwards, which in the current TR version 0.2.0 restarts from #1, to avoid confusion between the Use Cases in the different clauses 5.x. Alternatively, remove the use case numbers and keep the use case title as the unique label together with the clause number (most common in other TRs, and avoids the issue that related use cases don’t always have consecutive numbers).

# 4 Detailed proposal

# 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 the association between GNBDUFunction and NRCellDU, and the association between GNBCUCPFunction and NRCellCU.

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’s 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 associations between RAN nodes on-board satellite and the 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.

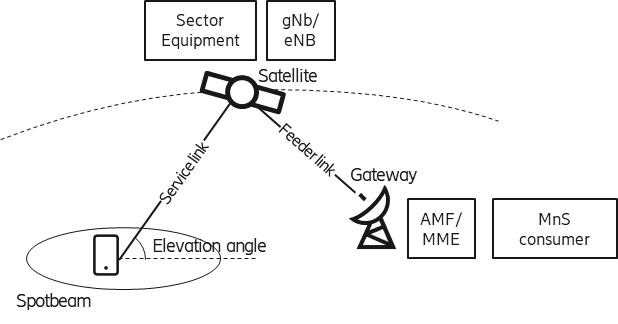


Figure 5.1.1.3.1-1 Location of NTN functions for regenerative eNB/gNB processed satellite payload.

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 replaced by 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 replaced by a 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 replaced by 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 replaced by a list where each list element consists of a FarEndEntity and a timeWindow.

Editor’s Note: This solution needs further consideration and evaluation, especially concerning the complexity and backward compatibility.

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)

1. 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.
2. 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.
3. 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.
4. 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.
5. 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 notificationservice.
6. 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 notificationservice.

##### 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 that triggers the 3GPP management to perform configuration operations on the gNB/eNB and AMF/MME.

Editor’s Note: Notification of a feeder link disconnection towards 3GPP Management system is FFS.

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, the 3GPP management system may removes/modifies 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 a AMF/MME and the time when the connection is disconnected.

##### 5.1.1.3.x 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 all current attributes in NRCellCU are replaced by one single 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. all current attributes in NRCellDU has been replaced by one single 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 5.1.1.3.1-X Sequence diagram of potential solution 3.1**

1. 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.
2. 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 consumercan receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.
3. ProvMnS consumersends, 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.
4. 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.
5. 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.
6. 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.y 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 5.1.1.3.1-Y Sequence diagram of potential solution 3.2**

1. 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.
2. 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.
3. 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.
4. 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.
5. 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 .
6. 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.

#### 5.1.1.4 Evaluation of potential solutions

Potential solution #<1>

* Pros:
  + Minimises the complexity and overhead when configuring all association time windows, as only one instance per association needs to be updated. Also minimises feeder link load as well as satellite CPU load and memory usage.
* Cons:
  + May lead to a potential backward compatibility issue. This could however be avoided with the following approach: Instead of modifying the existing association attributes to a list of associations with time stamps, the new list of association with timestamps can be introduced in a new additional attribute, with a “CO” (Conditional Optional) support qualifier constraint meaning that the new attribute may be supported when the NTN system is supported.

Potential solution #<2>

* Pros:
  + <TBD>
* Cons:
  + <TBD>

Potential solution #<3.1>

* Pros:
  + Minimises the complexity and overhead when configuring all association time windows, as only one instance per association needs to be updated. Also minimises feeder link load as well as satellite CPU load and memory usage.
* Cons:
  + May lead to a potential backward compatibility issue. This could however be avoided with the following approach: Instead of modifying the existing association attributes to a list of associations with time stamps, the new list of association with timestamps can be introduced in a new additional attribute, with a “CO” (Conditional Optional) support qualifier constraint meaning that the new attribute may be supported when the NTN system is supported.

Potential solution #<3.2>

* Pros:
  + Avoids potential backward compatibility issue with the above Potential solutions 1 and 3.1.
* Cons:
  + 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.

### 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’s 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.

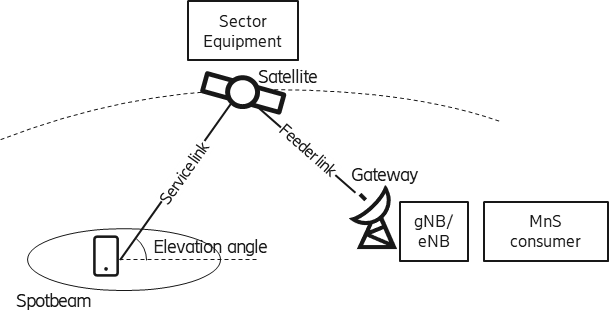
#### 5.1.2.2 Potential requirements

**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 replaced by 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 replaced by 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 replaced by 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.

Editor’s Note: It is not clearly stated that how SectorEquipmentFunction / NRSectorCarrier / Beam / NRCellDU are related to each other, and which of them are located on ground and/or in space. This needs further studies, and the suggestion mentioned in this clause can be seen as one alternative.

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)**

1. 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.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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.x 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.



1. 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.
2. 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.
3. 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.
4. 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.

#### 5.1.2.4 Evaluation of potential solutions

Potential solution #<1>

* Pros:
  + Minimises the complexity and overhead when configuring all association time windows, as only one attribute per association needs to be updated. Also minimises feeder link load as well as satellite CPU load and memory usage.
* Cons:
  + May lead to a potential backward compatibility issue. This could however be avoided with the following approach: Instead of modifying the existing association attributes to a list of associations with time stamps, the new list of association with timestamps can be introduced in a new additional attribute, with a “CO” (Conditional Optional) support qualifier constraint meaning that the new attribute may be supported when the NTN system is supported.

Potential solution #<2>

* Pros:
  + Avoids potential backward compatibility issue with the above Potential solutions 1 and 3.1.
* Cons:
  + 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.