6G via Satellite

PEPR: réseau du future, Atelier NTN
3rd Juin 2025
20 min

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3GPP NTN technology is being rolled-out

Deployment scenarios	A	B	C	D	E	F
Service	IoT-NTN, Messaging & voice			Broadband		
3GPP NTN RAT	IoT-NTN	IoT-NTN	IoT-NTN	NR-NTN	NR-NTN	NR-NTN
Orbit	GSO	NGSO	NGSO	NGSO	GSO	NGSO
Duplex mode	FDD	FDD	TDD	FDD	FDD	FDD
Payload	Transparent	Transparent/Regenerative			Transparent	Regenerative
Bands	Below 7.125 GHz (e.g. L/S bands)				Above 10 GHz (e.g. Ku/Ka band)	
Targeted devices	IoT & Smartphones (D2D)			Smartphones	Fiexed and Mobile VSAT	
Potential SNOs	*EchoStar Viasat/Inmarsat Ligado TerreStar Solutions Thuraya*	*Sateliot OQT EchoStar OmniSpace*	*Iridium*	*Echostar, MSS-A*	*Hispasat Intelsat, JSAT, KTSAT, Ovzon Eutelsat Group*	*SpaceRISE Eutelsat Group*

Earliest service opening for each scenario (and related 3GPP releases)

6G-NTN: 2 family use cases

- Satellite **connectivity to smart phones and IoT devices** (D2D) in frequency bands **up to 7.125 GHz**
  - enhanced performances compared to 5G (data rate, coverage, throughput, ..)
  - **Potential new spectrum: e.g. see ITU WRC-2027 AI**
    - **1.12: New MSS allocations for low data rate NGSO**
    - **1.13: New MSS allocations in certain bands below 2.7 GHz identified for IMT to complement terrestrial coverage (D2C)**
    - **1.14: New MSS allocations**
- Satellite **connectivity to vehicle/building mounted devices** (Flat Panel Antenna) in frequency bands **above 10 GHz** (e.g. Ku, Ka, Q/V band).
  - Terminal (SWAP) adapted to vehicles from the automotive, public safety, transport (aeronautic, railways, drone, maritime), utilities, agriculture and media & entertainment sectors are assumed.
  - **Potential new spectrum: Q/V band**

NTN in 6G: Service Requirements (via satellite access network)

Improved user experience

- **Improved service continuity** over the coverage
  - Enhanced NTN/TN mobility/multi connectivity especially in connected mode
- **Improved coverage**
  - Provision of emergency services (at least SMS) via satellite in light indoor/in vehicle conditions
  - Mobility in sub-urban/dense forest (i.e. several hundred ms fading duration)
- **Support of device diversity**
  - Handheld/IoT, vehicle/drone mounted
- **Improved data rate/throughput**

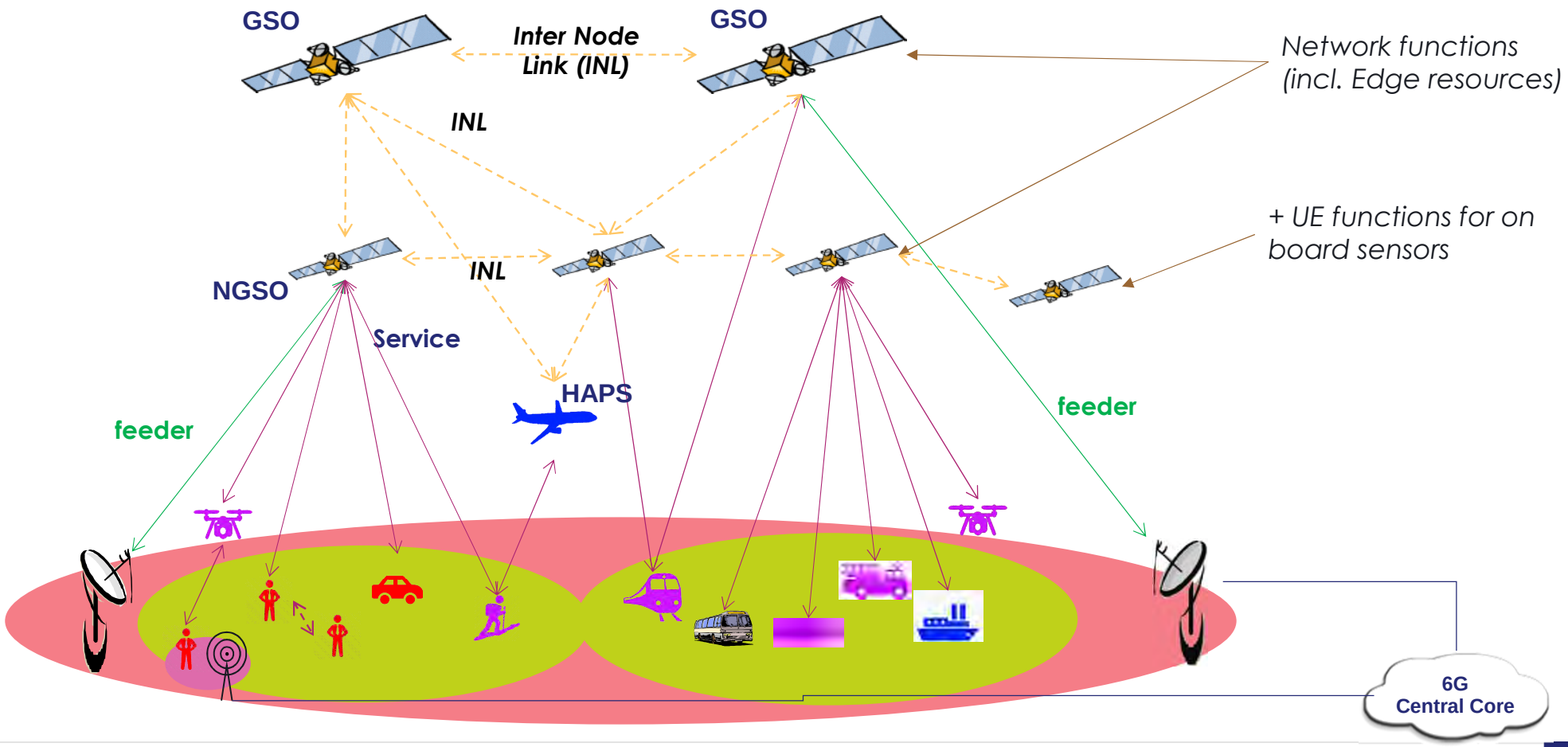
Improved network capabilities

- **Resiliency**
  - GNSS independent operation (i.e. initial access, ..)
  - GNSS independent capability for the UE to determinate its location
  - Service continuity with respect to temporary failure of a given node (e.g. NGSO, GSO, HAPS, TN node);
  - Fast set-up of an autonomous network over a specific region via satellite(s) and/or HAPS with no or intermittent connectivity to core networks (e.g. for crisis response)
- **Sustainability**: Minimise overall consumption
  - Energy based access network selection: under traffic or zero traffic conditions
- **Overall spectrum usage efficiency**
  - Multi access technology spectrum coexistence (i.e. NTN/TN)

NTN in 6G: Possible performances

Target service performances	NTN in 5G (As per 3GPP &/or ITU-R IMT2020 satellite requirements)	NTN in 6G
Peak data rate (DL/UL) wrt smartphones & low cost IoT devices	1/0.1 Mbps (Outdoor only) @ up to 3 km/h	Outdoor conditions: Tens of Mbps @ up to 250 km/h Light indoor/in car conditions: At least Short Message Service capability
Peak data rate (DL/UL) wrt Vehicle or drone (flying and surface) mounted devices	[50/25] Mbps @ up to 250 km/h (with 60 cm aperture)	Hundreds of Mbps (Outdoor only) @ up to 250 km/h (with <20 cm equivalent aperture)
Peak data rate (DL/UL) wrt Large Aeronautic, maritime platforms mounted devices	[50/25] Mbps @ up to 1000 km/h	Thousands of Mbps (Outdoor only) @ up to 1200 km/h (with <60 cm equivalent aperture)
Location service (target accuracy and acquisition time) in outdoor conditions only	respectively 1 meter and < 100 seconds (reliability through Network verification)	respectively 100 meter (TBC) @ 95% reliability through RAT dependent positioning method
Coverage	Outdoor only	Maximum Coupling Loss able to address light indoor/In car

NTN in 6G : 3D Network architecture concept



Sustainability in NTN for 6G

Mega constellation based satellite network:

- **a LEO space segment** able to provide global coverage but **oversized to meet a peak traffic demand over a specific geographical area** and setting high constraints on the coexistence with other constellations,
- **satellites with short lifetime** leading to high replacement rate,
- a relatively **high average power consumption of the terminal** due to continuous tracking of the successive serving satellites.

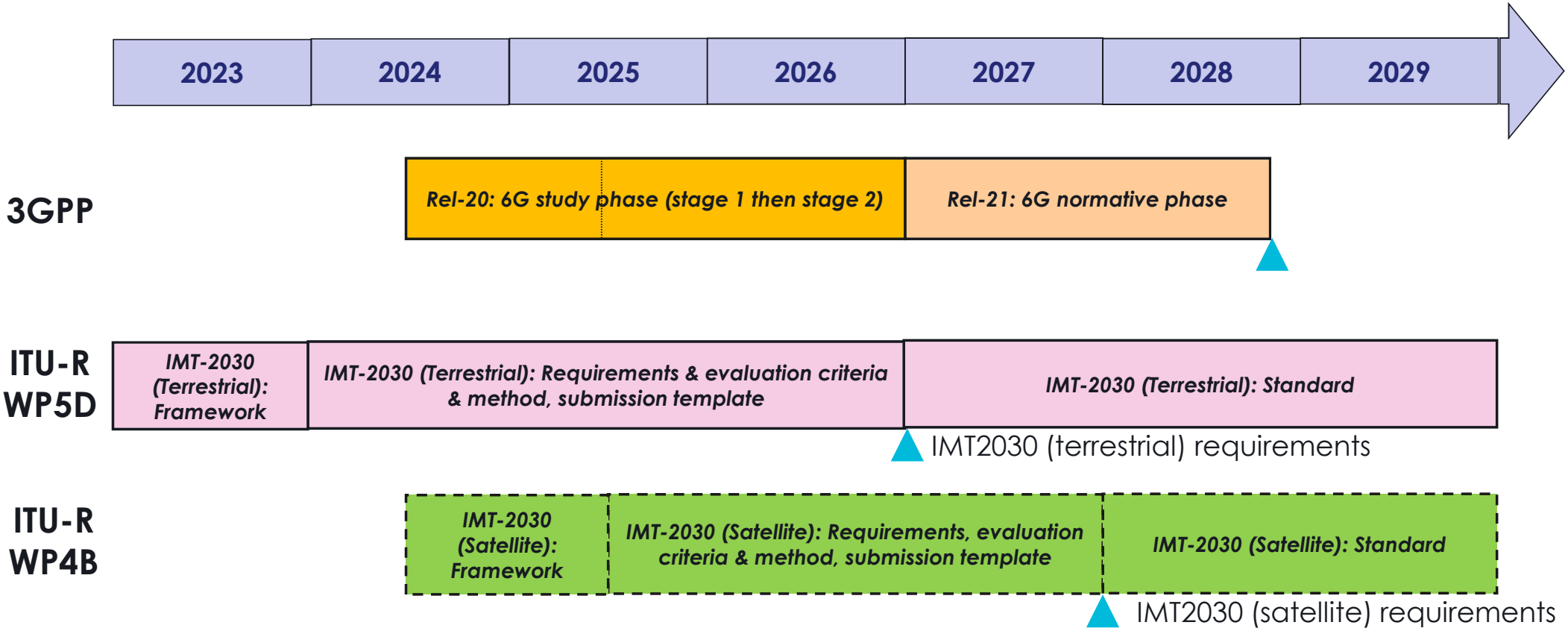
Vs Multi orbit satellite network

- ***space segment level***
  - Take advantage of
    - GEO for broadcast/multicast traffic, and common signalling (e.g. idle mode)
    - MEO for navigation and broadband traffic
    - LEO for broadband traffic
  - Optimization of
    - LEO sizing (overall mass to be launched) to the average traffic demand
      - => off load to MEO or GEO the geographically localized and/or temporary peak traffic demand,
    - LEO and MEO space segment power and extended lifetime
      - => Beam deactivation when no traffic demand

- ***Terminal level***
  - Energy saving:
    - served via the GSO space segment when in idle mode state. (no satellite tracking)

6G TN & NTN: 3GPP and ITU-R

TN = Terrestrial Network
NTN = Non Terrestrial Networks (Satellite, HAPS)



Calendar is driven by the terrestrial component of 6G !

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Nicolas Chuberre

5G/6G Solution Line Manager

+33 6 80 94 84 32

nicolas.chuberre@thalesaleniaspace.com

Note that

- *the views expressed in this presentation may not necessarily be the ones of Thales Alenia Space*
- *Part of the content of this presentation leverages the outcomes of the Horizon Europe 6G-NTN R&D project*

Some references

- « 3GPP Non-Terrestrial Network: A Global Standard for Satellite Communication Systems », Special Issue of the International Journal of Satellite Communications and Networking, Pages: 217-301, Edited by Mohamed El Jaafari and Nicolas Chuberre, published by Wiley, May/June 2023,
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