ETSI Conference on
Non-Terrestrial Networks,
A Native Component of 6G

# Non Terrestrial Networks

## From ubiquitous coverage to full integration and beyond

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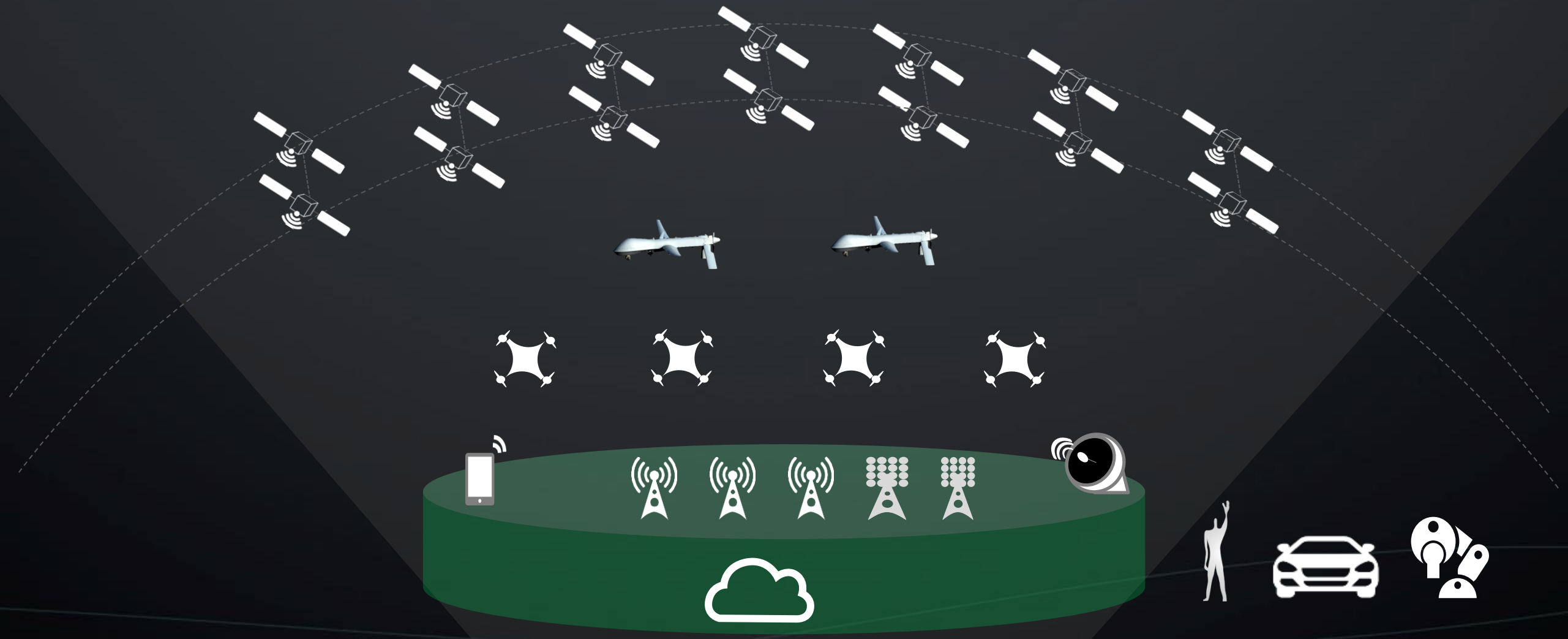
# Content

- Background and Motivation
- Potential challenges and impact on standardisation

# Interworking networks in 6G

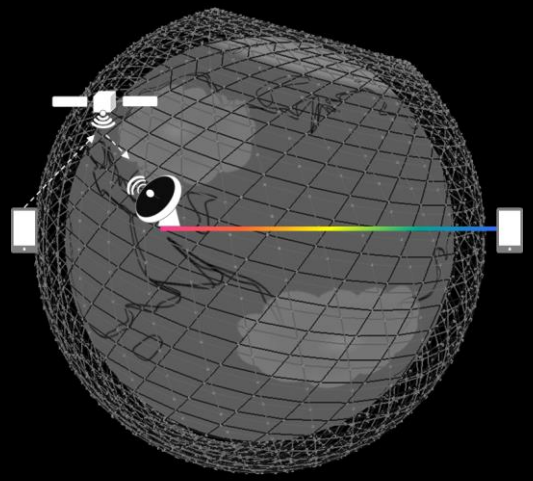


# NTN - Background and Motivations

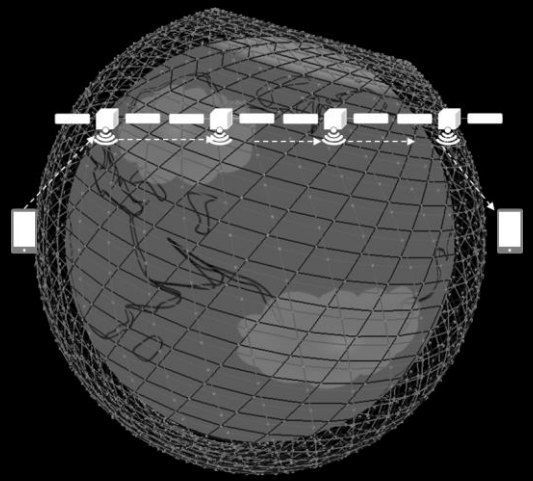
- **Unfavourable geographical and economical obstacles**
  - Gaps in broadband and wireless service deployment and coverage.
- **Significant advances in satellite-related technologies have made the possibility of deploying mega constellations of satellites economically feasible**
  - Reduced equipment and production cost.
  - Reusable launch vehicles has lowered orbit placement cost.
  - Advancements in ION and E propulsion systems can extend service life for LEOs.
- **Improvements in ground-to-satellite and satellite-to-satellite interfaces**
  - Progress in free-space optical (FSO) interfaces and ATP (Acquisition, Tracking and Pointing) systems are making it possible to use FSO interfaces as Inter-Satellite-Links (ISL).
- **Unique service offering for LEO satellite constellations**
  - LEO networks can offer long-distance, low-latency services.

# Different deployment models, different set of challenges

- **Passing the traffic to terrestrial networks at the first available opportunity**
  - Suitable for delay tolerant traffic or where low delay is not a requirement.
  - Covers remote areas within reasonable vicinity to terrestrial networks.
  - Traditional bent pipe model where each satellite is guaranteed to have a GW in its line-of-sight.
  - Multi hop through number of satellites where each satellite can reach a GW via other satellites within its radius.
    - Moderate to heavy use of ISLs

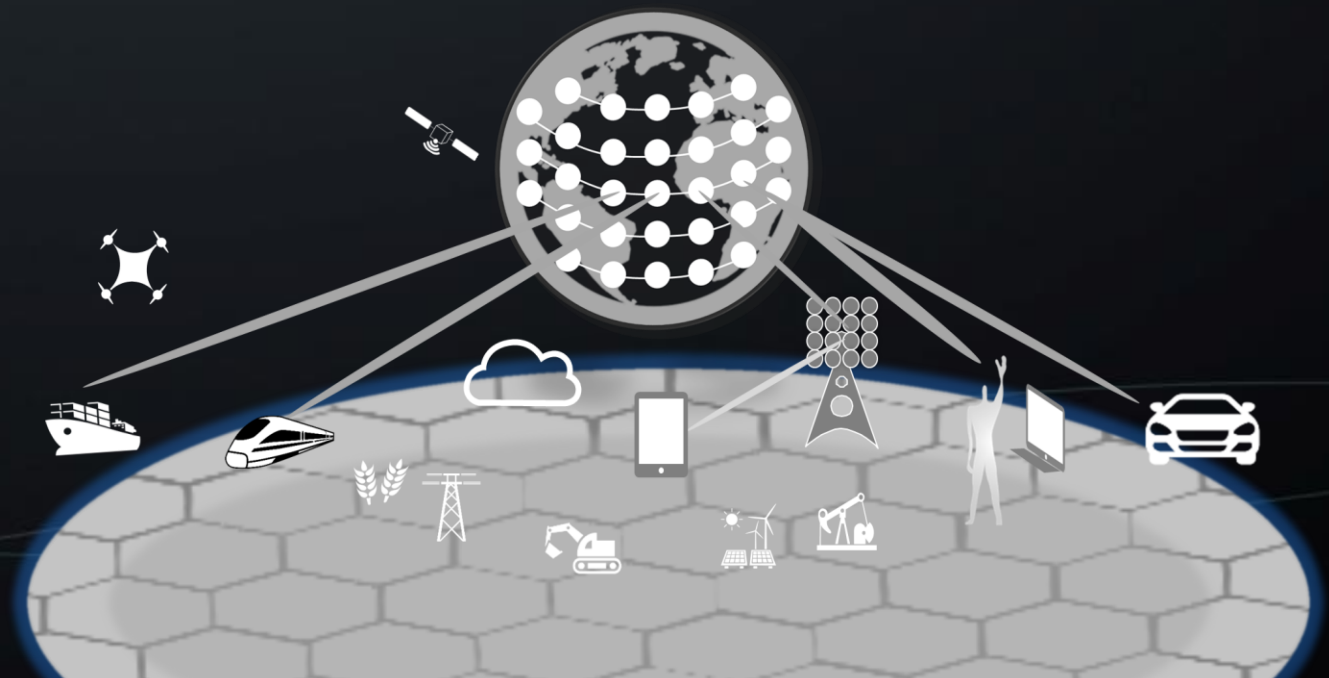


- **End to end traffic handling via satellite networks**
  - Suitable for delay sensitive traffic (e.g. financial transactions).
  - Heavy dependency on ISLs.
  - Potentially requires new approaches to traditional networking methods such as addressing, routing, forwarding, etc.



# Different deployment models, different set of challenges

- **Multi-vendor, multi-operator** (Not supported by existing eco system)
  - Opens the market, encourages competition.
  - Provides service providers and enterprises with the type of flexibility that is offered by terrestrial networks today.
  - Interworking NFs can be placed in different satellites from different satellite operators.
  - Ground station, GWs, and satellites can belong to different entities.
  - Satellite network operators can provide support to different terrestrial operators, enterprises, etc.
  - Prevents customised per operator APIs and interfaces.



# Content

- Background and Motivation
- Potential challenges and impact on standardisation

# Networking Issues （1）

- **Addressing, Routing, and Forwarding are fundamentals of networking.**
  - Network must provide support for scheduled, massive link fluctuations/events and peer adjacency changes.
    - Seam and polar areas in polar constellations.
    - Walker Delta constellation consisting of LEOs with 5+ links.
  - Network must support and safeguard against unpredictable link events.
  - Services carried over NTN are expected to be IP in nature.
  - Existing IP based networks are hierarchical.
  - IP does not lend itself well to nonhierarchical, massive scale networks of thousands of routers and millions of addresses.

    - IP employs address aggregation and topology abstraction to handle large scale networks.
      - Address aggregation: Achieved through wildcarding and best prefix match.
      - Topology abstraction: Achieved via the use of gateways.
        - Employ gateways and hide topologies behind them.
        - Route traffic to the gateways where more granular topologies are available for finer routing.

    - State of the art IP IGPs such as OSPF and ISIS can handle hundreds of routers and hundreds of thousands of addresses.
    - IP does not provide native support for mobility.
      - Additional protocols such as VxLAN are devised to support mobility in IP networks.

# Networking Issues (2)

- **Traditional large scale networking**
  - Aggregation and abstraction are crucial to scaling the network
  - Traditional link state protocols employ address abstraction & region definition to support hierarchy for network scalability.
  - Configuration and network engineering is essential.
    - Area IDs or region definition, interface addresses, etc. are configured attributes.
    - Peer adjacencies, regions, and topologies are established based on the above configured attributes.
  - Changing configuration attributes results in outage and floods to all other nodes in the area.

- **NTN factors**
  - Satellites move w.r.t each other and the earth.
  - Earth rotates under the constellations.
  - Satellites move and swap peers at the poles.
  - Satellites change peers at the seam.
  - All orbits in Walker Delta with 5+ links per satellite exhibit the seam effect

- **Network service orchestration**
  - Integrated/converged TN-NTN consists of nodes with different capabilities (e.g. storage, compute etc.). Resource orchestration and configuration is an essential requirement in service provisioning and delivery.

# Networking Issues（3）

- **Traditional IP mechanisms are not guaranteed to work or perform well in LEO networks**
  - Satellites' movement breaks configurable hierarchal membership mechanisms in traditional networking.
  - The notion of proximity that wraps around the earth is absent in IP and cannot be handled by IP longest prefix match.
  - IP is NOT designed to handle frequent link events and changes in the network.

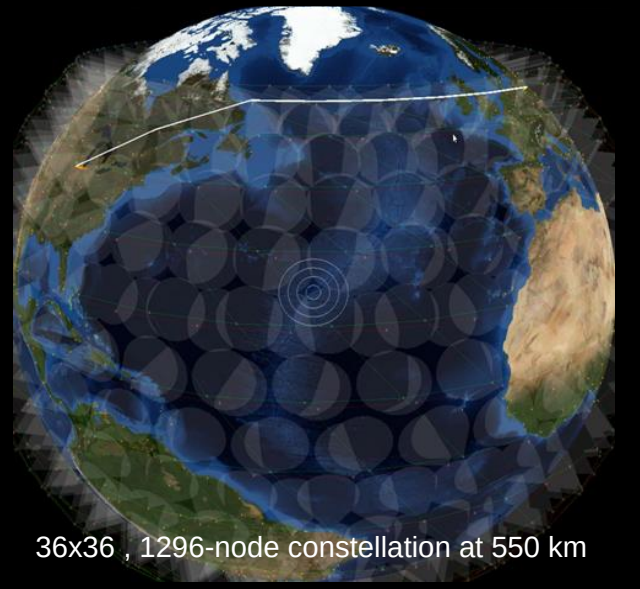
- **Aggregation, topology and address abstraction are key features for handling large scale networks.**
  - Nodes' movement is an obstacle in employing traditional configuration based hierarchy.
  - Satellite networks form a special Manhattan grid and are "FLAT" (i.e. They have no natural hierarchy and are wrapped on the surface of a sphere.)
- **We potentially need new mechanisms to support the hyper dynamic nature of NTN.**

# Coverage and connection stability

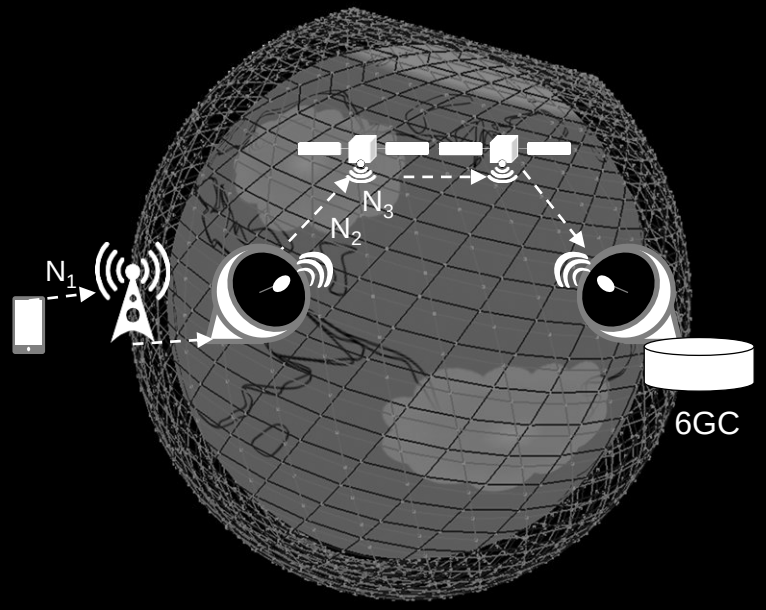
- **Support communications for any combination of**
  1. Inter satellite
  2. Ground Station
  3. Ground Terminals
  4. User Terminals(i.e. UE)

  - Depending on constellation density, ground to ground connectivity and coverage might not be stable and may fluctuate periodically.
    - This may impact data or control plane
    - Ground-based gNB supporting users connecting over NTN network to a remote core.
    - Direct UE connection to satellite must be considered as well (not shown).
    - Support for multiple operators.
    - Delay variations resulting from node movements and path changes.
    - Potential impact on network protocols.

- **Traffic engineering and QoS**
  - Nodes' movement w.r.t earth along with periodic link fluctuations make resource allocation/reservation extremely challenging especially when taking nodes' limited resources into account.

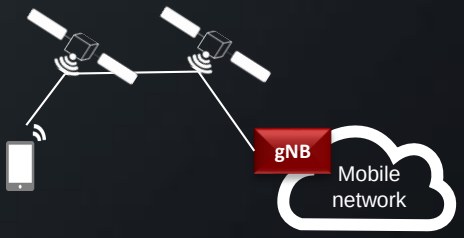


36x36 , 1296-node constellation at 550 km

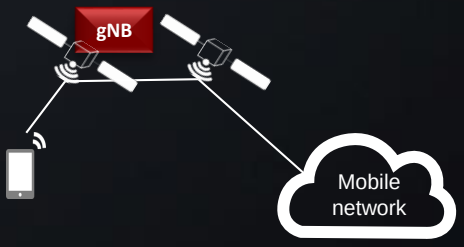


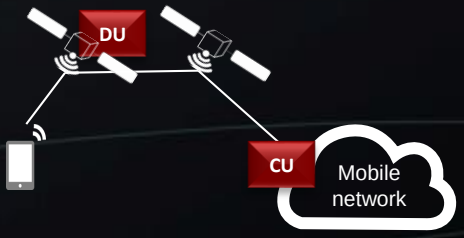
# Some other topics for consideration (1)

- **Mobility faces new challenges**
  - Earth rotates under network equipment
  - Network equipment and nodes move w.r.t each other.
  - Nodes can experience faster user mobility. (Fast moving terminal and UE (e.g. aircrafts).
  - Nodes can potentially experience more traffic variability compared to terrestrial nodes.
  - Hand-over between NTN and TN.




- **NTN configurations and architecture for mobile networks**
  - NTN for backhaul
  - NTN and different fronthaul flavors potentially including
    - LEO as RRH (UE direct connectivity to satellites)
    - LEO as gNB
    - LEO as DU component of access.



# Some other topics for consideration (2)

- **HAPs over urban area**
  - Handling much larger number of users in single gNB, RRH.
- **Power consumption aware routing and traffic delivery (Tidal networks)**
  - Scheduled based networking
  - Advanced power management.
  - Possible temporary traffic reroute and ground transmission based on anticipated power levels (or other factors) between adjacent nodes.
  - Federated/collaborative up/down link attachments to ground stations (GS).
- **Scalability is a major factor which requires special attention at different levels of integrated TN-NTN**

# Standardization Aspects (1)

- **NTN's impact on 6G standardization is derived by applications and use case scenarios such as**
  - Mobile services
  - Delay sensitive services
  - Cloud operators and bulk data transfer
  - Quantum key distribution

1. Transparent architecture where satellites act as relay nodes have been the primary mode of operations of satellite networks and the focus of standardization bodies so far.
2. Emergence of massive multi shell satellite networks with ISLs and compute is changing the above trend. Satellite networks are moving towards regenerative architecture.
3. Satellite technology and NTN related topics are scattered through standards development organizations.
4. Different SDOs have partial responsibilities when it comes to NTN.
5. Effective integration of satellite and terrestrial networks requires investigations and coordination of efforts among different SDOs.

**A wide variety of topics could be addressed including, but not limited to:**

- Use cases
- Architecture
- Scalability
- OAM and operational models
- Multi service and multi tenancy
- Networking, addressing, routing, and forwarding
- Network service orchestration
- QoS and traffic engineering
- Coverage and connectivity
- Mobility and power consumption aware traffic delivery
- High Altitude Platform Stations (HAPS)
- AI/ML for NTN, NTN for AI/ML
- LEOs and NANO satellites as sensors.
- Security and privacy

# Standardization Aspects (2)

- **Some satellite or NTN related activities include:**
  - Definition of broadband over GEO
  - General satellite network issues (e.g. DVB ecosystem)
  - Specific satellite (non-network)  issues (e.g. Regulatory)

- **Some network aspects are not new, but must now be examined in view of**
  - New dynamics and scale of LEO networks
  - New services may now require remote access (e.g. IOT)
  - New platforms (e.g. HAPS)

- **Sstandardisation efforts are in their very initial stages**
  - Some mobile operators and equipment manufacturers in partnership with satellite operators are starting to support basic services via proprietary solutions.
    - Location services
    - Emergency SOS
    - Short, predefined text messages

- **Applicability, feasibility, and the use of different networking technologies can be very useful**

# Closing Remarks

- **ETSI is in a unique position to make an impact on NTN standardization**
- **ETSI-led studies of NTN-TN integration in 6G can help paving the way towards standardization at an early stage**
- **These studies can build consensus by providing an arena that**
  - Brings together ETSI and non ETSI members from both industry and academia
  - To debate, study and investigate a wide variety of topics related to the integration of regenerative architecture NTN and terrestrial networks.
- **ETSI can propose use case scenarios, suggest requirements, work on solutions, and identify + liaise with appropriate standards bodies to further develop normative standards**

**Time to influence NTN related standardisation is now**

# Thank You.