

Non-Terrestrial Networks (NTN)

3GPP 6G Standardization: From
Study to Specification
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Agenda

- >Part 1: 5G NTN concept and status
- >Part 2: NTN in 5G at 3GPP
- >Part 3: 6G NTN concept
- >Part 4: NTN in 6G at 3GPP
- >Part 5: Conclusion



Part 1: 5G NTN concept and status

3GPP defined Non-Terrestrial Network: Overview

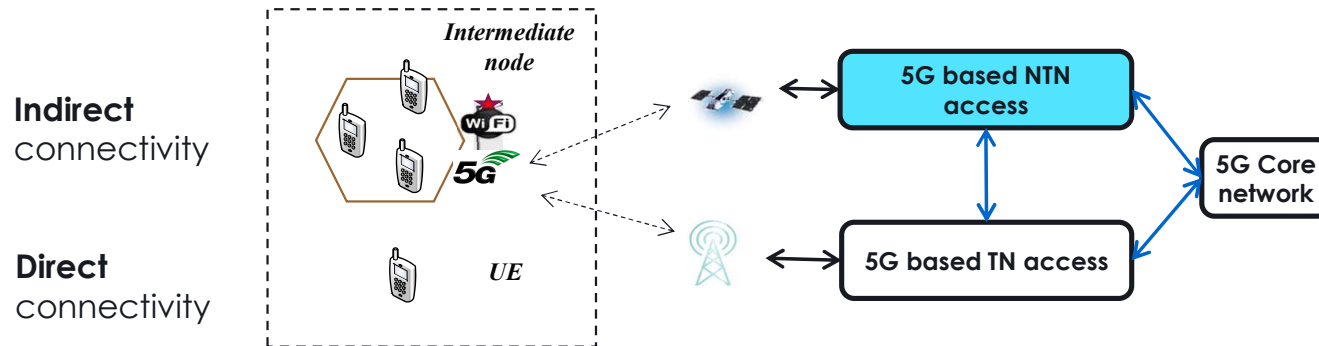
3GPP NTN: the **first and true global and open standard for all SatComs** (any device, orbit, service, frequency bands, beam size/type) and **supported by the 3GPP eco system** (satellite, mobile and vertical stakeholders)

NTN added value wrt TN: service continuity and reinforced reliability/availability

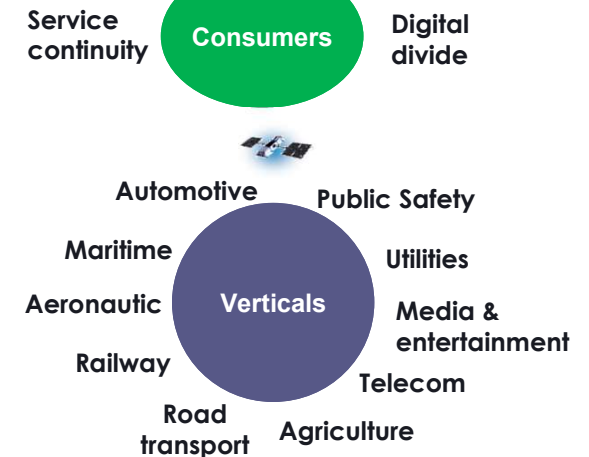
3 NTN reference scenarios wrt terminal types:

- **IoT devices** (Narrowband: hundreds of kbps) in < 7 GHz
- **Smartphones/vehicle** (Wideband: few Mbps) in < 7 GHz
- **Flat panel antenna terminal** on moving platforms (Broadband: hundreds of Mbps) in > 10 GHz

Radio Access Network: **mobility** across the access technologies



Targeted use cases

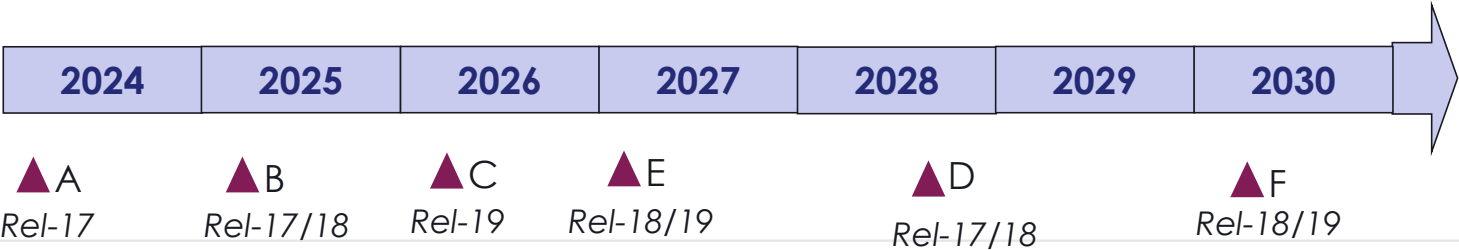


Common 5G technology framework to best manage (Perf., QoS, Security, Slicing) across the access technologies

3GPP NTN technology is being rolled-out

Deployment scenarios	A	B	C	D	E	F
Service	Messaging, voice, narrowband data			Wideband	Broadband	
NTN Radio Access Technology	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	Internet of Things & Smartphones (D2D)			Smartphones (D2D)	Fixed and Mobile VSAT	

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





Part 2: NTN in 5G at 3GPP

3GPP NTN standard: Release 17 & 18 features

- (Non) Geostationary Earth orbiting satellites
- Transparent payload architecture

- Addressing identified specific NTN issues
 - delays & Doppler: Extended & variable propagation
 - Radio cells: Wide, possibly moving, possibly cross borders.
 - Service continuity between Terrestrial Network and NTN.
 - Propagation impairments: channel, payload
 - Spectrum: satellite service allocated frequency bands (< 6GHz, >10 GHz)

Implicit compatibility to support HAPS (High Altitude Platform Station) and ATG (Air To Ground) scenarios

UEs with
GNSS
capabilities

FDD

Earth fixed
Tracking area



Highlights of 3GPP normative activities for NR-NTN in 5G/5G advanced

Areas	Rel-17	Enhancements in Rel-18, 19	Rel-20
Service requirements	Support of Direct to smartphones/IoT devices and broadband	IMS UE-SAT-UE, Emergency communication (text based via GEO), Resilient notification,	IMS call via GEO, non IMS UE-SAT-UE
System architecture	5G core support NR-NTN access	NR-NTN for satellite backhaul, Store and forward (S&F), IMS based UE-SAT-UE	Non IMS based UE-SAT-UE, Voice call over NB-IoT via GEO Ultra Low Bit Rate Voice codec
Radio Access network aspects	UL time and frequency synchronisation, UL/DL Timing relationship, Enhanced HARQ, Polarisation signalling for VSAT, ...	Network Verified UE location, UL coverage enh, mobility enh (NTN/NTN and NTN/TN mobility), DL coverage enh, broadcast, UL capacity enh, 4G TN/5G NTN idle mode mobility, Regenerative payload (gNB)	GNSS resilient NR-NTN Physical Layer operation 4G TN/5G NTN connected mode mobility Semi-persistent scheduling for DL/UL data transmission for voice packets
Spectrum	Below 7.125 GHz (FR1-NTN numerology): L, S bands in FDD mode	Below 14.5 GHz (FR1-NTN numerology): other L/S, Ku, extended L bands in FDD mode, L band in TDD mode Above 10.0 GHz (FR2-NTN numerology): Ku, Ka band in FDD mode	HD-FDD mode and Carrier Aggregation
Targeted terminals	FR1-NTN: Smartphone/IoT Devices (PC1: 23 dBm)	FR1-NTN: RedCAP UE, High Power UE (handheld, non handheld) FR2-NTN: Fixed VSAT for GSO/NGSO, Mobile VSAT only for GSO	FR1-NTN: High Power UE (handheld), HD-FDD FR2-NTN: Mobile VSAT for NGSO, HD-FDD



Part 3: 6G NTN concept

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, ..)
- ▶ 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.

6G-NTN : Potential new capabilities

PNT: Positioning Navigation and Timing
ICAS: Integrated Communication and Sensing

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 adverse propagation conditions (e.g. 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**
 - E.g. MIMO ?

Improved network capabilities

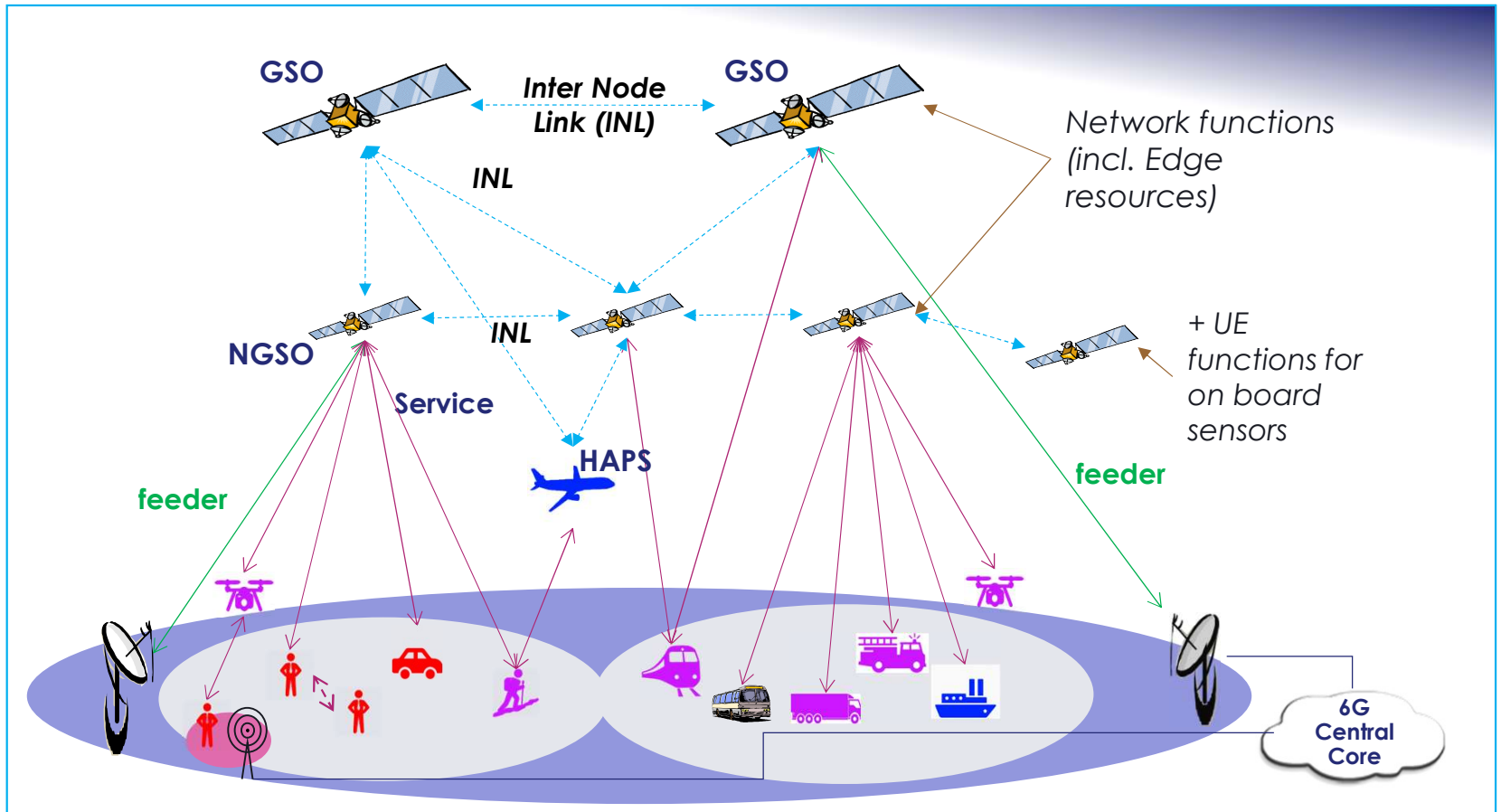
- **Resiliency**
 - GNSS independent access operation and PNT service
 - Service continuity with respect to temporary failure of a given node (e.g. NGSO, GSO, HAPS, TN node);
 - Fast set-up of an autonomous NTN over a specific region with no or intermittent connectivity to core networks (e.g. for crisis response)
- **Sustainability**: Minimise overall energy consumption
 - Energy based access network selection: under traffic or zero traffic conditions
- **Overall spectrum usage efficiency**
 - Enhanced spectrum coexistence (i.e. NTN/TN)
 - Flexible duplex mode: FDD, TDD, HD-FDD
- **ICAS**
- **New orbits**
 - +VLEO (300 to 600 km altitude) and GSO
- **Artificial Intelligence**
 - For dynamic channel adaptation, efficient resource scheduling, autonomous operation and maintenance,

6G-NTN : Possible performance targets

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: several of Mbps @ up to 250 km/h Adverse propagation conditions (e.g. light indoor): At least Messaging 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)	~50 Mbps (Outdoor only) @ up to 250 km/h (e.g. 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	Hundreds of Mbps (Outdoor only) @ up to 1500 km/h (e.g. 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)	From 3-5 to 100 meter (TBC) @ 95% reliability through RAT dependent positioning method
Coverage	Outdoor only	Increased maximum Coupling Loss able to address adverse propagation conditions (e.g. light indoor/In car)

6G-NTN : 3D Network architecture concept

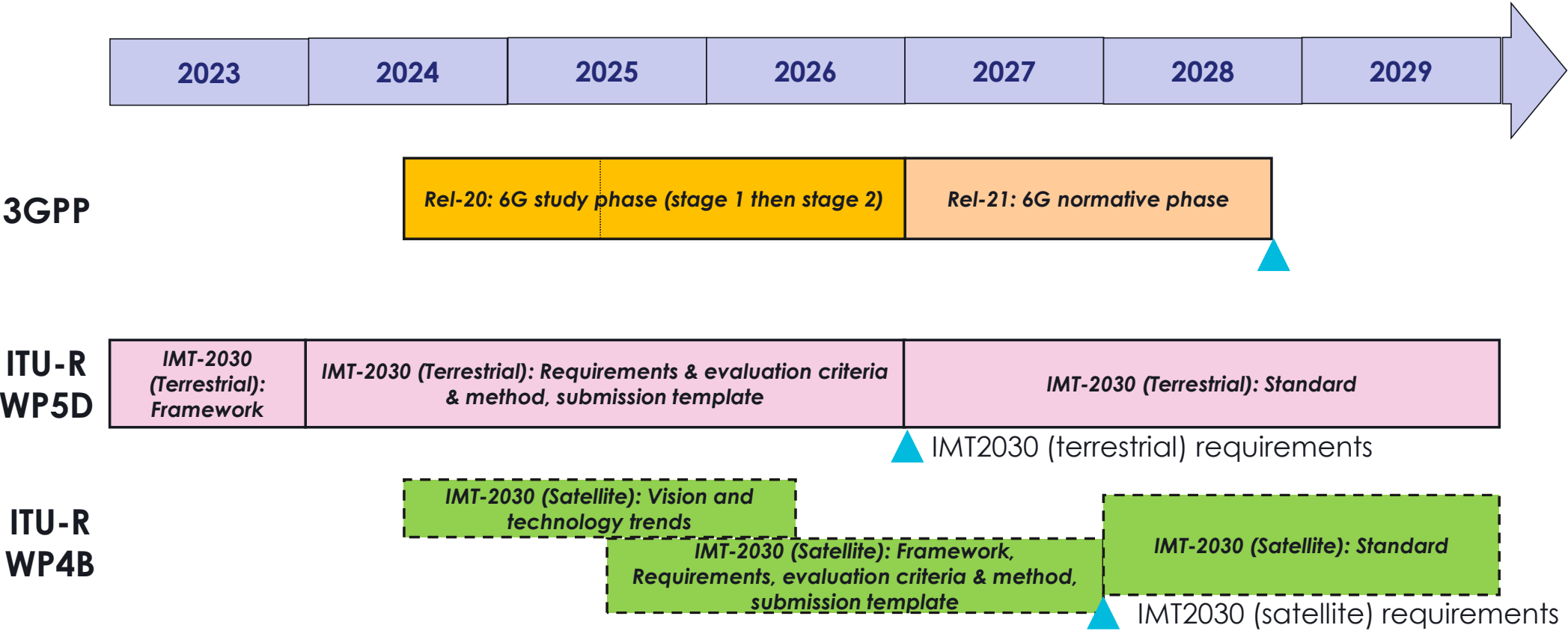
Towards Telecom,
Navigation,
Observation
convergence ?





Part 4: NTN in 6G at 3GPP

3GPP and ITU-R timelines for 6G





Recommendations on 6G radio interface features for the support of NTN

PRELIMINARY DRAFT NEW

ITU-R REPORT ON A FRAMEWORK FOR SATELLITE RADIO INTERFACE(S) OF IMT-2030

- **GNSS independent access operation**
- **GNSS independent Positioning, Navigation and Timing service (PNT)**
- **Enhanced coverage**
- **Enhanced satellite service area**
- **Enhanced transmission efficiency**
- **No retransmission**
- **Flexible duplex mode support at User Equipment level**
- **Support of HD-FDD at Network side**
- **Massive messaging capability**
- **Seamless terrestrial/satellite component mobility in connected mode**
- **Migration of an IMT2020 Satellite component to IMT2030**
- **Integrated Communication And Sensing (ICAS)**
- **Enhanced Mobility interruption**
- **Interference mitigation technology**
- **Enhanced beam management**



3GPP on going standardisation activities on 6G

Std projects	3GPP tDoC	Target completion	Scope (NTN related)	Outcomes
Rel-20 SA1 led SID 6G use cases and service requirements study item ph1	SP-241391	March 2026	Proposal of NTN related use cases for at least ubiquitous coverage but also system operations (Last use cases can be introduced in august meeting)	TR 22.870
Rel-20 SA2 led Study on Architecture for 6G System	SP-250806	[Dec 2026]	- WT#2: Study migration and interworking, including - How to support interworking between 6GS and 4G/5G NTN/satellite access that use EPS/5GS. - WT#7: Study how to support 6G RAT for NTN, based on RAN decision, and support service continuity aspects. - NOTE 8: The detailed scope for WT#7 will be coordinated and aligned with RAN	TR 23.801-01
Rel-20 RAN led Study on 6G Scenarios and requirements	RP-250810	June 2026	Performance Requirements Deployment scenarios Functional Requirements <i>j) Aim at a harmonized 6G Radio design for TN and NTN, including their integration..</i>	TR 38.914
Rel-20 RAN1 led Study on 6G Radio	RP-251881	March 2027	Radio interface and radio access aspects	TR 38.9XX, 38.8xx



Part 5: Conclusion

Conclusion

> Key Takeaways

- ▶ 3GPP has defined most enablers for 5G system to support most satellite network deployment scenarios
- ▶ Satellite eco system has started to deploy 5G NTN based satellite networks
- ▶ 3GPP is starting to work on 6G system aiming at supporting from day one, both terrestrial and non terrestrial network components

> Next Steps

- ▶ At stakes,
 - definitions of enhancements to optimise performances of 5G satellite networks
 - Smooth migration from 5G-NTN to 6G NTN for in orbit/soon to be launched satellites



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Note that

- the views expressed in this presentation may not necessarily be the ones of Thales Alenia Space*

Some references

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 - <https://onlinelibrary.wiley.com/toc/15420981/2023/41/3>
- « 5G Non-Terrestrial Networks » by Prof. Alessandro Vanelli-Coralli, Mohamed El Jaafari, Nicolas Chuberre, Gino Masini, Alessandro Guidotti, published by Wiley-IEEE Press, 12th January 2024
 - <https://www.amazon.co.uk/5G-Non-Terrestrial-Networks-Vanelli-Coralli/dp/1119891159>
- Other sources:
 - Horizon Europe 6G-NTN project, <https://6g-ntn.eu/>
 - Horizon Europe 6G-NTN² NEXUS project

