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Title: Use Case on resource and energy efficiency in a multi-orbit Satellite Access System

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*Abstract: This document proposes a use case on Multi-Orbit with Satellite Access System and potential requirements for TR22.887 v0.1.0 (FS\_5GSAT\_ph4)*

## x.1 Use case on resource and energy efficiency in a multi-orbit Satellite Access System

### x.1.1 Description

Satellite access in a 5G system aims in bridging connectivity gaps, especially in remote areas thanks to the following characteristics:

* **Global Coverage:** Satellites can provide coverage across vast geographical regions, including oceans, deserts, and polar regions.
* **Ubiquitous Connectivity:** Satellite networks ensure continuous connectivity, even areas with sparse population. This makes them ideal for emergency communication, disaster response, and remote monitoring.

Satellite-based 5G networks can be served by satellites that are operating in either NGSO (LEO & MEO) and/or GEO. A multi-orbit satellite access system is a network that is served by satellites that operate in different orbits.

Satellite-based networks come with additional challenges compared to terrestrial networks, and each of the aforementioned orbits comes with its advantages and disadvantages.

The biggest challenge is that in space, satellites operate in a power limited environment, relying on solar panels and batteries that store the excess energy produced by the solar panels. In principle, satellites in NGSO (LEO & MEO) are more compact compared to GEO satellites, limiting the size and capacity of solar panels and batteries of the former compared to the latter. Furthermore, the exposure of the LEO and MEO satellites to sunlight varies significantly due to orbital dynamics. In addition, LEO and MEO satellites experience atmospheric drag, which is higher for LEO compared to MEO. This necessitates frequent orbital adjustments, which in turn consume energy.

At the same time, NGSO satellites, due to their proximity to earth, can provide a superior capacity and lower latency, compared to GEO satellites, playing a vital role in providing connectivity to maritime vessels, aircrafts, offshore platforms, and remote islands.

On the other hand, the proximity to earth of NGSO comes with the price of very high orbital speeds, up to 7.5Km/s, making cell search and camping a tedious process, especially for VSATs (Very Small Aperture Terminal), which can take up to tens of minutes. In addition, the high orbital speed reduces the time that a UE is served by an NGSO satellite triggering frequent mobility events and associated control plane signalling.

A 5G system with multi-orbit satellite access shall exploit the advantages of each orbit to ensure optimal energy and resource efficiency of the satellite access network.

For example to achieve such energy efficiency, NGSO satellites can be intelligently turned off or the power of specific beams be reduced, when a lower threshold of connected users and/or throughput is reached, while the same area can still be served through lower capacity GEO satellites.

Similarly, to achieve resource efficiency when a UE (e.g. VSAT) is turned on it can connect to a GEO satellite and stay connected there until it needs to transmit data, in order to avoid a long NGSO satellite searching process and unneeded overhead control plane signalling required for frequent NGSO mobility events.

### x.1.2 Pre-conditions

During the beginning of the tourist season in the Caribbean, a large cruise ship departs from its first port full with passengers and crew. The ship normally uses a connection with a GEO/NGSO satellite operator.

During the off-peak season the operator has switched off the NGSO beams over the path of the cruise ships to reduce energy consumption and prolong the satellites’ life.

The VSAT UE onboard has a list of TLE coordinates of the operators’ GEO satellites

### x.1.3 Service Flows

According to this use case:

1. The VSAT UE onboard the ship is powered on and based on its current position, determines which GEO satellite it should connect to and quickly establishes a connection.
2. Once it connects to the GEO satellite, more passengers on the ship and connect to the WLAN onboard leading to higher data demand.
3. The satellite operator, through automated O&M, needs to turn on NGSO satellites that serve the region to meet the demand.

### x.1.4 Post-conditions

The satellite operator has successfully determined which beam/satellite from the NGSO constellation needs to be turned on. The VSAT UE has successfully established a link access to the network first through the GEO and then through the NGSO satellites.

The VSAT returns to the GEO satellite during times of the day that passenger demand is dropping, and the satellite operator is able to switch off the NGSO satellites over the area to optimize the systems’ energy performance.

The quick initial connection to GEO and seamless mobility to NGSO as data demand increased ensured a positive connectivity for passengers and crew onboard the ship, while ensuring a resource and energy efficient operation of the satellite access system.

### x.1.5 Existing features partly or fully covering the use case functionality

Requirements in 22.261 Rel19 that partly cover the described use case are:

* A 5G system providing service with satellite access shall be able to support GEO based satellite access with up to 285 ms end-to-end latency.

NOTE 1: 5 ms network latency is assumed and added to satellite one-way delay.

* A 5G system providing service with satellite access shall be able to support MEO based satellite access with up to 95 ms end-to-end latency.

NOTE 2: 5 ms network latency is assumed and added to satellite one-way delay.

* A 5G system providing service with satellite access shall be able to support LEO based satellite access with up to 35 ms end-to-end latency.

NOTE 3: 5 ms network latency is assumed and added to satellite one-way delay.

### x.1.6 Potential New Requirements needed to support the use case

[PR x.1.6-001] A 5G network supporting satellite access with multi-orbit operation shall be able to optimize for energy efficiency by considering, for example:

* user density and data demand to activate/deactivate different power saving modes

[PR x.1.6-002] A 5G system supporting satellite access with multi-orbit operation shall select satellite access type to optimize the resource use for each UE, for example considering the following criteria:

- connectivity state of UE

- data demand