TSN Profile for Terrestrial Space and Multi Orbits Satellite to Satellite Communications

An individual view and contribution initiating Discussion

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Introduction and Purpose

Background

P802.1DP – TSN for Aerospace Onboard Ethernet Communications is near completion as its SA ballots closed and it is proposed to go forward to RevCom at the July losing Plenary.

Scope of P802.1DP standard: This standard specifies profiles of IEEE 802.1 Time-Sensitive Networking (TSN) and IEEE 802.1 Security standards for **aerospace onboard bridged IEEE 802.3 Ethernet networks**. The profiles select features, options, configurations, defaults, protocols, and procedures of bridges, end stations, and Local Area Networks to build deterministic networks for **aerospace onboard communications**.

What's Next?!

Interest in Aerospace communication networks, SatComs and Space to Space Networks is growing with many constellation network already deployed and being extends and many more are being deployed – Starlinks, Kuiper, IRIS^2, Qianfan, Eutelsat OneWeb, C-LEO, and many more …

Terrestrial Space transport networks (i.e. integrated terrestrial and Inter-Satellite links) are currently being deployed with proprietary solutions to support various Satellite services, including IMT2030 envisaged **NTN use cases*** and governments services.

Non-Terrestrial Networks have been part of 5G since 3GPP Rel-17 and the use of NTN related technologies enables global coverage for a wide range of applications that require both high availability and high resilience.

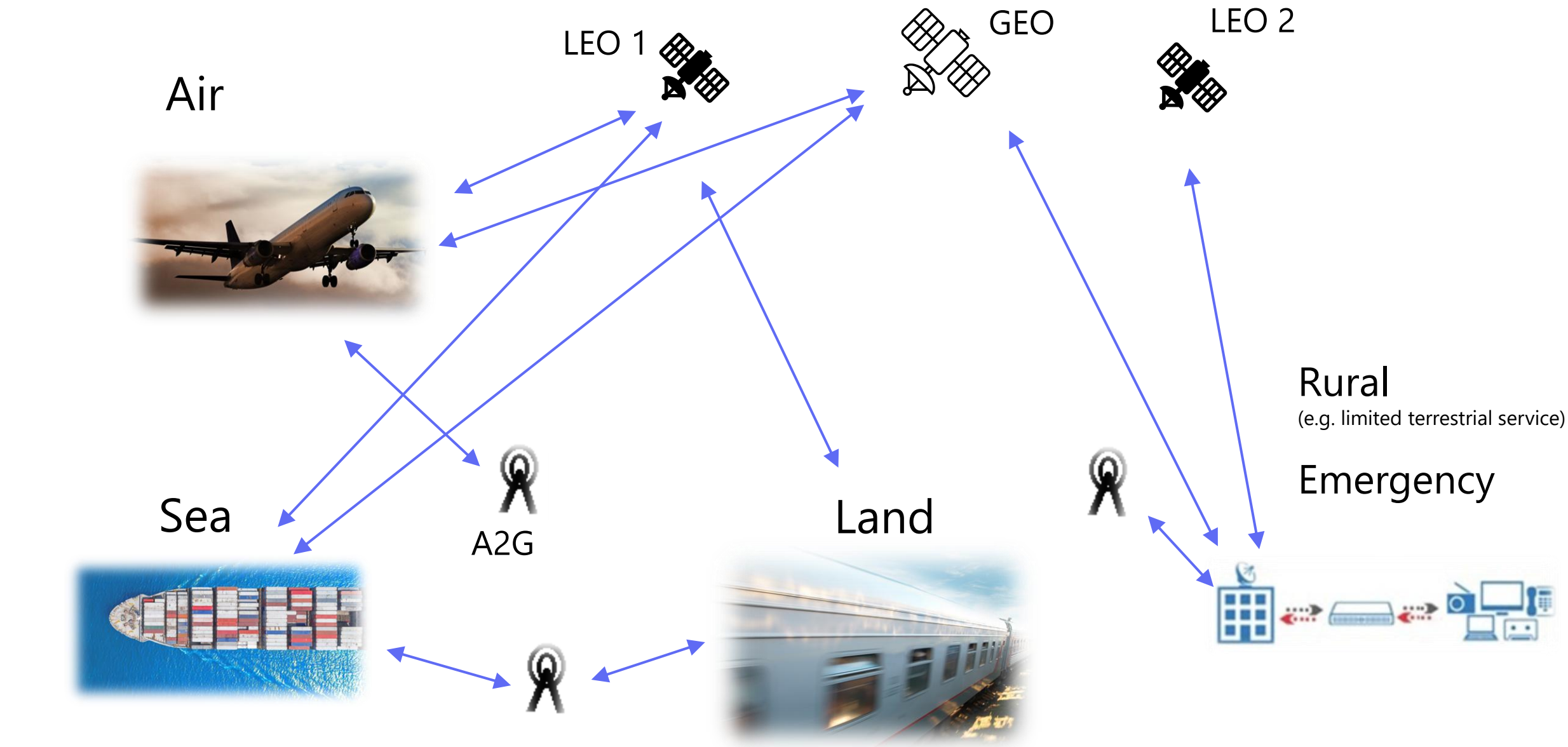
***See GSOA slide at the back**

Purpose

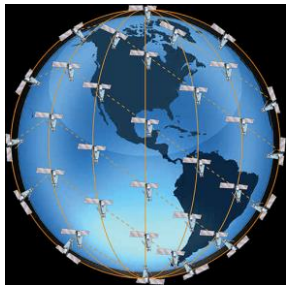
The purpose of this contribution is to trigger discussion within the WG and check if there is interest in working on a new project to either extend IEEE802.1DP (via an Amendment project) or initial new project to develop TSN Profile for Terrestrial Space and Multi Orbits Satellite to Satellite Communication transport network for payloads and inter satellite communications and services.

To help the discussion, an overview of a typical SatCom networks and topologies with focus on its transport network domain is briefly described in the following slides

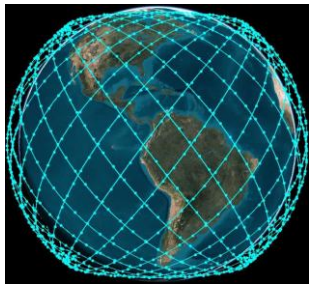
TN and NTN scenarios



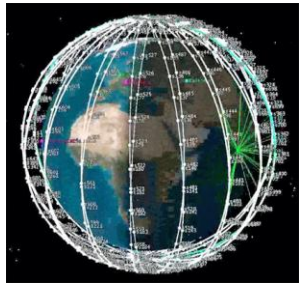
Examples of LEO satellite constellation



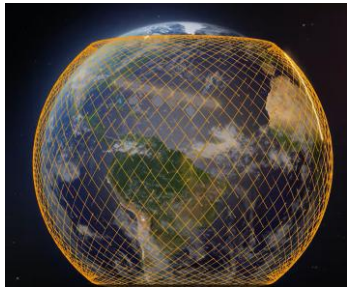
Iridium satellite constellation
- 66 active satellites
- 6 planes,



Starlink satellite network:
- 7,000 satellites (as of Sep 2024)
- 12.000 satellites in 1st phase

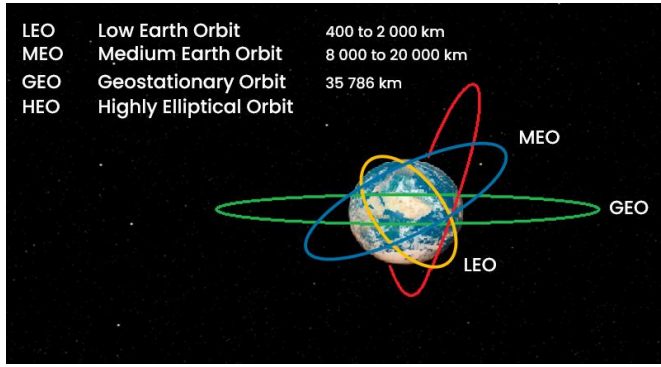


Eutelsat - OneWeb constellation
- 720 planned satellites in polar orbits



Amazon Kuiper satellite constellation:
- 2 prototype satellites (as of Jan 2025), planned for 3,236 satellites operating in 98 orbital planes
- in 3 orbital shells (590/610 /630 km alt)

Simplified Example overview of Satellite Transport network



MEO
7000 – 25000 km

ISL

Access Sat.

Access & feeder Sat.

Feeder Sat.

ISL

LEO 300 – 1500 km

Feeder

Feeder

UAS 8 – 50 km

RF links. Feeder or 3GPP NR Uu

optical links. Inter-Satellite links

Terrestrail transport backhaul network

Service

Pub
UT

Gov
UT

GW
Earth Station

GW
Earth Station

5GC
EPC

data center

SatCom constellation impact on bridged Network

- All satellites act as a bridge in a bridged network
- Satellites in the LEO and the bridges are in constant movement across their orbits; however, their movements (path, current and future locations) are predetermined and known to the Satellite operation center and can be shared with ethernet Controller (CNC or whatever management entity for that matter).
- ISL links are FSO with capacity expected in excess of 100Gbps (200Gbps already demonstrated by some constellations)
- Feeders' links are mainly radio (some hybrid are being studied), either case, feeder link is the bottle neck and GW and feeder paths diversity is required high availability and resiliency.
- Satellites spacing (distance between satellites) depends on orbit. In LEO the distance is between 100 and 2000 km (some reported in excess of 3000km in small constellation)
- Propagation delay between satellite in LEO and GW is roughly between 2 ms (Satellite at the Zenith) – 9 ms (satellite at the horizon)
- Bridges are dynamically changing (i.e. satellites connection to GWs as well inter-orbit ISL – intra orbit ISL may change in case of a failed or out of service satellites)
- Some network problems requiring TE solution:
  - Failed Bridges (failed or out of service satellite)
  - Feeder links outage (due to weather) or experiencing congestion
  - ISL congested or failed
- Need to isolate public/commercial traffic from the government traffic.
  Government traffic is prioritized.
- Others considerations to address …

Potential NTN Use Cases in 6G

Immersive Communication

- Direct connectivity to smartphones/wearable devices in light indoor/in car scenarios
- High speed broadband connectivity to transportation platforms (Trains, aircraft, vessels)
- Fast set-up of connectivity to an area/theater of operation (for utilities and public safety)

Artificial Intelligence and Communication

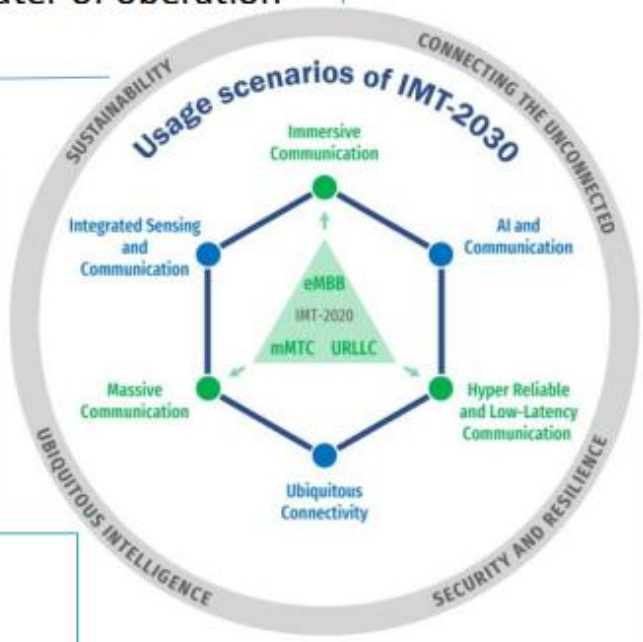
- Content distribution for media applications

Hyper Reliable and Low-Latency Communication

- PNT augmentation to enhance accuracy, reliability, and resilience of location-based services, where GNSS is an issue
- Low latency service over long distance

Integrated Sensing and Communication

- Safety critical applications
- JSAC (Joint Sensing & Communications)



Usage scenarios and overarching aspects of IMT-2030

Massive Communication

- Data collect from a wide area (e.g. utilities, agriculture, public safety)

Ubiquitous Connectivity

Broadband connectivity to:

- land vehicles
- drones (or UxV)
- homes and small offices
- aircrafts

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