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| 3GPP TR 22.865 V19.2.0 (2023-12) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on satellite access Phase 3;  (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:

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# 1 Scope

The present document describes use cases and aspects related to enhancements of the 5G system over satellite, including:

* Store and Forward (S&F) Satellite operation for delay-tolerant communication service
* UE-Satellite-UE communication
* GNSS independent operation
* Positioning enhancements for satellite access

Potential service requirements are derived for these use cases and are consolidated in a dedicated chapter.

The report ends with recommendations regarding the continuation of the work.

# 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: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.261: "Service requirements for the 5G system ".

[3] 3GPP TR 22.822: "Study on using Satellite Access in 5G".

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# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**direct network connection:** one mode of network connection, where there is no relay UE between a UE and the 5G network.

**emergency report:** in the context of this study, it is a data sent for emergency purpose (e.g., emergency messaging) and can be subject to international regulation.

**indirect network connection:** one mode of network connection, where there is a relay UE between a UE and the 5G network.

NOTE: The above definitions were taken from TS 22.261 [2].

**satellite access**: direct connectivity between the UE and the satellite.

NOTE: This definition was taken from TS 22.261 [2].

**serving satellite**: a satellite providing the satellite access to a UE. In the case of NGSO (Non-Geostationary Satellite Orbit), the serving satellite is always changing due to the nature of the constellation.

**S&F Satellite operation**: in the context of this study, S&F (Store and Forward) Satellite operation is an operation mode of a 5G system with satellite-access where the 5G system can provide some level of service (in storing and forwarding the data) when satellite connectivity is intermittently/temporarily unavailable, e.g. to provide communication service for UEs under satellite coverage without a simultaneous active feeder link connection to the ground segment.

**S&F data retention period:** it is the data storage validity period for the 5G system with satellite access supporting store and forward operation (e.g. after which undelivered data stored is being discarded).

**UE-Satellite-UE Communication**: for the 5G system with satellite access, it refers to the communication between UEs under the coverage of one or more serving satellites, using satellite access without going through the ground segment.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

ISL Inter-Satellite Link

NGSO Non-Geostationary Satellite Orbit

S&F Store and Forward

# 4 Overview

The present document captures a set of use cases and potential service requirements related to the 5G system with satellite access taking into account new capabilities such as:

1. S&F Satellite operation for delay-tolerant communication services: S&F Satellite operation is an operation mode of a 5G system with satellite-access, where the 5G system can provide some level of service (in storing and forwarding the data) when satellite connectivity is intermittently/temporarily unavailable, e.g. to provide communication service for UEs under satellite coverage without a simultaneous active feeder link connection to the ground segment. This is particularly relevant for delay-tolerant IoT services via NGSO space segment.
2. UE-Satellite-UE communication: In some scenarios, UEs need to communicate using satellite access without going to the ground network in order to avoid long delays and limited data rate as well as reducing the consumption of backhaul resources.
3. GNSS independent operation: This would allow to provide satellite access to UEs without GNSS receiver or with no access to GNSS services.
4. Positioning enhancements for satellite access: 3GPP positioning methods are needed in some scenarios for UEs using only satellite access.

In addition, the TR includes several use cases on other aspects, including LAN using satellite access and information collection via satellite connections.

# 5 Use cases

## 5.1 Use case on store and forward - MO

### 5.1.1 Description

This use case illustrates the realization of a S&F service between a UE with satellite access and an Application Server for a delay-tolerant/non-real-time IoT NTN service in the case of a Mobile Originated message.

A description of store and forward operation is provided in Annex A.

Company TrackingInc offers a service of remote monitoring of fields and deploys and tracks many battery-powered IoT type UEs across the globe. All the IoT remote monitoring UEs deployed include a 5G communication with satellite access. Some of the UEs are deployed in a remote area where there is no mobile coverage by MNO and only satellite is possible.

For the satellite access, TrackingInc uses the service of IoTSAT for the 5G IoT connectivity by satellite and IoTSAT uses a LEO constellation which supports S&F operation mode.

All IoT remote monitoring UEs regularly send information related to the area they are monitoring to the application server of TrackingInc and sometimes receive new parameters from the application server. In most of the cases, the messages exchanged are delay-tolerant/non-real-time IoT.

### 5.1.2 Pre-conditions

In the present use case, the IoT remote monitoring UE is in a remote area with no ground stations available for feeder link connectivity and the IoT remote monitoring UE is aware that IoTSAT constellation operates in S&F mode.

### 5.1.3 Service Flows

The IoT remote monitoring UE needs to send a message to the TrackingInc application server. The UE waits for satellite network coverage and sends its message when the satellite passes by.

The IoT remote monitoring UE and the satellite providing coverage interact over the service link, allowing the UE to transfer the message to the satellite, which has no connectivity to the ground segment. And consequently, the satellite has to store locally the received message.

At this point:

* Limitations to the size/amount of data that can be sent from the UE could be enforced.
* Forwarding priority for the stored data to the ground station and data retention period for the exchanged data could be established.
* Acknowledgement of the received data by the satellite could be issued.

At a later time, the satellite with the stored message establishes connectivity with the ground network via a feeder link and relays/forwards/downloads the message to the ground network. All accumulated and stored MO messages are delivered to the ground once the feeder link is available, at the same time, all accumulated and stored relevant MT messages are also delivered to the satellite via the same feeder link, which will impact the performance of the feeder link, 5GC, and satellite significantly. The relevant performance optimization method will be taken into consideration accordingly.

The ground network, based on established connectivity configuration and routing, delivers message to the TrackingInc application server.

### 5.1.4 Post-conditions

The message generated by the IoT remote monitoring UE has been either delivered successfully to the TrackingInc application server without relying on a continuous end-to-end network connectivity path between them or, in case the data retention period has been exceeded, the message has been discarded.

### 5.1.5 Existing features partly or fully covering the use case functionality

3GPP TS 22.261 [2], clause 6.3.2.3 on satellite access includes the following requirements:

*The 5G system shall be able to provide services using satellite access.*

*The 5G system with satellite access shall be able to support low power MIoT type of communications.*

However, it is not sufficient in regards of S&F operation especially for the delivery of delay-tolerant/non-real-time IoT NTN services with NGSO satellites.

### 5.1.6 Potential New Requirements needed to support the use case

[PR 5.1.6-001] The 5G system with satellite access shall be able to support store and forward operation.

[PR 5.1.6-002] The 5G system with satellite access shall be able to inform a UE that "store and forward" operation is applied.

[PR 5.1.6-003] Subject to operator policy, the 5G system with satellite access supporting store and forward operation shall be able to allow the operator or a trusted 3rd party to set and enforce, on a per UE basis, a S&F data retention period.

[PR 5.1.6-004] Subject to operator policy, the 5G system with satellite access supporting store and forward operation shall be able to allow the operator or a trusted 3rd party to set and enforce, on a per UE basis, a S&F data storage quota.

[PR 5.1.6-005] The 5G system with satellite access supporting store and forward operation shall be able to support a mechanism to configure and provision specific required QoS and policies for S&F operation (e.g. forwarding priority, acknowledgment policy).

[PR 5.1.6-006] The 5G system with satellite access shall be able to provide integrity protection and confidentiality for communications between an authorized UE and the network when store and forward operation is applied.

[PR 5.1.6-007] The 5G system with satellite access supporting the S&F operation shall be able to support suitable means to resume communication between the ground station and satellite once the feeder link becomes available.

[PR.5.1.6-008] Subject to operator’s policies, a 5G system with satellite access supporting Store & Forward Satellite operation shall be able to support forwarding of the stored data from one satellite to another satellite, which has an available feeder link to the ground network, through Inter-Satellite Links.

[PR.5.1.6-009] A 5G system with satellite access supporting S&F Satellite operation shall support mechanisms for a UE to register with the network when the network is in S&F Satellite operation.

[PR.5.1.6-010] A 5G system with satellite access supporting S&F Satellite operation, shall support mechanisms to authorize subscribers for receiving services when the network is in S&F Satellite operation.

NOTE: It is assumed that the constellation knows which satellite has a feeder link available. However, this is outside the scope of 3GPP.

## 5.2 Use case on store and forward - MT

### 5.2.1 Description

This use case illustrates the realization of a S&F service between a UE with satellite access and an Application Server for a delay-tolerant/non-real-time IoT NTN service in the case of a Mobile Terminated message.

A description of store and forward operation is provided in Annex A.

Company TrackingInc offers a service of remote monitoring of fields and deploys and tracks many battery-powered IoT type UEs across the globe. All the IoT remote monitoring UEs deployed include a 5G communication with satellite access. Some of the UEs are deployed in a remote area where there is no mobile coverage by MNO and only satellite is possible.

For the satellite access, TrackingInc uses the service of IoTSAT for the 5G IoT connectivity by satellite and IoTSAT uses a LEO constellation which supports S&F operation mode.

All IoT remote monitoring UEs regularly send information related to the area they are monitoring to the application server of TrackingInc and sometimes receive new parameters from the application server. In most of the cases, the messages exchanged are delay-tolerant/non-real-time IoT.

### 5.2.2 Pre-conditions

In the present use case, the IoT remote monitoring UE is in a remote area with no ground stations available for feeder link connectivity and the IoT remote monitoring UE is aware that IoTSAT constellation operates in S&F mode.

### 5.2.3 Service Flows

The TrackingInc application server needs to send new parameters to the IoT remote monitoring UE. Based on the information provided by the network, the application server is aware that the communication with UE is in S&F mode.

The TrackingInc application server message will send new parameters through dedicated messages by conventional means (e.g. IP routing, tunnels) to the network entry-point (e.g. a SCEF, PDN-GW, SMSC), and may provide additional information about the delivery priority, the acknowledgement, etc. to the network.

At this point:

* Limitations on the amount of data to be transferred to the IoT remote monitoring UE could be enforced.
* Forwarding priority to the UE could be established.
* Acknowledgement of the received data by the network could be issued to the application server, possibly with the additional information about the store and forward, e.g. estimated time to deliver the messages.
* End-to-end acknowledgement policy can be established.

The network stores the message until it can be delivered/relayed to a satellite expected to fly over and provide coverage to the destination IoT remote monitoring UE.

When the satellite is connected via the feeder link to the ground network, the message is uploaded into the satellite. All accumulated and stored MT messages are uploaded into the satellite via the feeder link. At the same time, all accumulated and stored MO messages are also delivered to 5GC via the same feeder link, which will cause a performance impact on the feeder link, satellite, and 5GC. It needs a performance optimization method here.When flying over the area that the IoT remote monitoring UE is located, the satellite with the stored message triggers paging over the service link for the UE to connect to the network.

The stored message is delivered/downloaded from the satellite to the IoT remote monitoring UE. Acknowledgment may be requested/issued. Mechanisms to ensure integrity of the delivered information may be in place.

### 5.2.4 Post-conditions

The message generated by the TrackingInc application server has been delivered successfully to the IoT remote monitoring UE without relying on a continuous end-to-end network connectivity path between them.

### 5.2.5 Existing features partly or fully covering the use case functionality

3GPP TS 22.261 [2], clause 6.3.2.3 on satellite access includes the following requirements:

*The 5G system shall be able to provide services using satellite access.*

*The 5G system with satellite access shall be able to support low power MIoT type of communications.*

However, it is not sufficient in regards of S&F operation especially for the delivery of delay-tolerant/non-real-time IoT NTN services with NGSO satellites.

### 5.2.6 Potential New Requirements needed to support the use case

[PR 5.2.6-001] The 5G system with satellite access shall be able to inform a trusted application server whether store and forward operation is applied for communication with a UE.

[PR 5.2.6-002] Subject to operator policy, the 5G system with satellite access supporting store and forward operation shall be able to allow the operator or a trusted 3rd party to set and enforce, on a per UE basis, a S&F data retention period.

[PR 5.2.6-003] Subject to operator policy, the 5G system with satellite access supporting store and forward operation shall be able to allow the operator or a trusted 3rd party to set and enforce, on a per UE basis, a S&F data storage quota.

[PR 5.2.6-004] The 5G system with satellite access supporting store and forward operation shall support a mechanism to configure and provision specific required QoS and policies for S&F operation (e.g. forwarding priority, acknowledgment policy).

[PR 5.2.6-005] The 5G system with satellite access shall be able to provide to a trusted third-party application the information about the store and forward operation applied to a UE (e.g. estimated delivery time to the UE).

[PR 5.2.6-006] The 5G system with satellite access shall be able to provide integrity protection and confidentiality for communications between an authorized UE and the network when store and forward operation is applied.

[PR 5.2.6-007] The 5G system with satellite access supporting the S&F operation shall be able to support suitable means to resume communication between the ground station and satellite once the feeder link becomes available.

## 5.3 Use case on store and forward - Inter-satellite

### 5.3.1 Description

To expand the market of delay-tolerant IoT devices, store and forward operations are necessary to be developed to sustain the user plane data during the feeder link disconnection between the satellite and the terrestrial gateway. Based on the earlier studies [3][4], there are many use cases can be further improved with such mechanisms.

Regardless of scenarios describing a relative static location relationship of a IoT device, a satellite without an available terrestrial gateway (as shown in section 5.1 and 5.2), the serving satellite may change to another one during the time when the feeder link is unavailable. And such unavailable state of feeder link may be caused by the temporary reconstruction or update of terrestrial gateway.

As shown in Figure 5.3.1-1, a mobile IoT device may move from the coverage of one satellite to the other (e.g. containers tracing and tracking), or as shown in Figure 5.3.1-2, a NGSO satellite may fly away and the other one will come and turn to serving a static IoT device. Under such circumstances, the serving satellite may forward the stored user plane date to the next serving satellite through Inter-Satellite Links, and the next serving satellite may help forward the data to the gateway.

Meanwhile, if the feeder link of the next satellite is also unavailable, it will continue the store operation until the recovery of its feeder link. In this way, for every single IoT device, there will be only one satellite for its data storage in the overall satellite system. And the mobile operators will be easier to manage and maintain the data rather than dealing with the separate data which is belong to one device but among different satellites.

Significantly, during the period that the feeder link is unavailable, the serving satellite only stores or forwards (Inter-satellite) the data received from an IoT device which is already able to send data to the application server through the mobile network with satellite access. Because of the disconnection separates the two parts of the mobile network temporarily, the part in the serving satellite will not be able to fulfill common communication procedures and it will refuse any access from an unregistered device.

Furthermore, considering the limited data storage in satellite and the large amount of IoT devices, a maximum storage for each IoT device should be pre-configured based on the application data characteristics, user subscriptions and overall performance of satellite communication system.



Figure 5.3.1-1: Serving satellite change during the feeder link disconnection - IoT device moving



Figure 5.3.1-2: Serving satellite change during the feeder link disconnection - satellite moving

### 5.3.2 Pre-conditions

A delay-tolerant device has a subscription with the terrestrial operator TerrA, and it is tagged on one container for tracing and tracking.

TerrA has agreement with the satellite operator SatA for satellite access.

SatA maintains multiple serving satellites for the satellite access of TerrA’s subscribers all over the world, including Adam and Bob.

### 5.3.3 Service Flows

1. The container will be shipped from the Harbour A to the Harbour B across the Pacific. After the cargo ship leaves the Harbour A, the device can send some packets through the satellite access during the shipping time.

2. Due to some reasons, the feeder link between the serving satellite Adam and terrestrial gateway is interrupted temporarily or couldn’t be used for a time.

3. Based on the configuration of store and forward operations, Adam will go on to receive the packets from the device, and store these packets until the feeder link recovers.

4. However, during the period of feeder link is unavailable, the cargo ship approaches the border of coverage of Adam and will head to the coverage of another satellite Bob. So, based on the movement of the cargo ship, the serving satellite will change.

5. During the period of the change, Adam sends the stored packets to Bob through the inter-satellite link and Bob will forwards the packets to the gateway if its feeder link is available.

6. Particularly, Bob will continue storing the packets if its feeder link is also unavailable.

### 5.3.4 Post-conditions

Those packets will be finally sent to the application server by the network behind the gateway, e.g. transportation network, core network, internet. And the application will parse some information from the packets.

### 5.3.5 Existing features partly or fully covering the use case functionality

3GPP TS 22.261 [2], clause 6.3.2.3 on satellite access includes the following requirements:

*The 5G system shall be able to provide services using satellite access.*

*The 5G system with satellite access shall be able to support low power MIoT type of communications.*

However, it is not sufficient in regards of S&F operation especially for the delivery of delay-tolerant/non-real-time IoT NTN services with NGSO satellites.

### 5.3.6 Potential New Requirements needed to support the use case

[PR.5.3.6-001] Subject to operator’s policies, a 5G system with satellite access shall be able to store data received from authorized UEs using delay-tolerant communication service while the feeder link is unavailable.

[PR.5.3.6-002] Subject to operator’s policies, a 5G system with satellite access shall be able to support forwarding of the stored data received from authorized UEs using delay-tolerant communication service from one satellite to another satellite through Inter-Satellite Links while preserving integrity protection, confidentiality and security of the data.

[PR.5.3.6-003] Subject to operator’s policies, a 5G system with satellite access shall be able to define the maximum amount of data storage per satellite per authorized UEs using delay-tolerant communication service.

[PR.5.3.6-004] The 5G system with satellite access shall be able to authorize the communication of a UE when the satellite access is operating in store and forward mode.

## 5.4 Use case on store and forward - data transfer for IoT devices in remote areas

### 5.4.1 Description

Data transfer at remote sites is a very common requirement. Research institutions can obtain data from remote sites for scientific research, e.g. animal tracking [5]. Government agencies can obtain data from remote sites for disaster mitigation and avoidance, e.g. via remote sensing [6]. Commercial companies can obtain data from remote sites for proper resource allocation. Data transmission at many remote sites is delay-insensitive, and satellite coverage does not always ensure that satellites connect to both the service link and the feeder link. In the past 30 years, many scholars have devoted themselves to studying the data transmission problem of remote sites, and developed the store and forward mechanisms to solve the problem [7][8][9].

In remote areas, there is no terrestrial network for various reasons, e.g. it is difficult to build and maintain communication towers. As a result, this makes it challenging to collect information for environmental protection purposes in these areas. For example, sensors installed on animals need to be monitored regularly. In this scenario, the sensors installed on the animals send the status information, e.g. the movements, physiology and surrounding environment of the animals, to the satellite; and the satellite stores the received status information of the animals, and forwards the information to the scientific centre when a feeder link becomes available.

### 5.4.2 Pre-conditions

EA Science Center has installed sensors (IoT devices) on the animals to collect information for environmental protection purposes in these remote areas. Satelles, the satellite communication operator, has launched the Store & Forward Satellite operation to support the data transferring for the remote areas. EA Science Center has signed contract with Satelles to allow sensors installed on animals to send the status information (e.g. the movements, physiology and surrounding environment of the animals) to the Science Center via satellite.

The satellite and the IoT devices are properly configured with sufficient information, e.g. credential/certificate that is needed for the devices to verify the authenticity of the satellite.

### 5.4.3 Service Flows



Figure 5.4.3-1: Animal tracking in the remote areas

1. The IoT devices are installed on animals and powered on, they are registered with the 5G network for the Store & Forward Satellite operation. The satellite with the store and forward function enables the IoT devices to transfer data to the network, even when the feeder link to the ground is not available. A secured connection between an IoT device and the satellite is established to protect the data security and privacy.

2. The IoT devices send sensor status information to the satellite, the satellite stores the sensor status information received from the IoT devices.

3. When the satellite has the feeder link available to the ground segment, the satellite forwards the sensor status information, as well as other necessary information, to the *ground* core network. The *ground* core network verifies the IoT devices based on the information received; if it is allowed, the *ground* core network forwards the sensor status information to its destination data network.

4. The *ground* core network sends the result of the operation to the satellite (the same satellite or a different one that will pass through the remote area).

5. When the satellite (or next satellite) passes through the remote area, the satellite pages the UE, and based on the result received from *ground* core network, the satellite sends result of the operation to the IoT devices.

6. If an IoT device needs to update the sensor status information, it can send it to the satellite when it is connected to the satellite. The satellite stores it and forwards the sensor status information to the *ground* core network when feeder link becomes available.

### 5.4.4 Post-conditions

After the scientific centre receives the sensor status information, the scientists can analyse the sensor status information, and track the status of the animals.

### 5.4.5 Existing features partly or fully covering the use case functionality

None.

### 5.4.6 Potential New Requirements needed to support the use case

[PR 5.4.6-001] The 5G system with satellite access shall support mechanisms to store user data, received from UEs via satellite access, on the satellite and forward it when feeder link between the satellite and the ground segment is available.

[PR 5.4.6-002] The 5G system with satellite access shall support mechanisms for a user to securely register a UE to use the Store & Forward Satellite operation when satellite connectivity is intermittently/temporarily unavailable.

NOTE: The user could be a human user using a UE with a certain subscription or a third party that is typically a business customer having service level agreement with the operator and interacting with the 5G network via an application server.

[PR 5.4.6-003] The 5G system with satellite access shall support mechanisms to authenticate and authorize a UE for the Store & Forward Satellite operation.

[PR 5.4.6-004] The 5G system with satellite access shall be able to limit the total amount of the stored data received from a UE when using the Store & Forward Satellite operation.

[PR 5.4.6-005] The 5G system with satellite access shall be able to collect charging information per UE for use of the Store & Forward Satellite operation (e.g., data volume, duration, involved satellites).

[PR 5.4.6-006] The 5G system with satellite access shall be able to collect charging information per application for use of the Store & Forward Satellite operation (e.g., number of UEs, data volume, duration, involved satellites).

## 5.5 Use case on LAN using Satellite Access

### 5.5.1 Description

Satellite access networks are designed to ensure ubiquitous coverage and availability to any users with communication need. Beyond wide coverage capabilities, satellite connectivity can add flexibility to the network topology by providing an alternative route through satellite when terrestrial link is unavailable. The integration of satellite system, to compensate for the limitation of terrestrial network will benefit more users with interim but necessary service need.

When scientist-explorers move to the “blink spots” of terrestrial access network networks (e.g. deserts, oceans, polar regions, etc.), they need to keep collecting scientific data during the regional expedition and store it in local Scientific Research Station for analytic, retrieval, and synchronization with remote Scientific Data Center. In such condition, a provisional local area network (LAN) using satellite access could be an option to provide a temporary reliable communication service.

Scientific Expedition Team with tens of explorers and vehicles arrives at Antarctica to start scientific expedition activities in area LocArea for a month as Figure 5.5.1-1 depicts.

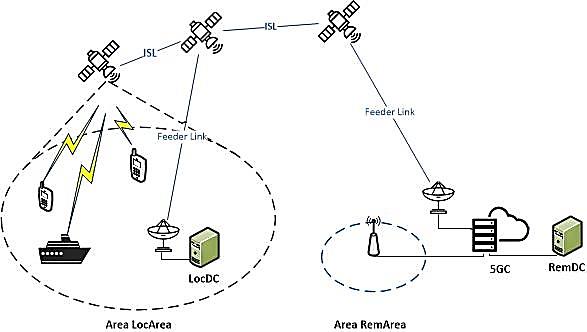


Figure 5.5.1-1: LAN using Satellite Access

In Figure 5.5.1-1, the local Scientific Research Stationequipped with a data center LocDC will support the data analytics and research in LocArea. The remote Scientific Data Center RemDC located in area RemArea served by Terrestrial Operator TerrA, can support the data analytics, as well as retrieve all the data and research results from LocDC in a fixed time every day.

### 5.5.2 Pre-conditions

All UEs of the Team capable of satellite access are the subscribers of TerrA in RemArea.

LocArea has no terrestrial network but covered by satellite-enabled NR-RAN (e.g. LEO) of Satellite Operator SatA.

SatA has an agreement with TerrA to provide 5G network services with the flexible network configuration of satellite and terrestrial elements in LocArea.

RemDC is connected through 5G core network of TerrA.

It’s assumed that UEs can always find serving satellites from the constellation. The serving satellite change is omitted from the flow.

### 5.5.3 Service Flows

Once the explorers settle down in Scientific Research Station, LocDC is provisioned and authorized to connect to 5G core network of TerrA through satellite or ground gateway regarding the management policy agreed by SatA and TerrA.

All UEs of the Team are enabled the corresponding services in LocArea regarding the device setting and subscription information.

During the activities in LocArea, all UE register to TerrA 5G network through SatA’s satellite access network to upload data to LocDC with the optimal route in time.

LocDC can sync up data to RemDC through 5G network configured by SatA and TerrA with the optimal route in each fixed time slot.

When leave LocArea, there are available terrestrial access network of TerrA or other operators in service agreement with TerrA (e.g. roaming, shared network), UEs will be steered to upload data via satellite access to LocDC or terrestrial access network to RemDC regarding the policy.

When LocDC is disconnected from 5G network regarding the original provisioning information, all UE will upload data to RemDC.

### 5.5.4 Post-conditions

Local satellite access network of SatA will be routed to LocDC for data exchange when LocDC is in service.

All the data is successfully transferred between UEs and LocDC, UE and RemDC, LocDC and RemDC.

### 5.5.5 Existing features partly or fully covering use case functionality

Regarding TS 22.261 [2], satellite access and satellite connectivity are supported in Rel-18, as

*The 5G system shall be able to provide services using satellite access.*

*UEs supporting satellite access shall support optimized network selection and reselection to PLMNs with satellite access, based on home operator policy.*

*The 5G system with satellite access shall support the use of satellite links between the radio access network and core network, by enhancing the 3GPP system to handle the latencies introduced by satellite backhaul.*

*The 5G network can also support multiple wireless backhaul connections (e.g. satellites and/or terrestrial), and efficiently route and/or bundle traffic among them.*

As TS 22.261 clause 6.5 illustrates, the requirement of efficient user plane for 5G system with satellite access will be,

* *A 5G system with satellite access shall be able to select the communication link providing the UE with the connectivity that most closely fulfils the agreed QoS.*

### 5.5.6 Potential New Requirements needed to support the use case

[PR 5.5.6-001] Subject to regulatory requirements and operator’s policies, the 5G system with satellite access shall be able to support an efficient communication path and resource utilization for a UE using only satellites access, e.g. to minimize the latencies introduced by satellite links involved.

[PR 5.5.6-002] Subject to regulatory requirements and operator policy, the 5G system with satellite access shall be able to support service continuity when the UE communication path moves between satellite access network and terrestrial access network.

## 5.6 Use case on Information Exchange between Ships at sea

### 5.6.1 Description

Information exchange in the maritime industry is very important [10] [11]. Information exchange allows for better coordination between ships, which is required regardless of the purpose for which ships are sailing. An effective information exchange system can better coordinate the ships and improve the safety of ships, such as resisting pirate attacks, avoiding accidents at sea, and rescuing.

At sea far from land, there is no terrestrial communication system. Ships can communicate directly with each other at short distance through various types of wireless technologies. At long distances, information can only be exchanged through satellites and then through remote data centres, which affects communication efficiency, especially in emergency situations. In addition, in some areas, the satellite has no available feeder link, which causes the communication interruption even though the communicating ships camp on the same satellite. In this scenario, communication between ships through satellites without going via remote data centres can improve communication efficiency and reduce losses caused by potential maritime accidents.

Satellite broadband can be suited to connecting remote areas which do not have reliable mobile or fixed broadband. There are new broadband satellites systems being developed, which use many satellites in a non-geostationary satellite orbit (NGSO) closer to the Earth than earlier satellites. Typically, the beam footprint size of Low-Earth Orbit (LEO) satellites and Medium-Earth Orbit (MEO) satellites is in the range of 100 – 1000 km [12].

### 5.6.2 Pre-conditions

MinosShipping, the shipping company, has many ships operating all over the world. MinosShipping signs a contract with Delphi, an operator with satellite communication services. Delphi has deployed NGSO satellites, which allows communication between ships via satellite without going through the ground network, that is, devices on a ship can communicate directly with devices on another ship via satellite.

### 5.6.3 Service Flows



Figure 5.6.3-1: communication via the same satellite without going through the ground network

1. Device A on ship #1 register with the 5G network via satellite, and device B on ship #2 (small) also register with the 5G network via satellite. The devices A and B can communicate with each other via the 5G network.

2. When the ship #1 and the ship #2 are under the same satellite coverage, the devices A and B want to communicate with each other. The remote core network authorizes the communication between the devices A and B based on e.g., subscription, and location information. After getting authorized, the data traffic between the devices A and B is routed through the same satellite. During the data traffic communication between devices A and B without going through the ground network, if the feeder link becomes unavailable, device A still can have the communication with device B.



Figure 5.6.3-2: communication via satellites with ISL without going through the ground network

3. Along the long journey, ship #1 and ship #2 move across the coverage of different satellites, i.e. ship #2 moves to the coverage of satellite #2 while ship #1 remains in the coverage of satellite #1. Inter satellite link is available between satellite #1 and satellite #2.

4. During the journey, the communication between devices A and B via satellite(s) continues without interruption.

5. The charging information of the traffic data exchanged via the satellites is collected in the satellites and reported to the remote core network.

### 5.6.4 Post-conditions

The ship #1 and the ship #2 can exchange information efficiently without data traffic transferred via the remote core network.

### 5.6.5 Existing features partly or fully covering the use case functionality

None.

### 5.6.6 Potential New Requirements needed to support the use case

[PR 5.6.6-001] The 5G system shall support mechanisms to authorize the communication between UEs using satellite access (without going through the ground network) based on e.g., location information and subscription.

[PR 5.6.6-002] The 5G system shall support mechanisms to collect charging information for the traffic data exchanged using satellite access without going through the ground network.

[PR 5.6.6-003] Subject to regulatory requirements and operator’s policy, the 5G system shall support communication between UEs using satellite access without going through the ground network.

[PR 5.6.6-004] Subject to regulatory requirements and operator’s policy, the 5G system shall maintain service continuity with minimum service interruption of the communication between UEs using satellite access without going through the ground network when a UE changes from the coverage of one satellite to another (due to the movement of the UE and/or the satellites).

[PR 5.6.6-005] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to support UE-Satellite-UE communication when the feeder link is temporarily unavailable.

## 5.7 Use case on the support of UE-satellite-UE phone call

### 5.7.1 Description

Known as the "Lung of the Earth", the Amazon Rainforest locates in the the Amazon Basin of South America, with a total area of 700 million hectares, spanning eight countries, and is the largest and most diverse tropical rainforest in the world. Although the Amazon rainforest is known as a paradise for animals and plants, it is a terrible "forbidden area" for human beings. Lives will be exposed to various dangers if we enter the Amazon rainforest without any preparation.

Vipers, crocodiles, bacteria and viruses, or even swamp can destroy the vulnerable human life. However, many explorers and tourists still step into this land every year. When they get into troubles, the most important thing is that they can communicate with the nearest first-aid station or other teams timely. However, in the deep of the dense primordial forest, there are no modern communication infrastructures and even no power supplies.

The satellite will help conquer such a desperate plight because it can provide timely access for the terminals without any surrounding terrestrial infrastructures. In this way, the injured can find the nearest first-aid station and make a quick phone call. Based on the potential positioning capability of the satellite, the rescue team can also find the position of the injured efficiently.

However, due to the explorers and tourists are always from different countries, they may not belong to only one mobile operator. So they need mechanisms, such as roaming, between different mobile operators’ network even all of them access the same one satellite.

Moreover, some studies show that the ground segment need to be detailed designed and implemented, and there will be a serious dilution of the communication efficiency based on existing mechanisms in both satellite network and mobile network, especially data transferring and switching. So, it will benefit that enhance the capabilities of data processing and switching within the satellites.



Figure 5.7.1-1: Phone call through one satellite without going through ground network

### 5.7.2 Pre-conditions

Ed is an explorer from Country A, and his phone has a subscription with the terrestrial operator TerrA.

Bell is a rescuer working in the Amazon Rainforest, and his phone has a subscription with the terrestrial operator TerrB.

TerrA has roaming agreement with TerrB and TerrB has agreements with the satellite operator SatA for satellite access.

SatA maintains multiple serving satellites for the 5G subscribers all over the world, Amazon Rainforest is one of SatA’s serving areas.

Ed signed up a roaming plan from TerrA for accessing TerrB’s mobile network in case of keeping in touch with others in the Amazon Rainforest.

### 5.7.3 Service Flows

1. Ed is hiking along the planned route in the Amazon Rainforest, with good connection to ground network through satellite access.

2. Suddenly, Ed is knocked by a piece of deadwood and his left arm is wounded.

3. Ed can not go on his ride with poor medical measures, so he dials the rescue phone number for help.

4. Based on the position information of Ed provided by SatA and TerrB, the rescue center finds Bell is the nearest rescuer and transfers the call to Bell.

5. Bell answers the phone call with satellite access and tries to find Ed based on the real-time position information of Ed. For lower communication latency, this phone call is routed by only one satellite without going through the ground network of TerrA and TerrB.

### 5.7.4 Post-conditions

Bell runs towards to Ed as soon as possible and keeps talking to him, finally Ed is saved.

### 5.7.5 Existing features partly or fully covering the use case functionality

3GPP TS 22.261 [2],

clause 6.1.2.1 on network slice includes the following requirements:

*The serving 5G network shall support providing connectivity to home and roaming users in the same network slice.*

*The 5G system shall be able to support IMS as part of a network slice.*

clause 6.2.4 includes roaming related requirements in diverse mobility management:

*For a 5G system with satellite access, the following requirements apply:*

*- A 5G system with satellite access shall enable roaming of UE supporting both satellite access and terrestrial access between 5G satellite networks and 5G terrestrial networks.*

*- UEs supporting satellite access shall support optimized network selection and reselection to PLMNs with satellite access, based on home operator policy.*

clause 6.3.2.3 on satellite access includes the following requirement:

*The 5G system shall be able to provide services using satellite access.*

clause 9.1 on charging aspect includes the following requirement:

The 5G core network shall support collection of charging information based on the access type (e.g. 3GPP, non-3GPP, satellite access).

### 5.7.6 Potential New Requirements needed to support the use case

[PR 5.7.6-001] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall support providing connectivity between UEs without going through the ground network regardless if they are registered in the HPLMN or a VPLMN.

[PR 5.7.6-002] The 5G system with satellite access shall support collection of charging information for a UE registered to the HPLMN or a VPLMN, without going through the ground network.

## 5.8 Use case on enabling multiple communication services between UEs

### 5.8.1 Description

The behaviours and trace of wild animals are the evidence of nature science. Researchers often use camouflage cameras blending in with their surroundings to observe wild animals. Meanwhile, researchers need to stay far enough away from the wild animals in order not to disturb their normal behaviour.

African savannah is a good place for research to observe and study lions. Usually, the researchers are camped far from the pride, and manipulate several mobile camouflage cameras to approach the pride and take videos for them. The camera with inner analysis functions can identify some typical behaviours and send corresponding notifications to the researchers. In this way, researchers can record and trace the pride and call the rescue centre for help when the lions get wounded.

In fact, to safeguard the ecology of wild animals, there is always no terrestrial network, and walkie-talkies are widely used for short distance communication there. However, because the camouflage camera, the rescue centre and the camp are usually far away from each other, the communication between them can only be easily realized with the help of satellites. In general, both the video stream and the voice call need to be transmitted to a nearby terrestrial network first, so it will affect communication efficiency, especially in emergency situations.

### 5.8.2 Pre-conditions

There is no terrestrial network in the African savannah, but it is covered and served by the satellites owned by Satellite Operator SatA.

TerA which is a terrestrial network operator contracts with SatA to allow communication services between devices in the African savannah via satellite. That is, devices can communication directly via satellite without going through the ground network.

To support multiple communication services simultaneously, TerA provides a variety of plans for different purpose, e.g., video stream, voice call, etc.

Emily is the leader of the researching team. All devices in the camp are subscribers of TerA. Emily signs video stream plan for every camera which is 2km away from Emily’s camp, and she signs both video stream and voice call plan for her mobile phone.

Vincent is an assistant at the rescue centre which is 10km away from the camp, and he is also a subscriber of TerA with voice call plan.

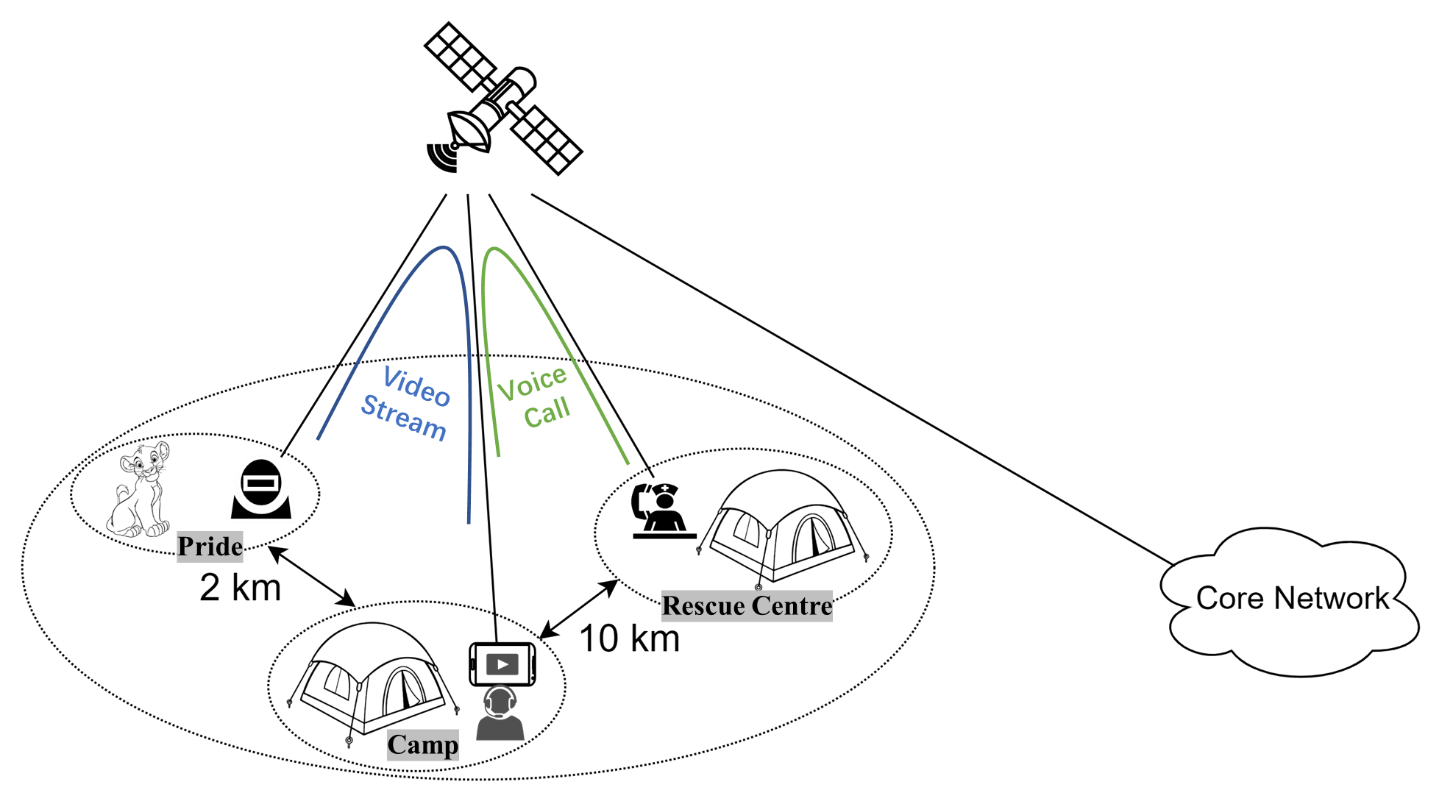


Figure 5.8.2-1: Multiple communication services via satellite without going through the ground network

### 5.8.3 Service Flows

1. One camera detects an injured lion, then it sends a notification to Emily’s phone via a satellite.

2. After receiving the notification, Emily opens the “Cam” App on her phone to watch the live video captured by the camera. The video stream from the camera to Emily’s phone is routed through the satellite.

3. By watching the video, Emily notices that the injured lion is being driven out of this pride. So Emily tracks the injured lion through the mobile camouflage camera. At the same time, she calls Vincent.

4. Vincent answers the phone and this voice call is also routed through the same satellite.

5. During the call, the satellite detects that the quality of voice call is impaired, so it re-choose a lower communication quality level for the video stream because of limited satellite resources and service priority.

### 5.8.4 Post-conditions

Emily can watch real-time video with lower resolution from the camera and keep the call with Vincent at the same time.

Both the video stream and voice call can be routed through the same satellite without being transmitted to the remote core network.

### 5.8.5 Existing features partly or fully covering use case functionality

There are a few related requirements specified in 3GPP TS 22.261 [2], which have been described as:

*The 5G system shall be able to support E2E (e.g. UE to UE) QoS for a service.*

*NOTE 2: E2E QoS needs to consider QoS in the access networks, backhaul, core network, and network to network interconnect.*

*For a 5G system with satellite access, the following requirements apply:*

*- The 5G system shall support service continuity between 5G terrestrial access network and 5G satellite access networks owned by the same operator or owned by different operators having an agreement.*

*- A 5G system with satellite access shall be able to select the communication link providing the UE with the connectivity that most closely fulfils the agreed QoS*

*- A 5G system with satellite access shall enable roaming of UE supporting both satellite access and terrestrial access between 5G satellite networks and 5G terrestrial networks.*

### 5.8.6 Potential New Requirements needed to support the use case

[PR 5.8.6-001] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to provide a mechanism for QoS control of the communication between UEs using satellite access without going through the ground network.

[PR 5.8.6-002] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to support different types of communication (e.g. services including unicast, multicast, broadcast) using satellite access without going through the ground network.

## 5.9 Use case on usage of satellite connectivity for collection of information to aid terrestrial network planning

### 5.9.1 Description

Network deployment in sparsely populated areas has been a major concern worldwide due to numerous challenges like affordability, infrastructure unavailability, and landscape or topographic conditions. Satellite connectivity can help to serve such areas. However, satellite access may not suffice in all scenarios (for low latency and high throughput applications) and there may be a need for terrestrial network deployment also. In such a situation, satellite connectivity can also facilitate information collection related to UE location and usage statistics, which can later be used for terrestrial network planning in these areas.

Connectivity can be provided in sparsely populated areas through satellite access using direct or indirect access through relay nodes/relay UEs (as shown in Figure 5.9.1-1). This eliminates the requirement of everyone having to use satellite UEs. The service provider can implement a subset of Minimization Drive Test (MDT) procedures to collect information such as location of the UEs through satellite connectivity that can be used by Network Management System (NMS). In addition, usage statistics (for UEs) may also be collected and analysed for the purpose of terrestrial network planning.

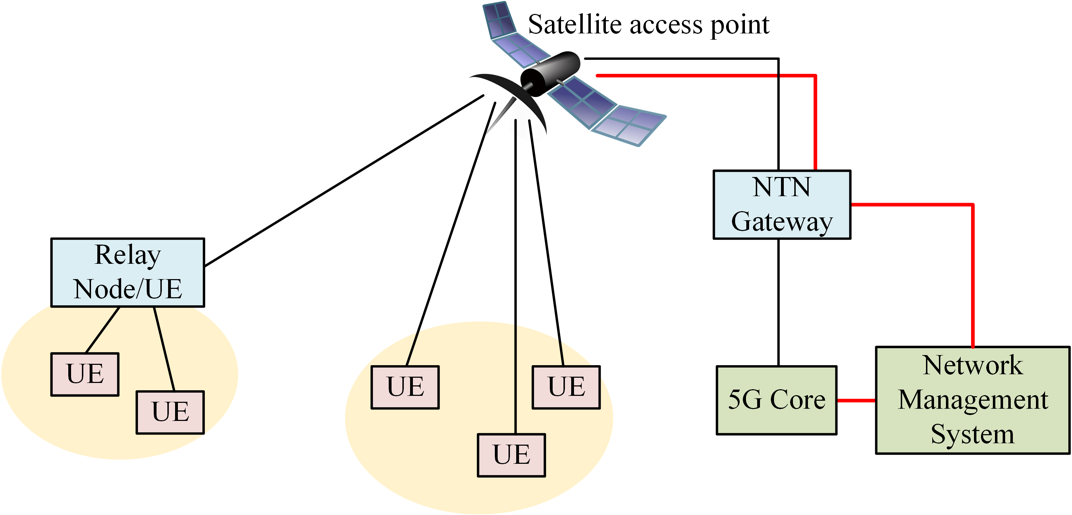


Figure 5.9.1-1: Connectivity and data collection from UEs through Satellite Access

### 5.9.2 Pre-conditions

There is satellite access coverage but no terrestrial access network deployed in a sparsely populated area. However, satellite access does not suffice and the service provider needs to augment it with the terrestrial network. Hence, the service provider can conduct some tests to understand the network deployment and planning needs. The service provider’s 5G System supports direct connectivity of satellite UEs and indirect connectivity for other UEs via relay nodes/relay UEs.

### 5.9.3 Service Flows

A village called Sittlingi has no terrestrial connectivity and residents of this village have to travel a few kilometres to a nearby village office for internet connectivity. Incidentally, this village is covered by satellite access from the service provider TTech Inc. The population in this village is not uniformly distributed and is sparsely populated. TTech is also interested in deploying terrestrial access networks in such areas. TTech wants to survey the area using some reliable mechanism to understand the usage needs of the villagers. Based on this knowledge, the number of base stations, their location and capabilities can be decided for deployment. TTech provides 5GS subscriptions to the users through satellite access. The provider also deploys relay nodes/UEs in the village to provide connectivity to people using non-satellite UEs. The relay nodes use satellite link as backhaul. Residents of the village subscribe and start availing services provided by 5GS. People who use standard off the shelf 5G UEs can be connected to satellite access through relay nodes/ relay UEs. As UEs are connected to the network, 5GS can collect traffic pattern related information from the 5G core user plane function and location related information through conventional Radio Resource Control (RRC) procedures. Based on this information, analysis for the needs and capabilities of terrestrial deployment can be done. Accordingly, terrestrial deployment is planned, designed and further executed. Once TTech completes terrestrial deployment, UEs can get connectivity through a terrestrial base station and satellite access connectivity can be terminated if desired.

### 5.9.4 Post-conditions

Service provider TTech is not required to perform some other kind of survey to identify the requirements. The provider utilizes existing 3GPP procedures to get information on usage statistics and location (using 5GS Satellite access) for terrestrial access network planning using optimum resources.

### 5.9.5 Existing features partly or fully covering the use case functionality

* Relay UE/ relay node (TR 38.821 [12], TS 22.261[2]) supports terrestrial connectivity to UEs on one end and connects to non-terrestrial access network on the other. The 5G system shall support connectivity using satellite access. (TS 22.261 [2])
* To collect UE specific measurements using control plane architecture, subset of MDT procedures (Reference: TS 37.320[x]) can be triggered.

### 5.9.6 Potential New Requirements needed to support the use case

[PR 5.9.6-001] Subject to regulatory requirements and operator’s policies, the 5G system with satellite access shall be able to support collection of information on usage statistics and location of the UEs that are connected to the satellite, for network (e.g. terrestrial) planning.

## 5.10 Use case on vehicle fleet management in the desert

### 5.10.1 Description

With the help of the construction of the transportation infrastructure, communication and information infrastructure, the modern logistics can deliver the goods to almost any corner of the world in a fast and reliable manner. Fleet management is a critical part of the logistics industry [13], which is being changed by IoT technologies in live vehicle monitoring, cargo management, driver behaviours’ monitoring and etc. The real-time data exchange is important for the staff of fleet management in route scheduling, decision making and safety assurance.

The convoy sometimes need to go across the area with sparse population or in extreme condition, where the network status fluctuates. Thus, besides remote management, local management by the team leader will also play a role in ensuring the speed and reliability of the transportation.

### 5.10.2 Pre-conditions

The logistic company ExpressX provides transportation services all over the world and well known for long distance transport. NetX, a mobile network operator has signed the contract with ExpressX to offer 5G communication service for all the vehicles and the staff, and promise the full coverage along all their transport routes including satellite services. NetX has deployed NGSO satellites to realize the radio coverage in rare population area and the deserts.

All the vehicles for long distance transport are equipped with Telematics Box (e.g Device #2) supporting all 5G RATs (e.g. NR, LEO) as well as on-vehicle IoT devices (e.g. Device#3) only capable of 5G NR for data service. The man-held UEs (e.g. UE1) of fleet team leaders support all 5G RATs.

Device#3 can connect to 5G network in either direct or indirect connection mode. Device#2 can help other UEs to connect to 5G network as a relay UE.

UE1, Device#2, and Device#3 have the subscription of NetX.

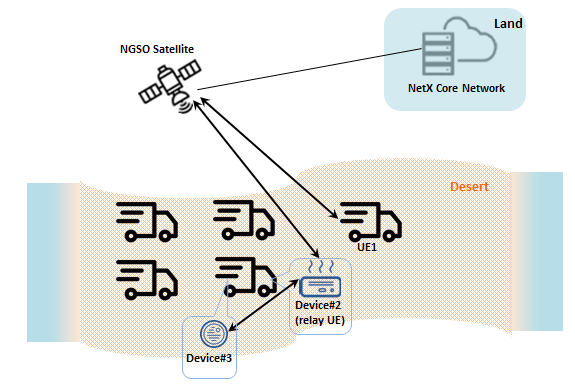


Figure 5.10.2-1: Fleet management in the desert via satellite access

### 5.10.3 Service Flows

1. UE1, held by the fleet team leader is registered to NetX core network via terrestrial access network at departure.

2. The Device#2 and on-vehicle device Device#3 are registered to NetX network when the transport starts, and keep reporting the vehicle’s status and the driver’s behaviours to remote management platform and UE1 via terrestrial access network and ground core network.

3. When the convoy approaches the desert highway, the fleet team leader will manage the fleet locally regarding the request of the remote management platform or application need. Device#3 is authorized and provisioned by 5G network to connect to 5G network in indirect network connection mode regarding the subscription, the location and the operator’s policy.

4. When there is no coverage of terrestrial access network, Device#2 and UE1 will exchange data between each other via satellite access without going to the remote ground network. Also, Device#3 will use Device#2 as relay UE to communicate with UE1via satellite access without going to the remote ground network.

5. As the movement, there is available coverage of terrestrial access network. Device#2 and UE1 can continue the communication with minimum interruption via terrestrial access network. Device#3 will communication with UE1 via terrestrial access network in direct network connection mode.

### 5.10.4 Post-conditions

UE1 can exchange data with Device#2 and Device#3, to obtain the vehicle status and driver’s information in real-time, and issue the action commands and distribute the route adjustment information in time.

### 5.10.5 Existing features partly or fully covering use case functionality

SA1 has performed several studies on connectivity models and satellite access. As a result, the associated service requirements are introduced to TS 22.261 [2].

Clause 6.9.1 describes the connectivity models as

*The UE (remote UE) can connect to the network directly (direct network connection), connect using another UE as a relay UE (indirect network connection), or connect using both direct and indirect connections. Relay UEs can be used in many different scenarios and verticals (inHome, SmartFarming, SmartFactories, Public Safety and others). In these cases, the use of relays UEs can be used to improve the energy efficiency and coverage of the system.*

Clause 6.5.2 defines the requirements of efficient user plane about satellite access as below.

*For a 5G system with satellite access, the following requirements apply:*

*A 5G system with satellite access shall be able to select the communication link providing the UE with the connectivity that most closely fulfils the agreed QoS*

Clause 6.9.2.5 defines the requirements of connectivity models about satellite access as below.

*A 5G system with satellite access shall be able to support relay UE's with satellite access.*

*NOTE: The connection between a relay UE and a remote UE is the same regardless of whether the relay UE is using satellite access or not.*

*A 5G system with satellite access shall support mobility management of relay UEs and the remote UEs connected to the relay UE between a 5G satellite access network and a5G terrestrial network, and between 5G satellite access networks.*

There is no explicit discussion about the efficient user data path when all the UEs are connecting to the 5G network via the same satellite but in different network connection modes.

### 5.10.6 Potential New Requirements needed to support the use case

[PR 5.10.6-001] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall support mechanisms to authorize a remote UE to use UE-Satellite-UE communication via a relay UE (using satellite access).

NOTE 1: It is assumed that the 5G system with satellite access is authorized to assign spectrum resources for the communication between a remote UE and a relay UE.

[PR 5.10.6-002] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall support service continuity for a remote UE when the UE communication path moves between a direct network connection via 5G terrestrial access network and an indirect network connection via a relay UE (using satellite access).

NOTE 2: It is assumed that the 5G terrestrial access network and the satellite access network belong to the same operator.

## 5. 11 Use case on service differentiation for UEs via satellite access

### 5.11.1 Description

Satellite network has been introduced to 5G system to improve the service availability and reliability since 3GPP Rel-15. In parallel, various UE models with different capabilities (e.g. eMTC UE, CPE) are defined to serve the vertical needs. How to facilitate different types of UEs to benefit from satellite network is worthwhile to study.

The current assumption of 3GPP normative work is, UE shall be capable of GNSS positioning to determine the location for obtaining 5G services via satellite access, which has excluded the possibility to provide 5G services to UEs without GNSS receiver, or unable to determine the location with GNSS receiver. In fact, some services such as broadcast or multicast service, public safety associated services are not highly sensitive to the precise location. Moreover, UEs in stationary mobility type such as for home access, for metering have fixed location to support the position relevant operation during satellite access. The use case illustrates how the UEs with different capabilities obtain 5G services via satellite access.

### 5.11.2 Pre-conditions

It is assumed that network operator has deployed NGSO (e.g. LEO) satellite enabled NG-RAN to provide 5G network PLMN#X in the area Area#A, where have sparse population and no coverage of terrestrial access network as a result.

All UEs support 5G satellite RATs but with different subscription, positioning capabilities and mobility type as Table 5.11.2-1 shows.

**Table 5.11.2-1: UEs with different capabilities**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Subscription | Positioning Capability | Mobility Type |
| UE1 | Subscriber of PLMN#X for eMBB services | No GNSS capability;  Support other 3GPP positioning technologies | Full mobility |
| UE2 | Subscriber of other PLMN with roaming agreement to PLMN\_X, for eMBB services | No GNSS capability;  Support other 3GPP positioning technologies | Full mobility |
| UE3 | Subscriber of PLMN#X for MIoT services | No GNSS capability;  Not support any 3GPP positioning technologies | Full mobility. |
| UE4 | Subscriber of PLMN#X for eMBB services | No GNSS capability;  Not support any 3GPP positioning technologies | Stationary |
| UE5 | Subscriber of PLMN#X for eMBB services | No GNSS capability;  Not support any 3GPP positioning technologies | unknown |

### 5.11.3 Service Flows

1. All UEs are registering to PLMN\_X to get services.

2. The network will provide the available services to authorized UEs considering UE’s location, the subscription and etc.:

* UE1: the network can determine UE’s location based on 3GPP positioning technologies, so it allows all the subscribed services after the location verification regarding regulatory requirements.
* UE2: the network can determine UE’s location based on 3GPP positioning technologies, but only allows limit broadband services such as public safety related services and emergency call regarding the roaming agreement.
* UE3: the network can’t determine UE’s location, so limit the services to those such as emergency message (e.g. PWS message) regarding the operator’s policy and regulatory requirements.
* UE4: the network knows UE4 is stationary and get the location from a reliable and trusted source. Then, the network allows subscribed eMBB services.
* UE5: the network detects UE5 is a dedicated user of digital broadband broadcast application, and fetch the location from the corresponding trusted application platform. Due to the lack of location verification, the network limits the services to those such as broadband broadcast services allowed by the regulatory requirements and the operator’s policy.

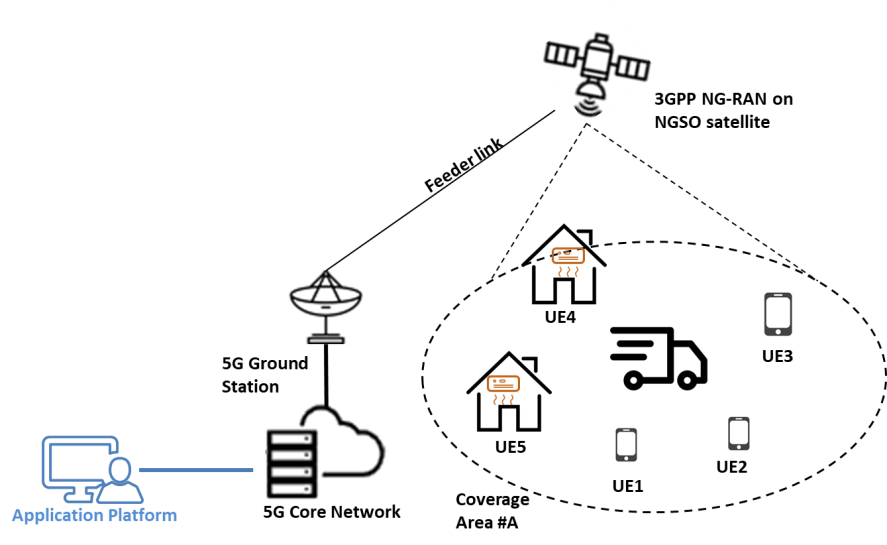


Figure 5.11.3-1: Service differentiation for UEs via satellite access

### 5.11.4 Post-conditions

All UEs can successfully register to PLMN\_X and get services based on the subscription, the regulatory requirements, the roaming agreement and the operator’s policy.

### 5.11.5 Existing features partly or fully covering use case functionality

SA1 has introduced several requirements about satellite access in TS 22.261[2].

Clause 6.3.2.3 describes basic requirements about satellite access for 5G system and UE.

*The 5G system shall be able to provide services using satellite access.*

*A UE supporting satellite access shall be able to provide or assist in providing its location to the 5G network.*

*A 5G system with satellite access shall be able to determine a UE's location in order to provide service (e.g. route traffic, support emergency calls) in accordance with the governing national or regional regulatory requirements applicable to that UE.*

*The 5G system with satellite access shall be able to support low power MIoT type of communications.*

Regarding the above requirements, UE shall have the ability to provide or assist in providing the location for obtaining the services from 5G system. The restriction of UE’s positioning capability has limited the potential users of 5G system using only satellite access, which expect to be served by 5G network.

### 5.11.6 Potential New Requirements needed to support the use case

[PR 5.11.6-001] Subject to the regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to provide services to an authorized UE independently of the UE’s GNSS capability.

[PR 5.11.6-002] Subject to the regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to provide services to an authorized UE registered to VPLMN independently of the UE’s GNSS capability.

[PR 5.11.6-003] Subject to the operator’s policy, the 5G system with satellite access shall be able to determine the location of a UE using only satellite access (e.g. based on 3GPP positioning technologies, based on the information from reliable and trusted sources) in order to provide services in accordance with the governing national or regional regulatory requirements applicable to that UE.

## 5.12 Use case on UAVs using satellite access

### 5.12.1 Description

In Mediterranean climate regions, forest fires are quite common in summer months due to temperature rise [14]. The early detection and monitoring of forest fire is important for fire suppression quickly and reducing the loss of human and property. Therefore, how to detect the forest fire in real time and accurately is an urgent problem to be solved. Another problem is that due to extremely low population density and complex geography, these regions are often not covered by terrestrial networks.

UAV equipped with satellite access capabilities is a feasible method, mainly through the following steps:

* The UAV collects real-time information (including high-precision three-dimensional surface topographic data, real-time pictures, real-time video, etc.);
* This real-time information is transmitted to the forest fire monitoring centre via the 5G network with satellite access;
* The forest fire monitoring centre monitors whether there is a fire, and may request the position of the UAV and adjust its route;
* The positioning services request and adjustment command are sent to the UAV via the 5G network with satellite access.

Forest fire monitoring centre with AI system can optimize the route through real-time information collected by UAV. In addition, the 5G system provides high-precision positioning of the UAV, which has been specified in 3GPP TS 22.261 [2]. But for UAVs using only satellites access, 5G system is difficult to provide high-precision positioning service under low latency. The end-to-end delay of LEO based satellite access can reach 35 ms [2]. After 5G system gets the real-time location data of flying UAV, it sends them to a trusted third party (e.g., The forest fire monitoring centre equipped with AI system) for UAVs to assist flying.

### 5.12.2 Pre-conditions

Forest fire monitoring centre has several UAVs to patrol the Forest A. Each UAV has a 4K camera for collecting real-time pictures.

In Forest A, there is no terrestrial network. So, the Forest fire monitoring centre has signed contract with Sat A, an operator with satellite communication services. Then, these UAVs can send real-time pictures to the forest fire monitoring centre via satellite.

The forest fire monitoring centre supports UTM function, and deploys AI system. It can evaluate these pictures to determine whether a fire is present or whether the UAV's flight route is off-course.

### 5.12.3 Service Flows

1. The UAV A takes a real-time picture with its 4-way 4K full-angle camera;

2. The picture is transmitted to the forest fire monitoring centre via the 5G network with satellite access network. This would require high data rate (e.g., 120Mbit/s) in UL direction.

3. The forest fire monitoring centre uses the AI system to determine whether there is a fire, according to the received picture. In case of fire, the forest fire monitoring centre will request the position of the UAV.

4. After receiving the positioning service request, the 5G network detects an error that the negotiated location delivery latency cannot be guaranteed. Then, it provides a lower position accuracy to ensure latency.

5. If the forest fire monitoring centre decides to adjust the route of UAV A, it will send adjustment commands to the UAV via the 5G network with satellite access network, which requires low delay and high reliability in DL direction.

### 5.12.4 Post-conditions

UAV adjusts its route.

### 5.12.5 Existing features partly or fully covering use case functionality

There are a few position requirements specified in 3GPP TS 22.125 [15], which have been described as:

*[R-5.1-009] The 3GPP system should enable an MNO to augment the data sent to a UTM with the following: network-based positioning information of UAV and UAV controller.*

*NOTE 1: This augmentation may be trust-based (i.e. the MNO informs the UTM that the UAV position information is trusted) or it may be additional location information based on network information, such as OTDOA, cell coordinates, synchronization source, etc.*

*NOTE 2: This requirement will not be applied to the case which the UAS and UTM has direct control communication connection without going through MNO, such as OTDOA, cell coordinates, synchronization source, etc.*

*[R-5.1-012] The 3GPP system shall enable a UAS to update a UTM with the live location information of a UAV and its UAV controller.*

*[R-5.1-013] The 3GPP network should be able to provide supplement location information of UAV and its controller to a UTM.*

*NOTE 3: This supplement may be trust-based (i.e. the MNO informs the UTM that the UAV position information* is *trusted) or it may be additional location information based on network information.*

There are also a few position requirements specified in 3GPP TS 22.261 [2], which have been described as:

*The 5G system shall support mechanisms to determine the UE’s position-related data for period when the UE is outside the coverage of 3GPP RAT-dependent positioning technologies but within the 5G positioning service area (e.g. within the coverage of satellite access).*

In 3GPP TS 22.071 [x], the following location service requirements are captured:

*The precision of the location shall be network design dependent, i.e., should be an operator’s choice. This precision requirement may vary from one part of a network to another.*

About horizontal accuracy:

*The LCS service shall provide techniques that allow operators to deploy networks that can provide at least the level of accuracy required by the regional regulatory bodies.*

*10m-50m: Asset Location, route guidance, navigation*

About vertical accuracy:

*For Value Added Services, and PLMN Operator Services, the following is applicable:*

*- When providing a Location Estimate, the LCS Server may provide the vertical location of a UE in terms of either absolute height/depth or relative height/depth to local ground level. The LCS Server shall allow an LCS Client to specify or negotiate the required vertical accuracy. The LCS Server shall normally attempt to satisfy or approach as closely as possible the requested or negotiated accuracy when other quality of service parameters are not in conflict.*

*- The vertical accuracy may range from about three metres (e.g. to resolve within 1 floor of a building) to hundreds of metres.*

About location delivery latency:

*Location Delivery Latency (Time to First Fix) is set at a maximum of 30 seconds from the time the user initiates an emergency service call to the time it is available at the location information center.*

### 5.12.6 Potential New Requirements needed to support the use case

[PR 5.12.6-001] The 5G system with satellite access shall be able to support suitable positioning mechanisms for UAV services.

[PR 5.12.6-002] The 5G system with satellite access shall be able to support positioning services and to provide information to a UE on delivered performance of positioning services.

## 5.13 Use case on Enhanced Positioning Service using Satellite Access

### 5.13.1 Description

During natural disasters, the recovery of communication services and the acquisition of the survivors’ location are important to aid the rescue activities. Normally, satellite communication networks and standalone GNSS are utilized to serve communication and positioning independently. With the integration of satellite access in 5G systems, it’s possible to provide both communication and positioning services by 5G system together to address the cases that GNSS cannot provide reliable positioning service (e.g. poor GNSS signal, limited visible satellites). Meanwhile, the positioning performance like accuracy can be improved with the assistance of 5G satellites (e.g. LEO), network information, etc. [16]

Indonesia is famous for its extraordinary natural landscapes attracting millions of tourists around the world. Meanwhile, it is widely recognized as one of the most disaster-prone countries in the world according to data released by the United Nations International Disaster Reduction Agency (UN-ISDR) [17]. A disaster (e.g. earthquake, tsunamis) will impact tens of millions of people, who may get support from the sustainable and reliable communication service and positioning service of the 5G system.

### 5.13.2 Pre-conditions

Bali, Indonesia is covered by terrestrial access network of Operator TerrA and satellite access network of Operator SatA, which shares the core network of TerrA deployed in Jakarta with mutual agreement. 5G communication service and positioning service have been launched all through Indonesia.

GNSS (e.g. GPS, BeiDou) are allowed to use in Indonesia, but are independent from 5G satellite constellation.

It is assumed that UEs with the subscription of TerrA network are capable of 5G satellite access. Some of them are incapable of GNSS receivers and some are integrated with different types of GNSS receivers.

### 5.13.3 Service Flows

A tsunami strikes Bali and has destroyed most infrastructures and terrestrial access networks. The core network is still in service without damage.

The awake survivors will initiate an emergency call or send an emergency message to report personal information, injuries, and surrounding conditions to Indonesia Rescue Center for rescue requests through SatA access network. During the interaction, the precise location information (e.g. accurate latitude) of the survivors is requested to report to Rescue Center from UE or/and the network with the help of 3GPP positioning methods or non-3GPP positioning methods (e.g. GNSS) within the requested response time of local regulatory requirements. The location of the survivors and rescue personnel will be sent to the survivors as well for preparation.

All powered-on UEs will autonomously update registration in TerrA’s network using satellite access. The network identifies the areas where the devices are located and authorizes Rescue Center to fetch real-time devices’ location and tracing log during the Rescue UAV or Helicopter searching for the survivors in a coma or not able to report emergency information actively.

### 5.13.4 Post-conditions

The locations of the awake survivors are identified as compliant with regulatory requirements.

The location information of powered-on devices is available in Rescue vehicles.

### 5.13.5 Existing features partly or fully covering use case functionality

Regarding TS 22.261[2] as below, UE using satellite access shall have the capability to offer the location, and 5G system needs to determine the location for service, but not consider the situation that the location cannot be decided by UE alone.

*A UE supporting satellite access shall be able to provide or assist in providing its location to the 5G network.*

*A 5G system with satellite access shall be able to determine a UE's location in order to provide service (e.g. route traffic, support emergency calls) in accordance with the governing national or regional regulatory requirements applicable to that UE.*

The legacy requirements for positioning service defined in TS 22.261 [2] are not well adapted to all types of UE with satellite access considering the satellite characteristics (e.g. latency).

*The 5G system shall provide 5G positioning services in compliance with regulatory requirements.*

*The 5G network shall be able to request the UE to provide its position-related-data on request—together with the accuracy of its position—triggered by an event or periodically and to request the UE to stop providing its position-related data periodically.*

*The 5G System with satellite access shall be able to negotiate the positioning methods according to the operator's policy or the application’s requirements or the user's preferences and shall support mechanisms to allow the network or the UE to trigger this negotiation.*

### 5.13.6 Potential New Requirements needed to support the use case

[PR 5.13.6-001] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to support 3GPP positioning methods for UEs using only satellite access.

[PR 5.13.6-002] The 5G system with satellite access shall be able to negotiate the positioning methods according to 3GPP RAT and UE positioning capability, the availability of non-3GPP positioning technologies (e.g. GNSS) and shall support mechanisms to allow the network or UE to trigger the negotiation.

[PR 5.13.6-003] Subject to regulatory requirements, the 5G system with satellite access shall be able to provide positioning services (e.g. with the availability of 99%, the accuracy of several kilometers) independently of UE’s GNSS capability when the UE is using only satellite access.

NOTE: The regulatory requirements for positioning (e.g. service requirements of Public Safety by GSMA [22]) could be taken into account.

## 5.14 Use case on service continuity for UE-to-UE communication between satellites

### 5.14.1 Description

The provision of Internet services using mega-constellations of LEO (Low Earth Orbit) satellites is a promising solution on the path to the future mobile communication systems. LEO is the Earth-centered orbit with an altitude in the range of 350km and 2000km above sea level. The LEO satellites at 600km altitude travel at a speed of about 7.8km/sec [18]. Due to the fast movement of LEO satellite, the service duration of a satellite for the coverage with 1000km diameter is less than 3 minutes. Therefore, guaranteeing robust service continuity and satisfactory user experience is the most critical issue in LEO satellite system.

In some countries, the state government operates Aviation Branches for Forest Protection Service to fight forest fires and assist in search and rescue missions [19]. The helicopters are part of the Aviation Branch and used for fire detection and firefighting, dropping water, and moving firefighters and equipment to rural and remote locations. In these locations, there may be no terrestrial network, so the helicopters and firefighters can collaborate with each other by communicating in the help of satellite. Moreover, since it takes several hours or days to complete their missions, it should be considered how to ensure the continuity of communication service using satellite access across multiple NGSO satellites.

Furthermore, the draft report of ITU-R for IMT2020-satellite requirement for mobility interruption time in satellite radio interfaces is 50ms [20].

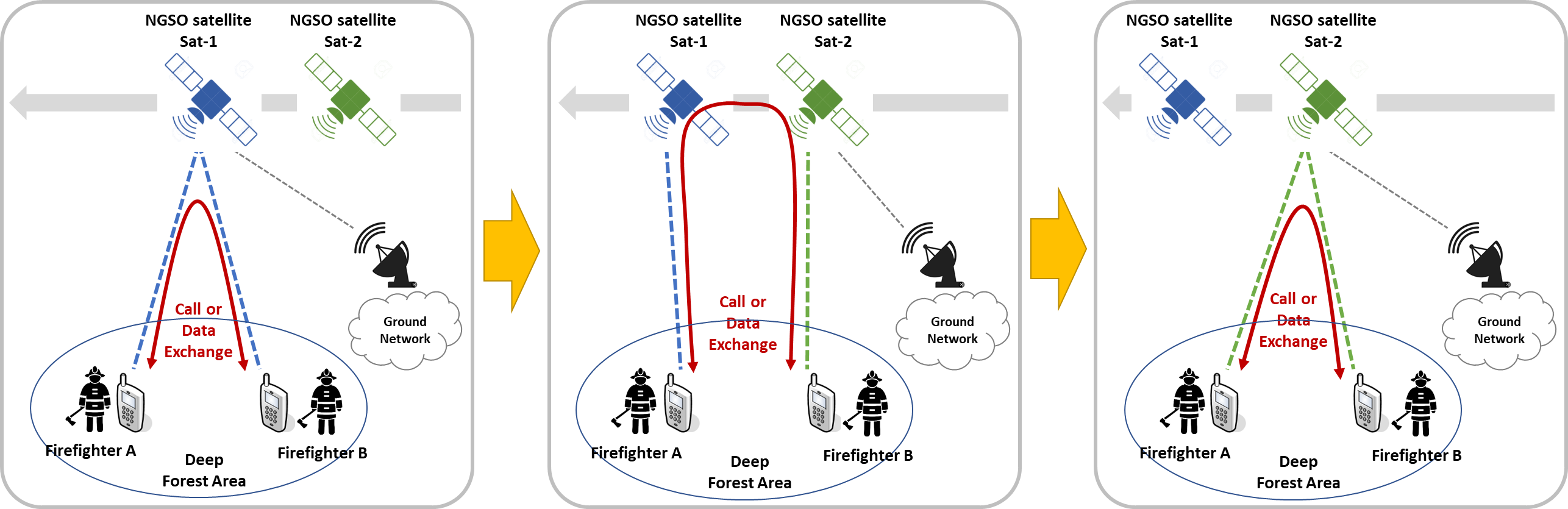


Figure 5.14.1-1: Example of service continuity for UE-to-UE communication between satellites without going through the ground network

### 5.14.2 Pre-conditions

Satellite operator Sat-OP has deployed NGSO satellites and has an agreement with Terrestrial Operator Ter-OP to provide communication services for UEs under satellite coverage.

Firefighter A and B have signed contract with Sat-OP for communication services using satellite access. Thus, their devices can communicate with each other directly via satellite without going through the ground network.

Firefighter A and B move to the rural or remote area in which there is no terrestrial network, but the satellites operated by Sat-OP can provide communicate services.

### 5.14.3 Service Flows

1. Firefighter A and B make a phone call or exchange some data (e.g. pictures, video streams) during their work. Then, their data traffic is routed through satellite Sat-1.
2. During the communication service, if Firefighter B is located in the coverage of satellite Sat-2, Firefighter B has a connection to satellite Sat-2 and the communication between Firefighter A and B is provided by satellite Sat-1 and Sat-2 through inter satellite link.
3. After some time, if satellite Sat-2 serves the area in which Firefighter A and B are located, the satellite Sat-2 takes over the data sessions for Firefighter A and B from satellite Sat-1, and then the data traffic is routed through satellite Sat-2.

### 5.14.4 Post-conditions

Firefighter A and B can finish the phone call or data exchange without any discontinuation of communication service with the support of multiple NGSO satellites.

### 5.14.5 Existing features partly or fully covering the use case functionality

Regarding TS 22.261 [2], satellite access and satellite connectivity are supported in Rel-18, as

*The 5G system shall be able to provide services using satellite access.*

*The 5G core network shall support collection of charging information based on the access type (e.g. 3GPP, non-3GPP, satellite access).*

*For a 5G system with satellite access, the following requirements apply:*

*- A 5G system with satellite access shall enable roaming of UE supporting both satellite access and terrestrial access between 5G satellite networks and 5G terrestrial networks.*

### 5.14.6 Potential New Requirements needed to support the use case

[PR 5.14.6-001] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to support the establishment of a communication path between UEs via one or multiple serving satellites without going through the ground network.

[PR 5.14.6-002] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall be able to support service continuity of a communication between UEs without going through the ground network when the UE communication path moves between serving satellites.

[PR 5.14.6-003] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall support service continuity of a communication between UEs without going through the ground network when the communication path between UEs via one or multiple serving satellites extends across several satellites (through inter satellite links).

## 5.15 Use case on service continuity for UE-to-UE communication in case of mobility between satellite and terrestrial network

### 5.15.1 Description

UAM (Urban Air Mobility) refers to a safe and efficient air transport system. UAM is used for transporting passengers or cargo in urban or suburban areas. Recently, in some countries, telecom operators have already started the collaboration with aviation companies for UAM business building from airframes to service platforms [21].

In order to control and manage the UAM body for safe and sound travel, the UAM vehicles should receive various information about the movement of other flying vehicles, climate conditions, location, and so on. Additionally, the UAM vehicle can provide the in-flight Internet service allowing the passengers to communicate with the users in the remote networks and on other flying vehicles as well.

Even though the UAM vehicles generally operate at an altitude less than 1km, they may fly over the air out of terrestrial network coverage. Thus, the commercialization of UAM depends on the establishment of a telecommunication network service including LEO satellite communications. While flying out of terrestrial network coverage, the vehicles can communicate with each other via satellite without going through the ground network. But, as a vehicle approaches the ground and hence has a connection to the terrestrial network, the communication between vehicles via satellite should be continuously provided through the satellite and terrestrial network.

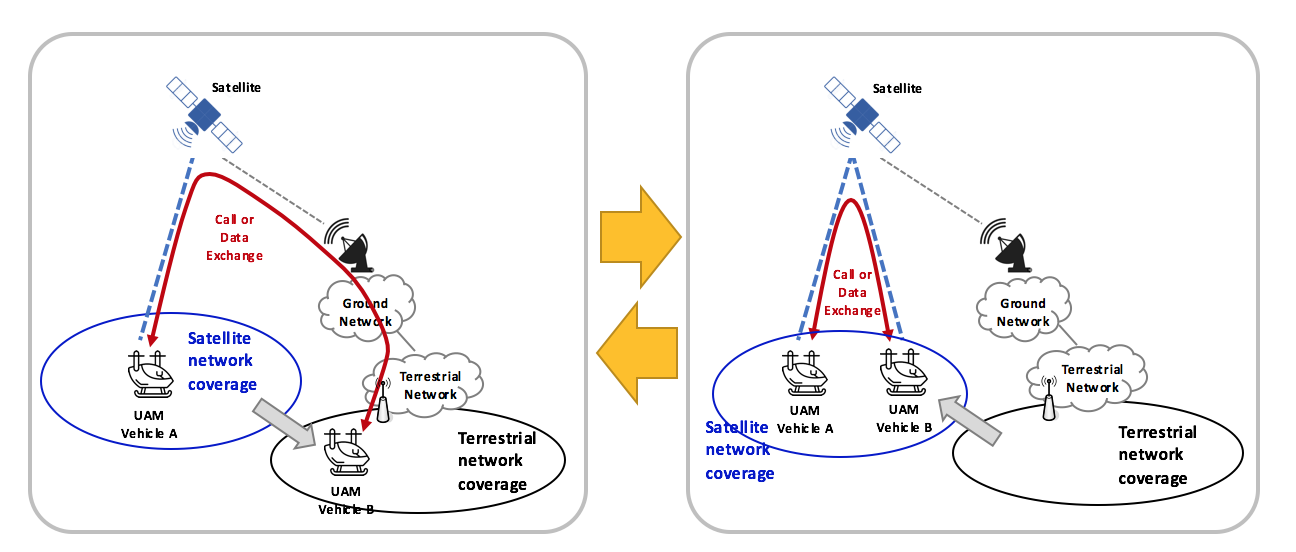


Figure 5.15.1-1: Service continuity for UE-to-UE communication in case of mobility between satellite and terrestrial network without going through the ground network

### 5.15.2 Pre-conditions

UAM company UAM-Co operates many UAM vehicles in urban and suburban areas.

UAM company UAM-Co contracts with Terrestrial Operator Ter-OP to provide communication services for the devices on UAM vehicles.

UAM company UAM-Co also have signed contract with Sat-OP for communication services via satellite access. Their devices on UAM vehicles can communicate with each other directly via satellite without going through the ground network.

Satellite Operator Sat-OP has an agreement with Terrestrial Operator Ter-OP to provide communication services for UEs under satellite coverage.

The devices on UAM vehicle A and B have a subscription with the Terrestrial Operator Ter-OP.

### 5.15.3 Service Flows

1. The devices on UAM vehicle A and B register with the Ter-OP network.
2. UAM vehicle A is flying out of Ter-OP network coverage, thus its device has a connection to the satellite operated by Sat-OP.
3. UAM vehicle B is ready to fly in the ground station, and hence its device has a connection to the Ter-OP network.
4. Before or Just after taking off, UAM vehicle B needs to gather the information on the movement of other flying vehicles including vehicle A. The data traffic between UAM vehicle A and B is routed though the satellite and terrestrial networks.
5. UAM vehicle B keeps gathering the movement information of vehicle A even after it moves out of Ter-OP network coverage. Since the information exchange between UAM vehicles should be performed in real time (with very low latency), the vehicles communicate with each other via satellite directly without going through the ground network.
6. After then, as UAM vehicle B approaches the ground, it has a connection to the terrestrial network.
7. The traffic between UAM vehicle A and B is going through the satellite and terrestrial network.
8. As a result, the communication between UAM vehicle A and B keep going without any discontinuation of service.

### 5.15.4 Post-conditions

User A and B can finish the exchange of their movement information without any discontinuation of communication service regardless of their roaming between satellite and terrestrial network.

### 5.15.5 Existing features partly or fully covering the use case functionality

3GPP TS 22.261 [2],

clause 6.2.4 includes roaming related requirements in diverse mobility management:

*For a 5G system with satellite access, the following requirements apply:*

*- A 5G system with satellite access shall enable roaming of UE supporting both satellite access and terrestrial access between 5G satellite networks and 5G terrestrial networks.*

clause 6.3.2.3 on satellite access includes the following requirement:

*The 5G system shall be able to provide services using satellite access.*

clause 9.1 on charging aspect includes the following requirement:

*The 5G core network shall support collection of charging information based on the access type (e.g. 3GPP, non-3GPP, satellite access).*

### 5.15.6 Potential New Requirements needed to support the use case

[PR 5.15.6-001] Subject to regulatory requirements and operator’s policy, the 5G system with satellite access shall support service continuity, when the UE communication path moves between 5G terrestrial access network and 5G satellite access network owned by the same operator or owned by different operators having an agreement.

## 5.16 Use case on store and forward – emergency report

### 5.16.1 Description

This use case illustrates the realization of a S&F service between a UE with satellite access and an Application Server for an emergency reporting service.

A description of store and forward operation is provided in Annex A.

Bob was sailing on an intercontinental containership, which sank for some exotic reason. Bob is now shipwrecked on a remote island and while he is not in immediate danger, he needs rescue within a matter of days as food and water is scarce.

A few items from the containership washed ashore with Bob, one of which is an IoT device from Company TrackingInc with a subscription to IoTSAT for the 5G IoT connectivity by satellite and IoTSAT is using a LEO constellation which supports S&F operation mode.

The IoT device allows Bob to send an emergency report including his position via the S&F network. A confirmation is received by the IoT device that the emergency report “went through” as soon as possible. As the indicator light by the emergency button of the IoT device starts blinking green, Bob knows that it is a matter of time before Alice rescues him.

### 5.16.2 Pre-conditions

In the present use case, the emergency reporting UE is in a remote area with no ground stations available for feeder link connectivity and the emergency reporting UE is aware that IoTSAT constellation operates in S&F mode.

### 5.16.3 Service Flows

1. Bob is sailing on an intercontinental containership, which sinks.

2. Bob is ashore and finds an IoT device from Company TrackingInc with a subscription to IoTSAT for the 5G IoT connectivity by satellite.

3. Bob sends an emergency report including his position with the IoT device from Company TrackingInc through IoTSAT.

4. The emergency report from Bob is received by the fly-by satellite of the IoTSAT constellation and is stored in the satellite waiting to be delivered as there is no feeder link available in the area where Bob is ashore.

5. The satellite of the IoTSAT constellation is able to deliver the “emergency report” from Bob in a matter of seconds as soon as a first feeder link is available as it identified the service as emergency and there is no restriction to use any feeder link and ground station for such service.

6. Bob is informed that the emergency report has been delivered upon the next fly-by of a satellite from the IoTSAT constellation.

### 5.16.4 Post-conditions

The emergency report generated by the IoT UE has been delivered successfully to the TrackingInc application server and forwarded to a service able to treat the report and a response has been forwarded to the IoT UE without relying on a continuous end-to-end network connectivity path between them.

### 5.16.5 Existing features partly or fully covering the use case functionality

3GPP TS 22.261 [2], clause 6.3.2.3 on satellite access includes the following requirements:

*The 5G system shall be able to provide services using satellite access.*

*The 5G system with satellite access shall be able to support low power MIoT type of communications.*

However, it is not sufficient in regards to S&F operation especially for the delivery of delay-tolerant/non-real-time IoT NTN services with NGSO satellites and considering here the case of emergency delivering in area where there is only a LEO constellation covering the device and using store and forward operation.

### 5.16.6 Potential New Requirements needed to support the use case

[PR.5.16.6-001] The 5G system with satellite access, and when the satellite access is operating in store and forward mode, shall be able to inform an authorized UE about how long the data is expected to be stored before being delivered.

[PR.5.16.6-002] Subject to regulatory requirements and operator’s policy, a 5G system with satellite access supporting S&F Satellite operation shall be able to forward an emergency report as soon as there is a feeder link available and shall be able to notify as soon as possible the UE about the successful forwarding.

NOTE 1: Subject to regulation, the emergency report could have priority over other communication

# 6 Consolidated requirements

## 6.1 Introduction

The following requirements represent a consolidation of the various potential requirements captured in the above use cases related to a 5G system with satellite access.

## 6.2 Store & Forward Satellite operation

The potential requirements corresponding to the support of S&F Satellite operation are listed in the table below.

Table 6.2-1 – Consolidated Requirements for S&F Satellite operation

| CPR # | | | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- | --- | --- |
| CPR 6.2-1 | | | Subject to operator’s policies, a 5G system with satellite access shall be able to support S&F Satellite operation for authorized UEs e.g. store data on the satellite when the feeder link is unavailable; and forward the data once the feeder link between the satellite and the ground segment becomes available. | [PR 5.1.6-001]  [PR.5.3.6-001]  [PR 5.4.6-001]  [PR.5.16.6-002] |  |
| CPR 6.2-2 | | | A 5G system with satellite access shall be able to inform a UE whether S&F Satellite operation is applied. | [PR 5.1.6-002]  [PR.5.16.6-001] |  |
| CPR 6.2-3 | | | Subject to operator’s policies, a 5G system with satellite access supporting S&F Satellite operation shall be able to allow the operator or a trusted 3rd party to apply, on a per UE and/or satellite basis, an S&F data retention period. | [PR 5.1.6-003]  [PR 5.2.6-002] |  |
| CPR 6.2-4 | | | Subject to operator’s policies, a 5G system with satellite access supporting S&F Satellite operation shall be able to allow the operator or a trusted 3rd party to apply, on a per UE and/or satellite basis, an S&F data storage quota. | [PR 5.1.6-004]  [PR 5.2.6-003]  [PR.5.3.6-003]  [PR 5.4.6-004] |  |
| CPR 6.2-5 | | | A 5G system with satellite access supporting S&F Satellite operation shall be able to support a mechanism to configure and provision specific required QoS and policies for UE’s data subject to store and forward operation (e.g. forwarding priority, acknowledgment policy). | [PR 5.1.6-005]  [PR 5.2.6-004] |  |
| CPR 6.2-6 | | | A 5G system with satellite access supporting S&F Satellite operation shall be able to provide related information (e.g. estimated delivery time to the authorised 3rd party) to an authorized UE. | [PR.5.16.6-001] |  |
| CPR 6.2-7 | | A 5G system with satellite access shall be able to inform an authorised 3rd party whether S&F Satellite operation is applied for communication with a UE and to provide related information (e.g. estimated delivery time to the authorised UE). | | [PR 5.2.6-001]  [PR 5.2.6-005] |  |
| CPR 6.2-8 | Subject to operator’s policies, a 5G system with satellite access supporting S&F Satellite operation shall be able to support forwarding of the stored data from one satellite to another satellite (e.g., which has an available feeder link to the ground network), through ISLs.  NOTE: It is assumed that the satellite constellation knows which satellite has a feeder link available. However, this is outside the scope of 3GPP. | | | [PR.5.1.6-008]  [PR.5.3.6-002] |  |
| CPR 6.2-9 | Subject to operator’s policies, a 5G system with satellite access supporting the S&F Satellite operation shall be able to support suitable means to resume communication between the satellite and the ground station once the feeder link becomes available. | | | [PR 5.1.6-007]  [PR 5.2.6-007] |  |
| CPR 6.2-10 | A 5G system with satellite access supporting S&F Satellite operation shall support mechanisms for a UE to register with the network when the network is in S&F Satellite operation. | | | [PR.5.1.6-009]  [PR 5.4.6-002] |  |
| CPR 6.2-11 | A 5G system with satellite access supporting S&F Satellite operation shall support mechanisms to authorize subscribers for receiving services when the network is in S&F Satellite operation. | | | [PR.5.1.6-010]  [PR 5.4.6-003] |  |

## 6.3 UE-Satellite-UE communication

The potential requirements corresponding to the support of UE-Satellite-UE communication are listed in the table below.

Table 6.3-1 – Consolidated Requirements for UE-Satellite-UE communication

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.3-1 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall support UE-Satellite-UE communication regardless of whether the feeder link is available or not. | [PR 5.6.6-003]  [PR 5.7.6-001]  [PR 5.14.6-001]  [PR 5.6.6-005] |  |
| CPR 6.3-2 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to support service continuity (with minimum service interruption) of a UE-Satellite-UE communication when the UE communication path moves between serving satellites (due to the movement of the UE and/or the satellites). | [PR 5.6.6-004]  [PR 5.14.6-002] |  |
| CPR 6.3-3 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall support service continuity (with minimum service interruption) of a UE-Satellite-UE communication when the communication path between UEs extends to additional satellites (through ISLs). | [PR 5.14.6-003] |  |
| CPR 6.3-4 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to provide QoS control of a UE-Satellite-UE communication | [PR 5.8.6-001] |  |
| CPR 6.3-5 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to support different types of UE-Satellite-UE communication (e.g. voice, messaging, broadband, unicast, multicast, broadcast). | [PR 5.8.6-002] |  |
| CPR 6.3-6 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall support service continuity (with minimum service interruption) of a UE-Satellite-UE communication when one UE communication path moves between a direct network connection via 5G terrestrial access network and an indirect network connection via a relay UE (using satellite access).  NOTE: It is assumed that the 5G terrestrial access network and the satellite access network belong to the same operator. | [PR 5.10.6-002] |  |

## 6.4 GNSS independent operation & positioning enhancements for satellite access

The potential requirements corresponding to the support of GNSS independent operation & positioning enhancements for satellite access are listed in the table below.

Table 6.4-1 – Consolidated Requirements for GNSS independent operation & positioning enhancements for satellite access

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.4-1 | Subject to the regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to provide services to an authorized UE independently of the UE’s GNSS capability. | [PR 5.11.6-001] [PR 5.11.6-002] |  |
| CPR 6.4-2 | Subject to the regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to determine the location of a UE using only satellite access (e.g. based on 3GPP positioning technologies, based on the information from reliable and trusted sources) in order to provide services. | [PR 5.11.6-003] |  |
| CPR 6.4-3 | Subject to regulatory requirements and operator’s policy, a 5G system with satellite access shall be able to support 3GPP positioning methods for UEs using only satellite access. | [PR 5.13.6-001] [PR 5.12.6-001] |  |
| CPR 6.4-4 | A 5G system with satellite access shall be able to provide positioning service to a UE using only satellite access and the information on positioning services (e.g. supported positioning performance).  NOTE: UE can be with or without GNSS capabilities. | [PR 5.12.6-002]  [PR 5.13.6-003] |  |
| CPR 6.4-5 | A 5G system with satellite access shall be able to support negotiation of positioning methods, between UE and network, according e.g. to 3GPP RAT and UE positioning capability, the availability of non-3GPP positioning technologies (e.g. GNSS). | [PR 5.13.6-002] |  |

## 6.5 Other aspects for satellite access

The potential requirements corresponding to the support of enhancements of other aspects of satellite access are listed in the table below.

Table 6.5-1 – Consolidated Requirements for other aspects of satellite access

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.5-1 | Subject to regulatory requirements and operator’s policies, a 5G system with satellite access shall be able to support an efficient communication path and resource utilization for a UE using only satellites access, e.g. to minimize the latencies introduced by satellite links involved. | [PR 5.5.6-001]  [PR 5.5.6-002]  [PR 5.15.6-001] |  |
| CPR 6.5-2 | Subject to regulatory requirements and operator’s policies, a 5G system with satellite access shall be able to support collection of information on usage statistics and location of the UEs that are connected to the satellite. | [PR 5.9.6-001] |  |

## 6.6 Security aspects

The potential requirements corresponding to the security aspect are listed in the table below.

**Table 6.6-1 – Consolidated Requirements for security aspects**

| **CPR #** | **Consolidated Potential Requirement** | **Original PR #** | **Comment** |
| --- | --- | --- | --- |
| CPR 6.6-1 | Subject to operator’s policies, a 5G system with satellite access supporting S&F Satellite operation shall be able to preserve security of the data stored and forwarded. | [PR.5.3.6-002]  [PR.5.1.6-008] |  |
| CPR 6.6-2 | A 5G system with satellite access supporting S&F Satellite operation shall be able to support mechanisms to authorize a UE to use the S&F Satellite operation. | [PR.5.3.6-004]  [PR 5.4.6-003]  [PR 5.4.6-002]  [PR 5.1.6-006]  [PR 5.2.6-006] |  |
| CPR 6.6-3 | A 5G system with satellite access shall be able to support mechanisms to authorize the UE-Satellite-UE communication, based on e.g., location information and subscription.  NOTE: UEs can use satellite access directly or via a relay UE (using satellite access assuming that the 5G system with satellite access is authorized to assign spectrum resources for the communication between remote UE and relay UE). | [PR 5.6.6-001]  [PR 5.10.6-001] |  |

## 6.7 Charging aspects

The potential requirements corresponding to the charging aspects are listed in the table below.

**Table 6.7-1 – Consolidated Requirements for charging aspects**

| **CPR #** | **Consolidated Potential Requirement** | **Original PR #** | **Comment** |
| --- | --- | --- | --- |
| CPR 6.7-1 | A 5G system with satellite access supporting S&F Satellite operation shall be able to collect charging information per UE or per application (e.g., number of UEs, data volume, duration, involved satellites). | [PR 5.4.6-005]  [PR 5.4.6-006] |  |
| CPR 6.7-2 | A 5G system with satellite access shall be able to collect charging information for a UE registered to a HPLMN or a VPLMN, for UE-Satellite-UE communication. | [PR 5.6.6-002]  [PR 5.7.6-002] |  |

# 7 Conclusions and recommendations

This technical report identifies several use cases and potential new requirements related to the 5G system with satellite access.

The resulting service requirements have been consolidated in clause 6.

It is recommended to consider the consolidated requirements identified in this TR as the baseline for the subsequent normative work.

Annex A (informative):  
Store and Forward Satellite operation

The Store and Forward Satellite 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.

An example of “S&F Satellite operation” is illustrated in Figure A-1, in contrast to what could be considered the current assumption for the “normal/default Satellite operation” of a 5G system with satellite access.

As shown in Figure A-1:

* Under “normal/default Satellite operation” mode, signalling and data traffic exchange between a UE with satellite access and the remote ground network requires the service and feeder links to be active simultaneously, so that, at the time that the UE interacts over the service link with the satellite, there is a continuous end-to-end connectivity path between the UE, the satellite and the ground network.

- In contrast, under “S&F Satellite operation” mode, the end-to-end exchange of signalling/data traffic is now handled as a combination of two steps not concurrent in time (Step A and B in Figure A-1). In Step A, signalling/data exchange between the UE and the satellite takes place, without the satellite being simultaneously connected to the ground network (i.e. the satellite is able to operate the service link without an active feeder link connection). In Step B, connectivity between the satellite and the ground network is established so that communication between the satellite and the ground network can take place. So, the satellite moves from being connected to the UE in step A to being connected to the ground network in step B.

|  |  |
| --- | --- |
| **“Normal/default Satellite operation” mode** | /Users/Berisot/Downloads/sa1 - sataccess /Sat mode default.png |
| **“S&F Satellite operation” mode** | /Users/Berisot/Downloads/sa1 - sataccess /sf sat mode.png |

Figure A-1: Illustration of “normal/default operation” and “S&F operation” modes in a 5G system with satellite access.

The concept of “S&F” service is widely used in the fields of delay-tolerant networking and disruption-tolerant networking. In 3GPP context, a service that could be assimilated to an S&F service is SMS, for which there is no need to have an end-to-end connectivity between the end-points (e.g. an end-point can be a UE and the other an application server) but only between the end-points and the SMSC which acts as an intermediate node in charge of storing and relying.

The support of S&F Satellite operation is especially suited for the delivery of delay-tolerant/non-real-time IoT satellite services with NGSO satellites.

Annex B (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-08 | SA1#99e |  |  |  |  | Inclusion of agreed pCRs: S1-222089; S1-222326; S1-222327; S1-222334; S1-222335; S1-222328; S1-222333; S1-222329; S1-222331; S1-222332; S1-222330; S1-222336 | 0.0.0 |
| 2022-11 | SA1#100 |  |  |  |  | Inclusion of agreed pCRs: S1-223531; S1-223392; S1-223393; S1-223533; S1-223535; S1-223639; S1-223715; S1-223638 | 0.2.0 |
| 2023-02 | SA1#101 |  |  |  |  | Inclusion of agreed pCRs: S1-230475; S1-230673; S1-230674; S1-230469; S1-230139; S1-230470; S1-230656; S1-230141; S1-230472; S1-230785; S1-230676; S1-230669; S1-230670; S1-230679 | 0.3.0 |
| 2023-03 | SA#99 | SP-230224 |  |  |  | MCC clean-up for presentation to SA#99 | 1.0.0 |
| 2023-05 | SA1#102 | S1-231339 |  |  |  | Inclusion of agreed pCRs: S1-231560, S1-231575, S1-231576, S1-231577, S1-231563, S1-231578, S1-231579, S1-231208, S1-231700, S1-231740, S1-231722, S1-231121, S1-231574, S1-231702, S1-231737, S1-231088 | 1.1.0 |
| 2023-06 | SA#100 | SP-230515 |  |  |  | MCC clean-up for approval by SA#100 | 2.0.0 |
| 2023-06 | SA#100 | SP-230515 |  |  |  | Raised to v.19.0.0 by MCC following approval by SA#100 | 19.0.0 |
| 2023-09 | SA#101 | SP-231025 | 0001 |  | D | Updates in scope, terms and overview | 19.1.0 |
| 2023-09 | SA#101 | SP-231025 | 0002 | 1 | B | update of consolidation for TR 22.865 | 19.1.0 |
| 2023-09 | SA#101 | SP-231026 | 0003 | 3 | C | Updates on use case on Store and Forward-MO for TR 22.865 | 19.1.0 |
| 2023-09 | SA#101 | SP-231025 | 0004 | 3 | B | update of clause 5.16 | 19.1.0 |
| 2023-12 | SA#102 | SP-231409 | 0006 | 1 | D | Small editorial fixes to 22.865 | 19.2.0 |