



6GNTN

NON-TERRESTRIAL NETWORK (NTN) IN 6G

6G-NTN technical manager

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Hexa-X-II 6G series workshop


E-meeting, 13th February 2024



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Research and Innovation SERI

6G-NTN

Facts and figures



Addressing call: "[SNS-2022-STREAM-B-01-03: Communication Infrastructure Technologies and Devices](#)"



Overall goal: Develop an NTN component fully integrated with the 6G infrastructure able to provide enhanced Mobile BroadBand (eMBB) and Ultra Reliable Low Latency (URLL) services to vertical industries and consumers terminals in outdoor and light indoor conditions.



Targeted TRL: 2 - 4



Duration: 36 months

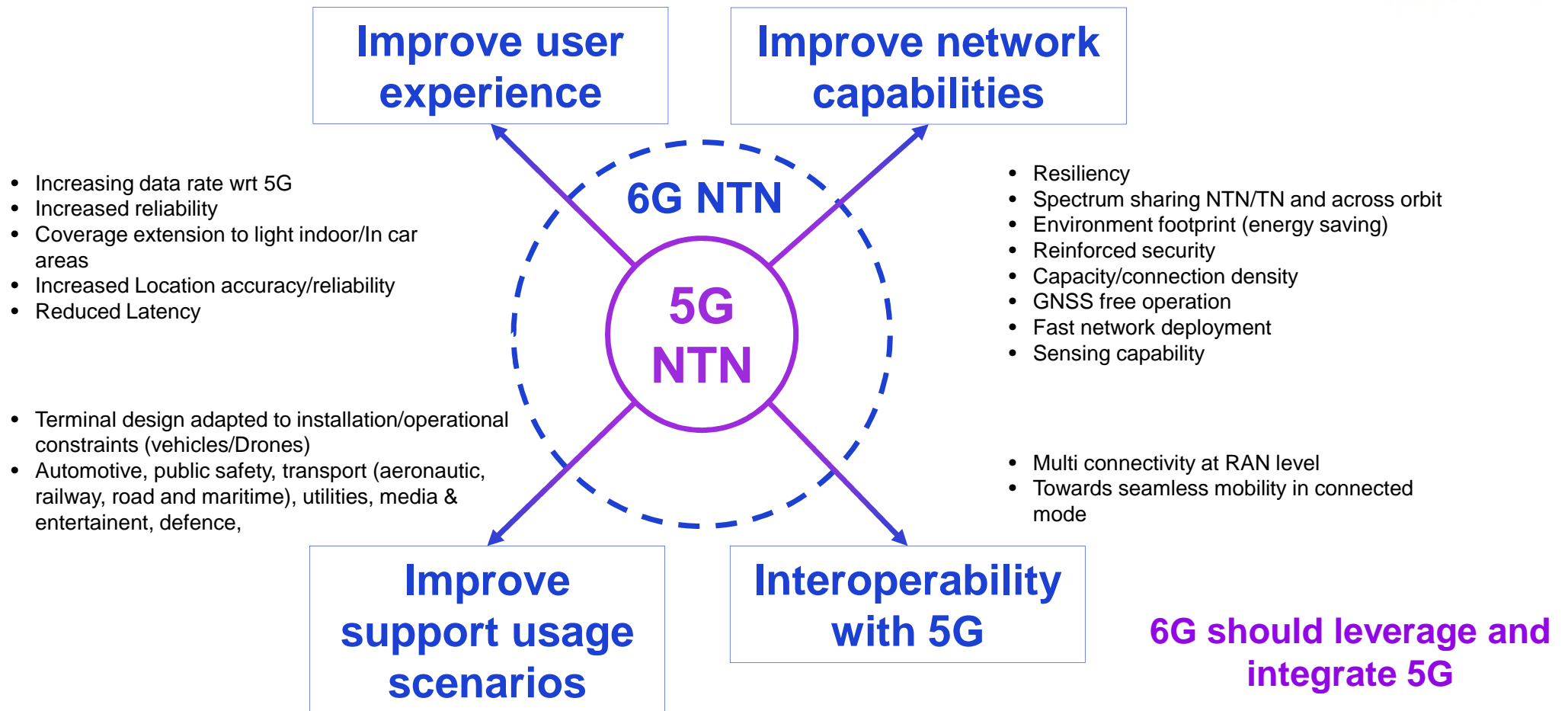


Project kick-off: 1 January 2023

Alessandro Vanelli-Coralli, Project Coordinator (UniBo), **Nicolas Chuberre**, Technical Manager (TAS-F), **Sandro Scalise**, Innovation Manager (DLR), **Monique Calisti**, Communication & Dissemination Manager (MAR)

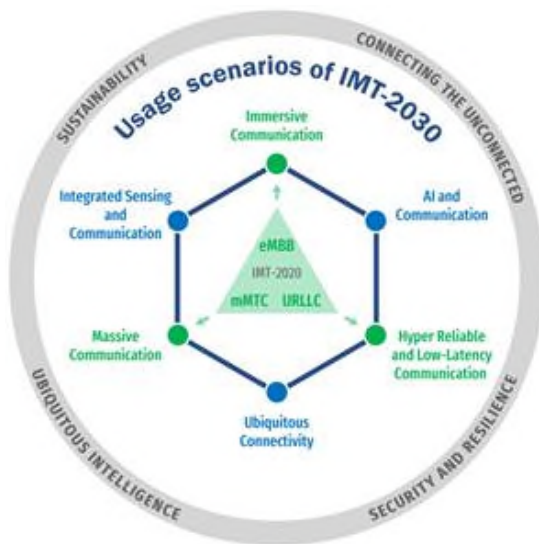
6G-NTN project ambitions is to become the flagship R&I project for **developing the 6G NTN component and driving its standardization** phase in 3GPP as part of Rel-20+

6G-NTN Ambitions



Use Cases enabled/enhanced by 6G-NTN

Ubiquitous & resilient connectivity



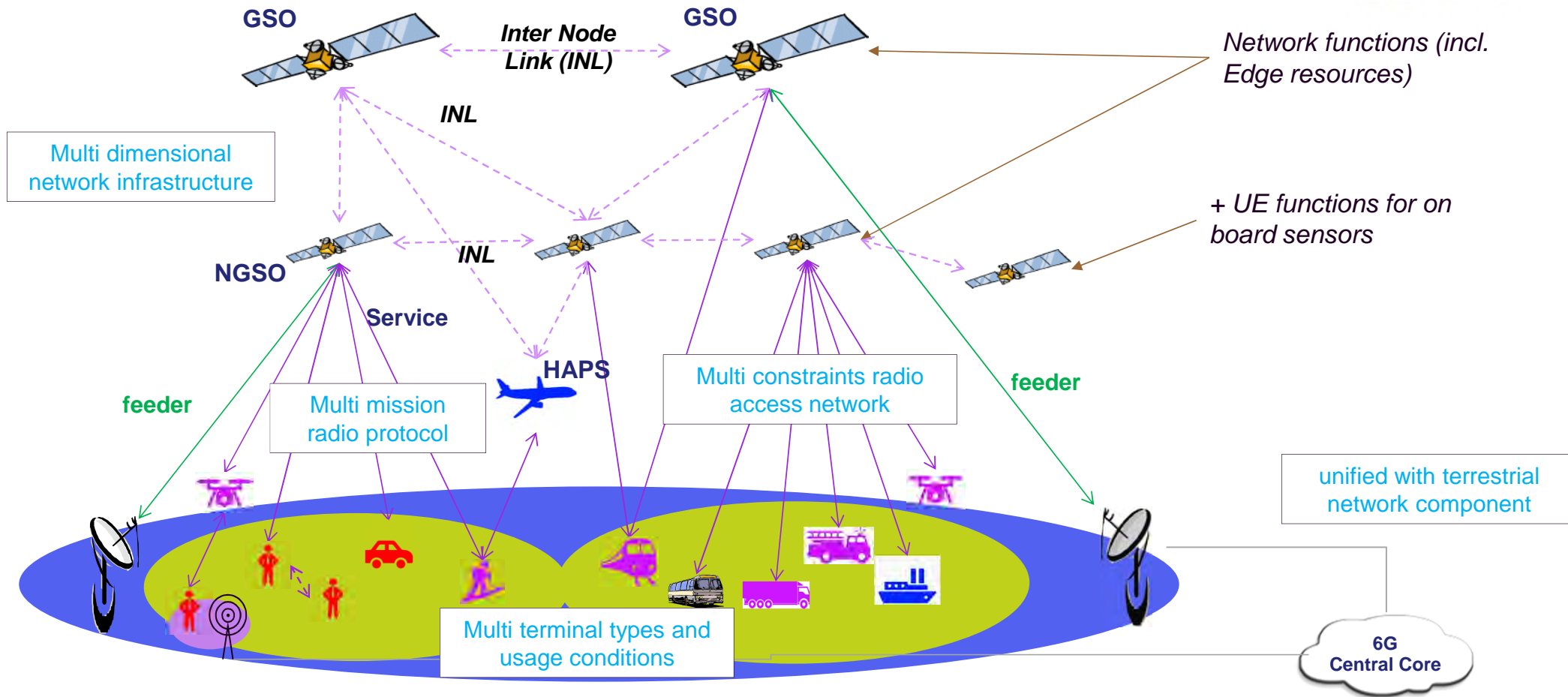
- **UC5:** Consumer Handheld Connectivity and Positioning in Remote Areas,
 - **UC6:** Continuous Bi-directional Data Streams in High Mobility,
 - **UC7:** Direct Communication over Satellites.
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- **UC1:** Maritime Coverage for search and rescue coast guard intervention,
 - **UC3:** Urban air mobility,
 - **UC2:** Autonomous power line inspection using drones,
 - **UC4:** Adaptation to PPDR or Temporary Events,

Possible performance Requirements



Target service performances	NTN in 5G (As per 3GPP &/or ITU-R IMT2020 satellite requirements)	NTN in 6G
Peak data rate (DL/UL) wrt Handheld & 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 1 meter and < few seconds (95% reliability through Network based positioning method)
Coverage	Outdoor only	Light indoor/In car
Reliability	up to 99.9% (1-10 ⁻³)	up to 99.999% (1-10 ⁻⁵)
Over the air Latency for eMBB-s and uRLLC-s	Control plane: 40 ms User plane: 10 ms	Control plane (propagation delay excluded): same as IMT-2030 terrestrial Radio Interface User plane (propagation delay excluded): same as IMT-2030 terrestrial Radio Interface
Connection density	Up to 500 per km ²	>1000 per km ²

NTN Architecture: 3D Network Concept



NTN radio interface: design drivers (1/2)



Spectrum efficient and flexible waveform optimized for both terrestrial and non-terrestrial network components

Candidate radio interface features	Rationale
Multi carrier waveform enhancements	<ul style="list-style-type: none">▪ OFDM evolution offering relaxed synchronization requirements.▪ Supporting UE without GNSS capabilities (also referred as « GNSS free/independent operation »).▪ Mitigating specific satellite constraints: Reduce the Peak-to-Average Power Ratio (PAPR) on the downlink to maximize the spectral efficiency in case of reduced number of channels in a single on board amplifier.
Advanced modulation, coding and multiple access schemes	<ul style="list-style-type: none">▪ Minimizing error rate performance under low SNR conditions.▪ Enabling the support high link margin to mitigate challenging radio link conditions (e.g. to overcome building penetration loss).
Design flexible UL/DL framing structure	<ul style="list-style-type: none">▪ Adapt the frame structure to satellite Orbit, frequency range etc...▪ Reduce the overhead penalty since there are quasi no multi-paths in satellite propagation channel.

NTN radio interface: design drivers (2/2)

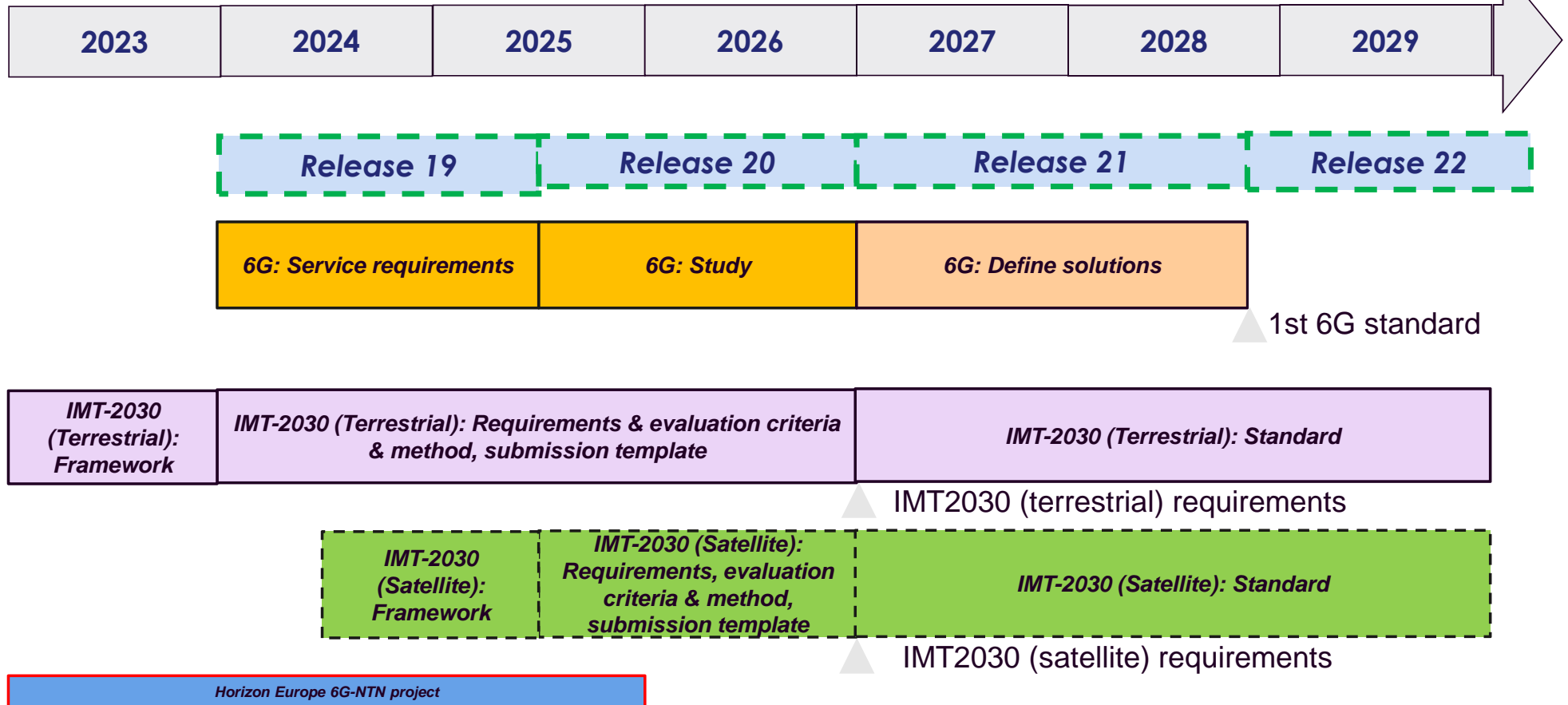


Candidate radio interface features	Rationale
Design appropriate robust reference signals for enhanced positioning	<ul style="list-style-type: none"> Support reliable (i.e. trusted) network based solution for accurate and fast response Positioning, Navigation and Timing (PNT) service. Potential narrow-band synchronization signals could be also designed, where the PRS resources could be defined over multiple slots.
Joint communication and sensing	<ul style="list-style-type: none"> Provide low to medium resolution sensing capabilities with sensing capability directly integrated/embedded into the design of the waveform.
Support of broadcast and multicast	<ul style="list-style-type: none"> Leverage the large coverage area of satellites
Enablers for Artificial Intelligence driven radio resource control	<ul style="list-style-type: none"> Increase the “goodput” of a radio link through dynamic optimization of the radio interface configuration (e.g. Modulation, coding, power, signal occupancy, interleaving depth, HARQ) according to the radio link conditions
Spectrum sharing between TN and NTN	<ul style="list-style-type: none"> Revise the methodology of coexistence study and RF/RRM specification, and potentially consider co-channel spectrum sharing between TN and NTN.
New spectrum	<ul style="list-style-type: none"> Some additional MSS allocations may be granted at the WRC-2027 as per agenda items 1.12, 1.13 and 1.14. Moreover, some additional bands such as Q/V bands should be considered for broadband connectivity.
TDD support	<ul style="list-style-type: none"> Unpaired spectrum may be allocated to NTN in selected bands, e.g. in order to support TDD operation in some frequency bands for NTN nodes at 800 km altitude and lower.

Here under frequency bands that may be considered for respectively 5G and 6G non-terrestrial networks:

Services	NTN in 5G (Currently)	NTN in 6G
Narrow/Wideband connectivity to smartphones, vehicle/drone mounted & low cost IoT devices	FR1: MSS allocations in L & S bands (e.g. see Rel-17 work).	FR1: same as 5G NTN and additional Satellite service allocations in bands up to 7.125 GHz.
Broadband connectivity to vehicle/drone mounted devices and to large Aeronautic, maritime platforms	Above 10 GHz: FSS and MSS allocations in Ka band (e.g. see Rel-18 work).	Above 10 GHz: same as 5G NTN + Satellite service allocations in Ku and Q/V bands.

Standardisation Approach: 3GPP, ITU-R



ANNEX

NTN Development/Deployment Wrt Reference Scenarios



Solutions	Narrow band connectivity to IoT devices		Narrow to wideband connectivity to handheld devices	Broadband connectivity to non-handheld devices	
Spectrum	< 7 GHz			Above 10 GHz	
Service	Up to hundreds of kbps		Up to few Mbps	Up to hundred Mbps	
3GPP radio interface	4G NB-IoT/eMTC		5G New Radio		
Example of applications	<i>Verticals (smart grids, water distribution, oil & gas), agriculture)</i>		<i>Consumers + Verticals (Automotive, public safety, utilities, agriculture ..)</i>	<i>Verticals: Telco (e.g. Backhaul), IPTV service providers, Satellite News Gathering, Transport (aeronautical, maritime, railway), public safety,</i>	
Space segment	GSO	NGSO	NGSO	GSO	NGSO
Timeline indication (NOTE 1)	2023-2025	2024-2029	2026-2029	2026-2029	2026-2029

NOTE 1: Sources: 3GPP RP-232732 (source: GSOA)

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,

▪ <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, 14th January 2024

▪ <https://www.amazon.co.uk/5G-Non-Terrestrial-Networks-Vanelli-Coralli/dp/1119891159>

Horizon Europe R&D « 6G-NTN » project:
<https://www.6g-ntn.eu>



5G Non-Terrestrial Networks

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IEEE PRESS

WILEY

Workshop on 6G NTN Standardisation with ETSI



Date: 3-4th april 2024

Location: ETSI premises

See <https://www.etsi.org/events/2306-etsi-ntn-conference>

The Consortium





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THANKS
