JOINT 6G SATELLITE-TERRESTRIAL NETWORK INTEGRATION AND OPERATIONS CHALLENGES

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Joint 6G Satellite-Terrestrial Network Integration and Operations Challenges

1. Unified NTN and TN operations
   Multi-orbit satellite systems integrated with terrestrial cellular networks

2. Integrating 3GPP 5G/6G NTN and TN operations
   Interfaces between satellite operations and TN operations

3. Multicast and Broadcast Use Case

4. Multi-link and multi-band connectivity support

Objectives for 6G unified network operation
Joint operation of SAN and MNO networks
With different SNO/MNO cooperation schemes

Seamless reliable roaming between SNO and MNO operations

Integrated unified 3D TN/NTN network with multi-orbit and multi-frequency connectivity
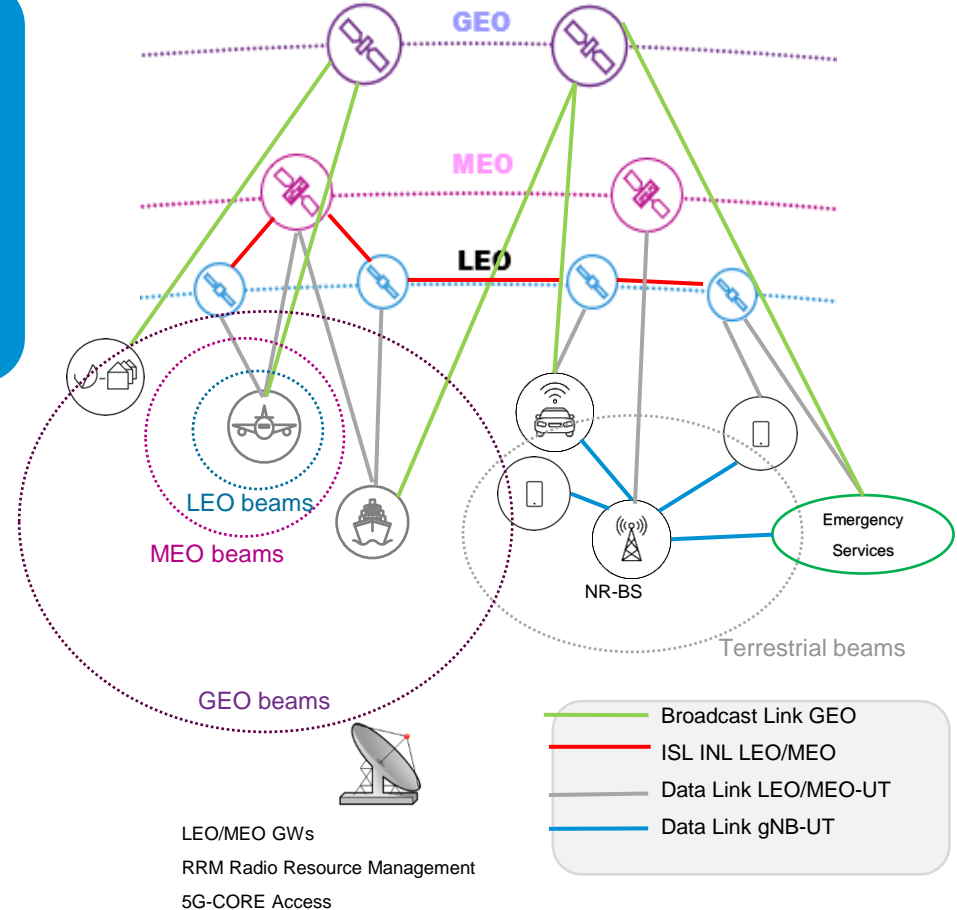
6G-NTN Unified Integrated Network - Architecture Reference

▲ The 3D layered 5G Advanced and 6G Network foresees network segments on the Ground, Sky and at different possible orbits

▲ The NTN network components are **interconnected with the terrestrial network** as an integral part of the joint network

▲ User Equipment can access networks through either network segments and roam seamlessly between the network segments

▲ This architecture enables applications that require seamless wireless coverage, especially mobility, automotive mobile, maritime, Aero NR users as well as IoT applications relying on mobility, such as Drones

▲ Direct to handheld is also a possible use case under consideration

Satellite components

3D layered network

Multi-link connectivity

Terrestrial components

Integrated Core Network
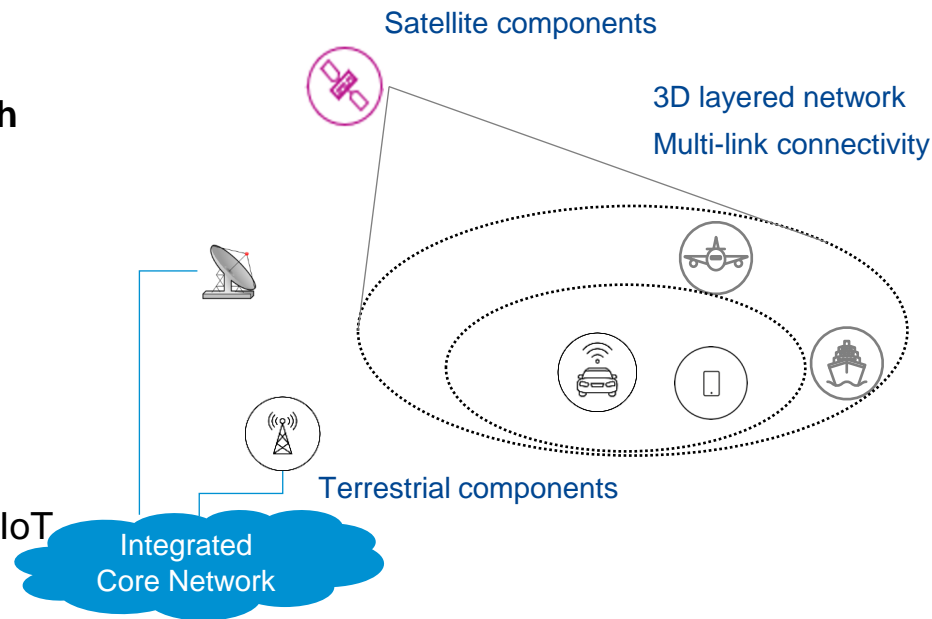
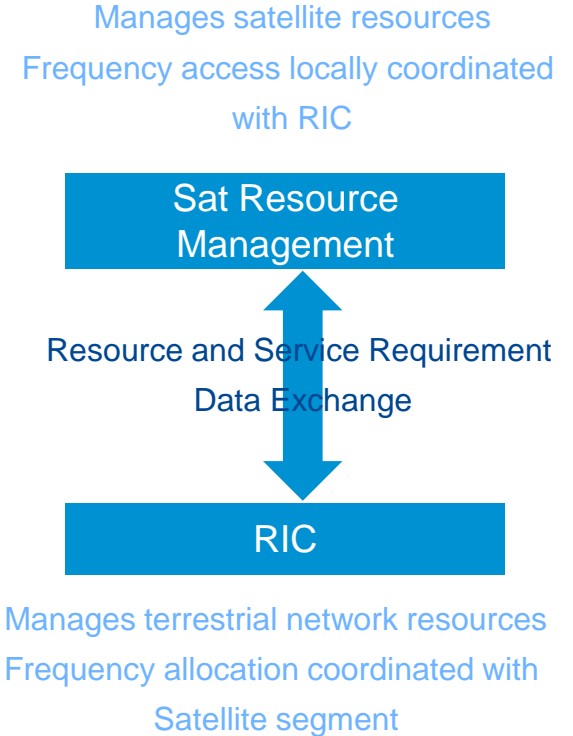# SES▲ Integrated Multi Orbit Network Perspective

- ▲ Different orbits, GEO, MEO, LEO provide different NTN cell sizes, all for 5G-NTN access in all frequency bands considered
  - • GEO for wide area coverage for 5G-MBS
  - • MEO/LEO for operationally configurable global cells of different sizes where needed by traffic demand of the network
- ▲ ISL for traffic routing to global Gateways when required
- ▲ Seamless service aggregation with terrestrial 3GPP cells

- ▲ LEO satellite constellations are best suited for the TN/NTN integration and Direct-to-device connectivity
- ▲ High local data relay needs and local congestion is unavoidable with LEO constellations
- ▲ MEO can support the LEO constellation with targeted high data rate links to Gateways and connect to LEO and terminals to de-congest the network
- ▲ GEO capacity leveraged for multicasting and broadcasting


GEO

MEO

LEO

LEO beams

MEO beams

GEO beams

Emergency Services

NR-BS

Terrestrial beams

— Broadcast Link GEO
— ISL INL LEO/MEO
— Data Link LEO/MEO-UT
— Data Link gNB-UT

LEO/MEO GWs
RRM Radio Resource Management
5G-CORE Access

Multi-link and multi-band access scheme with integrated RIC and Sat Resource management

▲ Multi-connectivity enabled through the joint operation of the different access options of the unified TN/NTN network

▲ Joint resource management satellite network and terrestrial network (Sat RC <> RIC)

▲ Real time RIC to Satellite Resource Management coordination

▲ The Near-Real Time RAN Intelligent Controller shall be enhanced to support feeding configuration of the constellation (ephemeris info, epoch time, time-based handover info, distance-based handover info, distance-based measurement info …) to configure continuously the gNB with the up-to date Information Elements values.

Manages satellite resources
Frequency access locally coordinated with RIC

Sat Resource Management

Resource and Service Requirement Data Exchange

RIC

Manages terrestrial network resources
Frequency allocation coordinated with Satellite segment

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Multicast and Broadcast complementary services from NTN networks

▲ Multicast services to mobile platforms from NTN networks

▲ Broadcast services to defined geographic areas from NTN networks with mobile users between TN and NTN

▲ Building on and complementing eMBMS and MBS, reliable multicast and broadcast requires solutions for seamless handover handling

▲ Filling the gap for mobility between TN and NTN networks and NTN network mobility

▲ Lossless transitions of connections in a mobile connected environment

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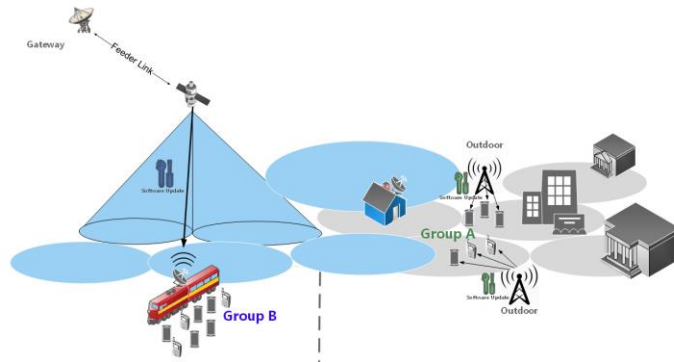
Multi-link and multi-band connectivity solution

▲ The challenge of 6G should focus among others on:

▲ **Interoperability**

- Solutions for interoperability between SNO and MNO operations in a context in which there is a diverse approach to cooperation between SNO and MNO

▲ **Ubiquitous connectivity**

- NTN connectivity can provide real solutions for the ubiquitous connectivity in a unified TN/NTN network
- This requires a true fully integrated TN/NTN network architecture

▲ **Lossless connectivity services** are required for a multitude of user terminals (Handheld, Car mounted terminals, Aero terminals, Drones, etc.)

▲ Some services require a **reliable connection that is guaranteed uninterrupted**

This requires solutions to manage multiple link connections to TN and NTN nodes and dynamically manage resource usage between TN and NTN networks