

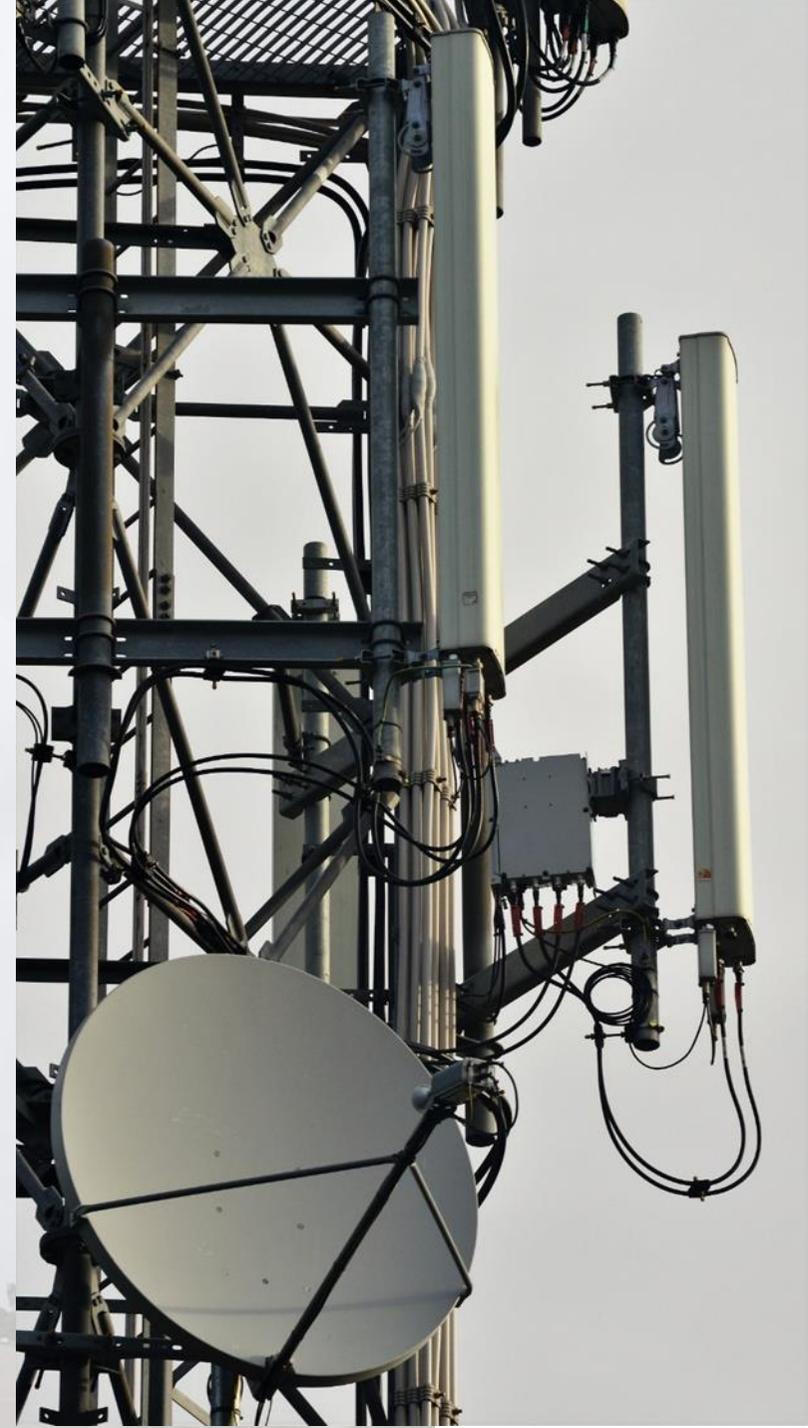


Integration of Terrestrial and Space Based Communications

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22nd June 2022

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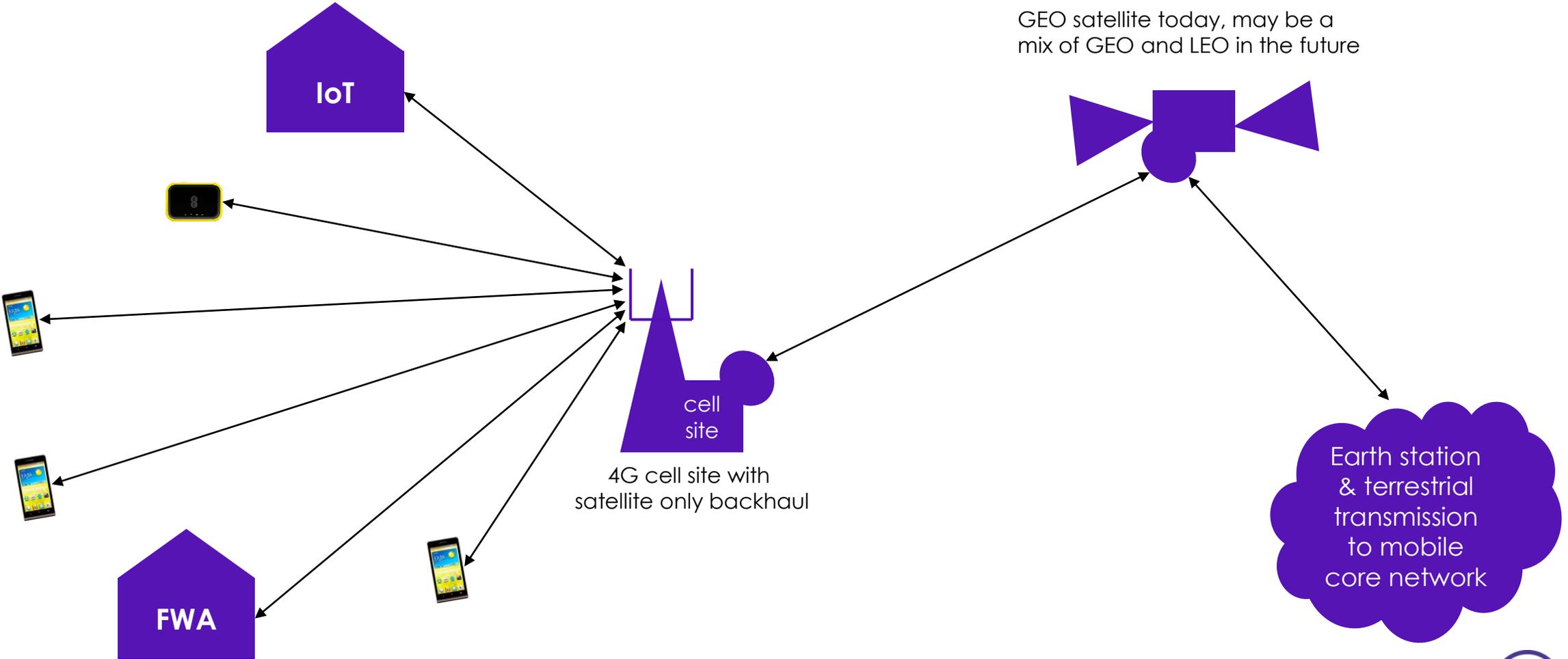
Mobile network use cases for Satellite Communications

- Network availability uplift
- Extreme rural coverage - no terrestrial solution available
- Rapid deployment - while awaiting terrestrial delivery
- Disaster recovery
- Tactical coverage
- Special events
- Future - direct to device comms?

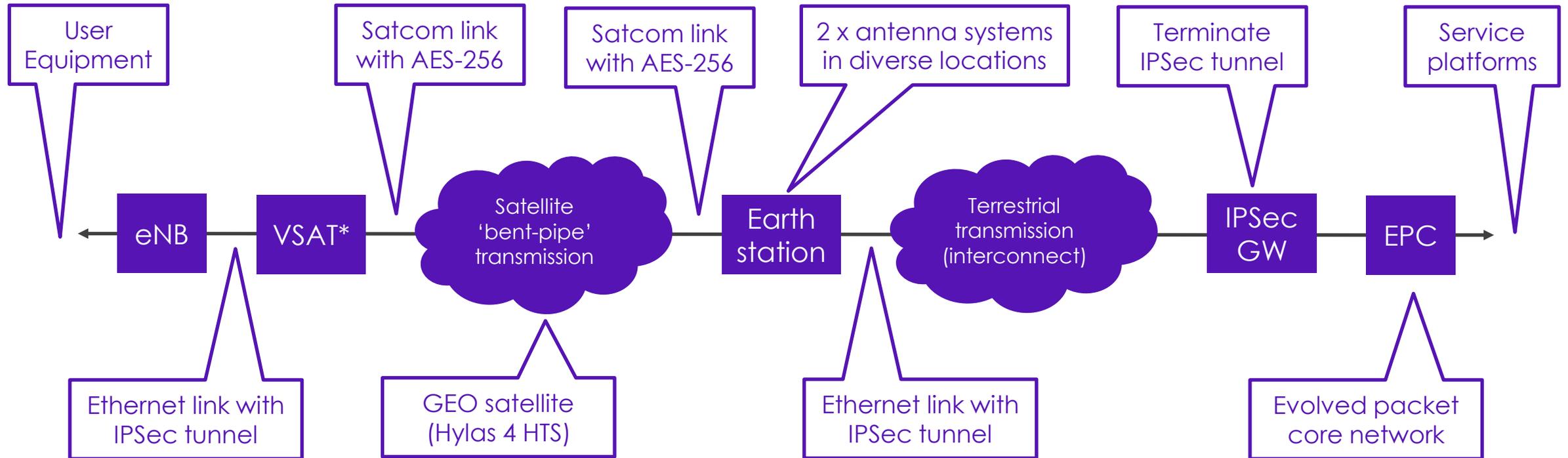


Mobile backhaul via GEO satellite

Capacity will be constrained compared with terrestrial solution (fibre or microwave radio)

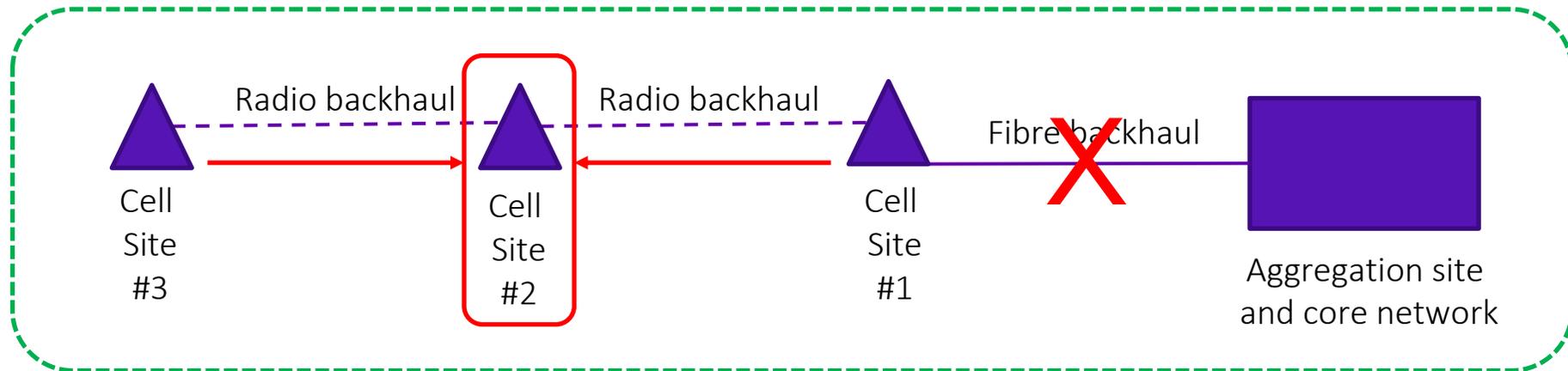
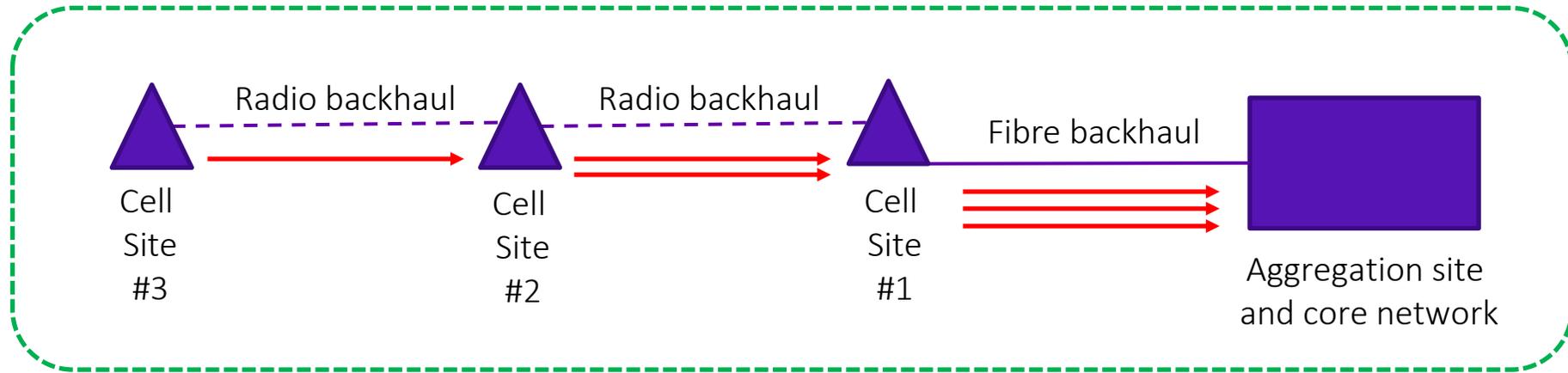


High level network architecture for mobile backhaul over GEO satellite



*VSAT block includes Gilat SkyEdge II-c Capricorn-Pro modem (with TCP acceleration and IPSec/AES-256 plus Ka band radio transceiver and offset fed parabolic antenna)

Addition of satellite communications to enhance service availability - backing up terrestrial transmission



Satellite orbits and low earth orbit constellations

- There are two new LEO constellations currently being deployed - OneWeb & Starlink
- LEO satellites operate at altitudes between 200 and 2,000km (Starlink ~550km, OneWeb ~1200km)
- OneWeb is planning on 588 satellites in phase 1 and 6,372 in a second phase - each satellite provides 7.2Gbps of downlink capacity
- Starlink is planning on 4408 satellites in phase 1 followed by 7500 in a second phase - each ph1 satellite provides 16Gbps of downlink capacity
- Earth stations - OneWeb currently served from several European based gateways (for UK service) - Starlink currently at 3 sites in UK

Geostationary Earth orbit (GEO)

36000km altitude:

- **Challenging power budget;**
- **Latency: 500ms round trip.**

Orbit period: 24hrs; fixed relative to the earth

- **1 satellite for 24x7 coverage of a region**

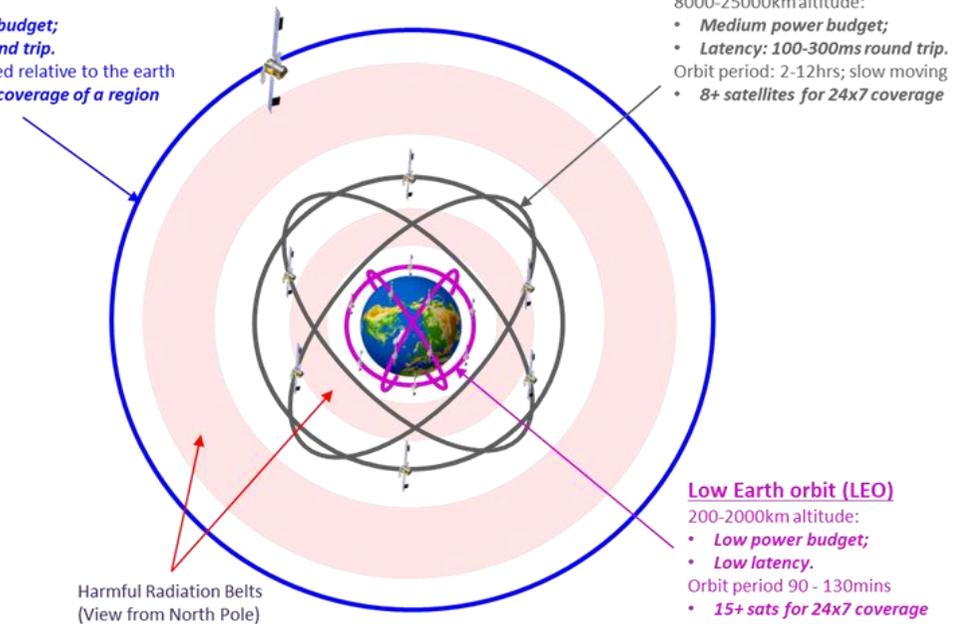
Medium Earth orbit (MEO)

8000-25000km altitude:

- **Medium power budget;**
- **Latency: 100-300ms round trip.**

Orbit period: 2-12hrs; slow moving

- **8+ satellites for 24x7 coverage**



Harmful Radiation Belts
(View from North Pole)

Low Earth orbit (LEO)

200-2000km altitude:

- **Low power budget;**
- **Low latency.**

Orbit period 90 - 130mins

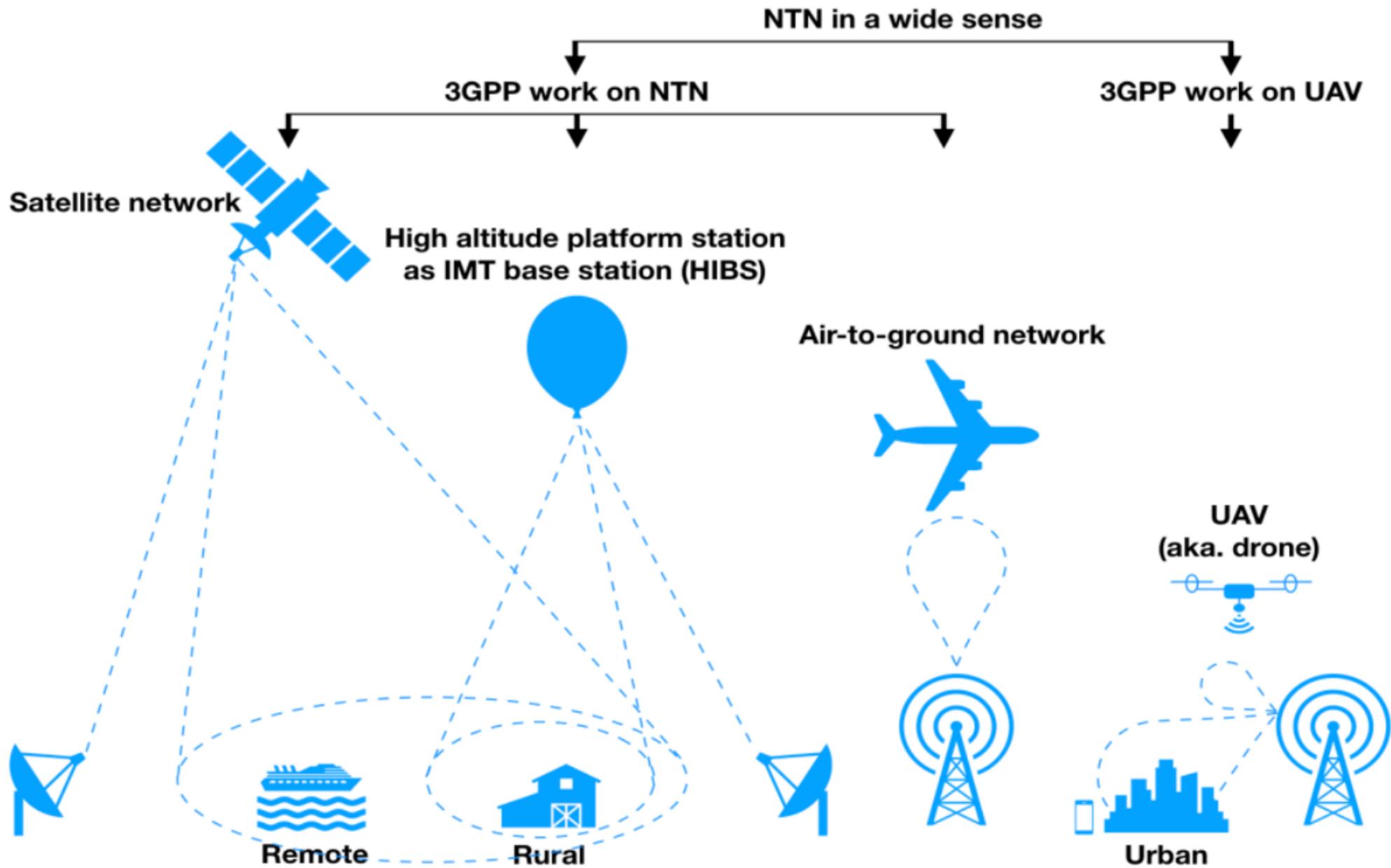
- **15+ sats for 24x7 coverage**

Working within the eco-system to address diverse use cases



Roles for Non-Terrestrial Networks in 5G system

- Thanks to the wide service coverage capabilities and reduced vulnerability of space/airborne vehicles to physical attacks and natural disasters, Non-Terrestrial Networks are expected to:
 - foster the roll out of 5G service in un-served areas that cannot be covered by terrestrial 5G network (isolated/remote areas, on board aircrafts or vessels) and to upgrade the performance of limited terrestrial networks in a cost effective manner
 - reinforce the 5G service reliability by providing service continuity for M2M/IoT devices or for passengers on board moving platforms (e.g. passenger vehicles-aircraft, ships, high speed trains, bus) or ensuring service availability anywhere especially for critical communications, future railway/maritime/aeronautical communications and to enable 5G network scalability by providing efficient multicast/broadcast resources for data delivery towards the network edges or even user terminal



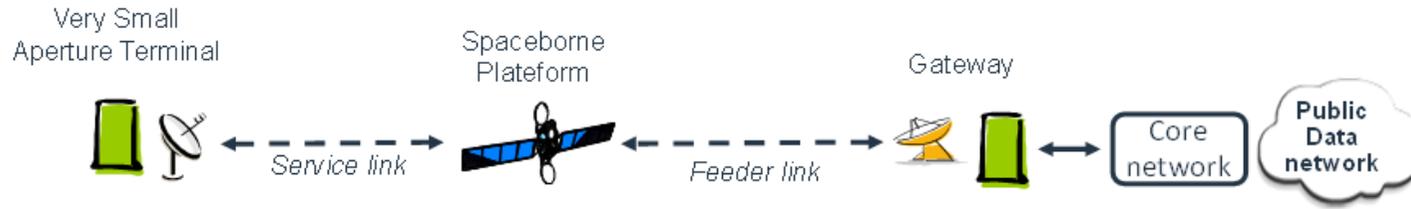


Figure 4.3-1: Satellite access network (without ISL) with a service link operating in frequency bands above 6 GHz allocated to Fixed and Mobile Satellite Services (FSS and MSS)

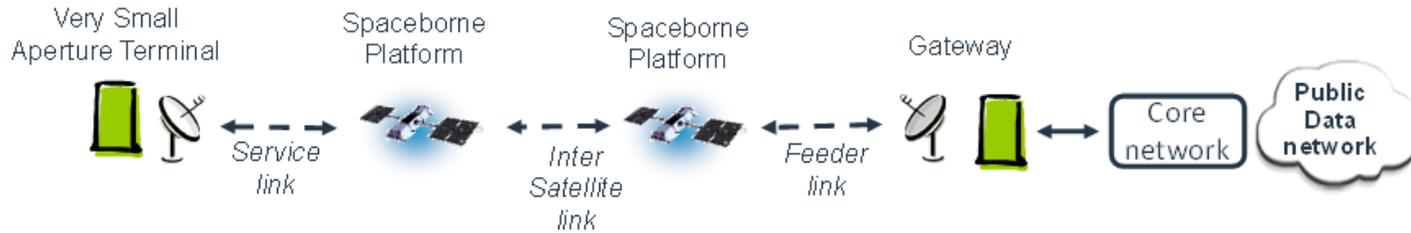


Figure 4.3-2: Satellite access network (with ISL) with a service link operating in frequency bands above the 6 GHz allocated to Fixed and Mobile Satellite Services (FSS and MSS)



Figure 4.3-3A: Satellite access network with a service link operating in frequency bands below 6 GHz allocated to Mobile Satellite Services (MSS)

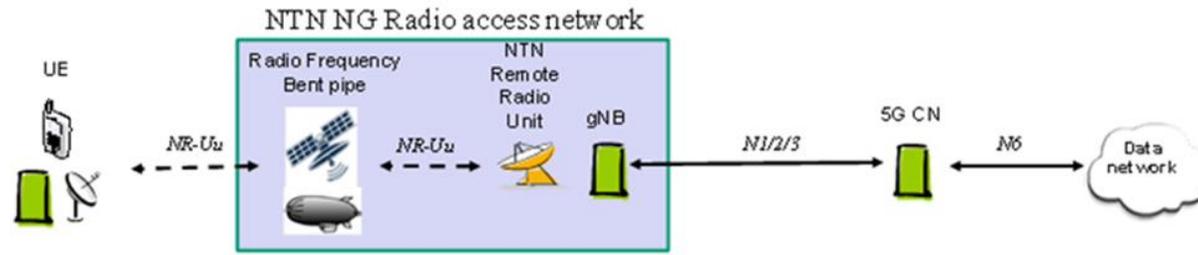


Figure 7.3.8.1.2-1: Mapping option 1 - NG RAN architecture in Non Terrestrial network with bent pipe payload

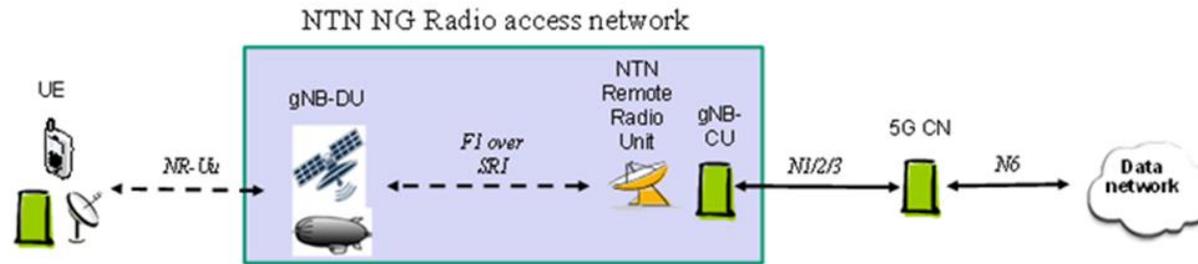


Figure 7.3.8.1.2-2: Mapping option 2 - NG RAN architecture in Non Terrestrial network with gNB-DU processed payload

NOTE: SRI refers to Satellite Radio Interface

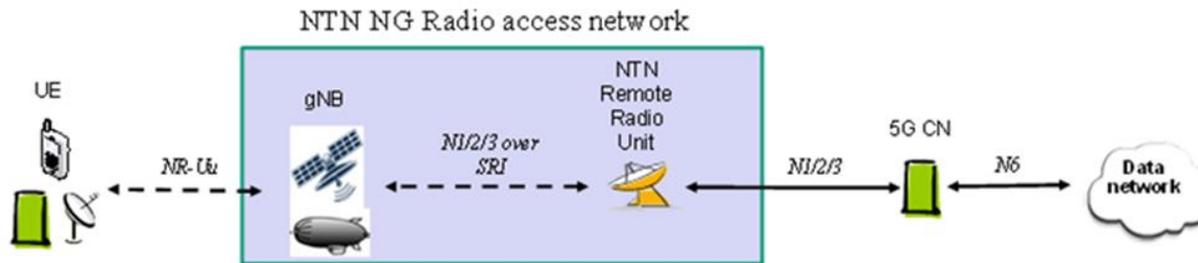


Figure 7.3.8.1.2-3: Mapping option 3 - NG RAN architecture in Non Terrestrial network with gNB processed payload

Conclusions from 3GPP NTN study item

The consensus and wider agreement on the key advantages of satellite networks which can add value to the 5G ecosystem are:

- **Ubiquity:** Satellite provides high speed capacity across the globe using the following enablers: capacity in-fill inside geographic gaps, overspill to satellite when terrestrial links are over capacity, general global wide coverage, backup / resilience for network fall-back and especially communication during emergency
- **Mobility:** Satellite is the only readily available technology capable of providing connectivity anywhere on the ground, in sea or air for moving platforms, such as airplanes, ships and trains
- **Broadcast (Simultaneity):** Satellite and aerials can efficiently deliver rich multimedia and other content across multiple sites simultaneously using broadcast and multicast streams with information centric networking and content caching for local distribution
- **Resiliency:** A key component of 5G is network resiliency. As satellite and aerial networks are not subject to the same weather and man-made disasters that happen to terrestrial communications systems, they bring to the network an important component of resiliency

Sat5G project: [SaT5G Project - Sat 5G \(sat5g-project.eu\)](http://sat5g-project.eu)



Sat5G project partners



Summary

- The integration of terrestrial and space based communications enables truly heterogeneous networks
- Traditional interfaces between systems are breaking down; radio access, trunk communications, satcom, core network, edge computing, service platforms, etc.
- A growing number of industry verticals are requesting mission critical communications systems
- A multi-orbital space strategy provides complimentary connectivity to support an integrated terrestrial & space based communications network, offering enhanced coverage, increased reliability & new ways of building networks & services
- LEO is an exciting new addition to the space based portfolio, enabling global coverage, lower latency, higher system capacity and higher data rates
- The future is service centric, the network is an enabler...



