A UNIFIED 6G ARCHITECTURE FOR VERTICAL MARKETS: THE 6G-NTN VISION

Alessandro Vanelli-Coralli and Carla Amatetti

University of Bologna

Nicolas Chuberre and Mohamed El Jaafari

Thales Alenia Space France

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Facts and figures

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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 ambition

6G-NTN project ambitions 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+

Project partners (15)

ThalesAlenia Space
a Thales / Leonardo company

(2 companies)

MARTEL innovate

DIGITAL FOR PLANET

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Telit Cinterion

THALES
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Qualcomm

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ERICSSON

DLR Deutsches Zentrum für Luft- und Raumfahrt

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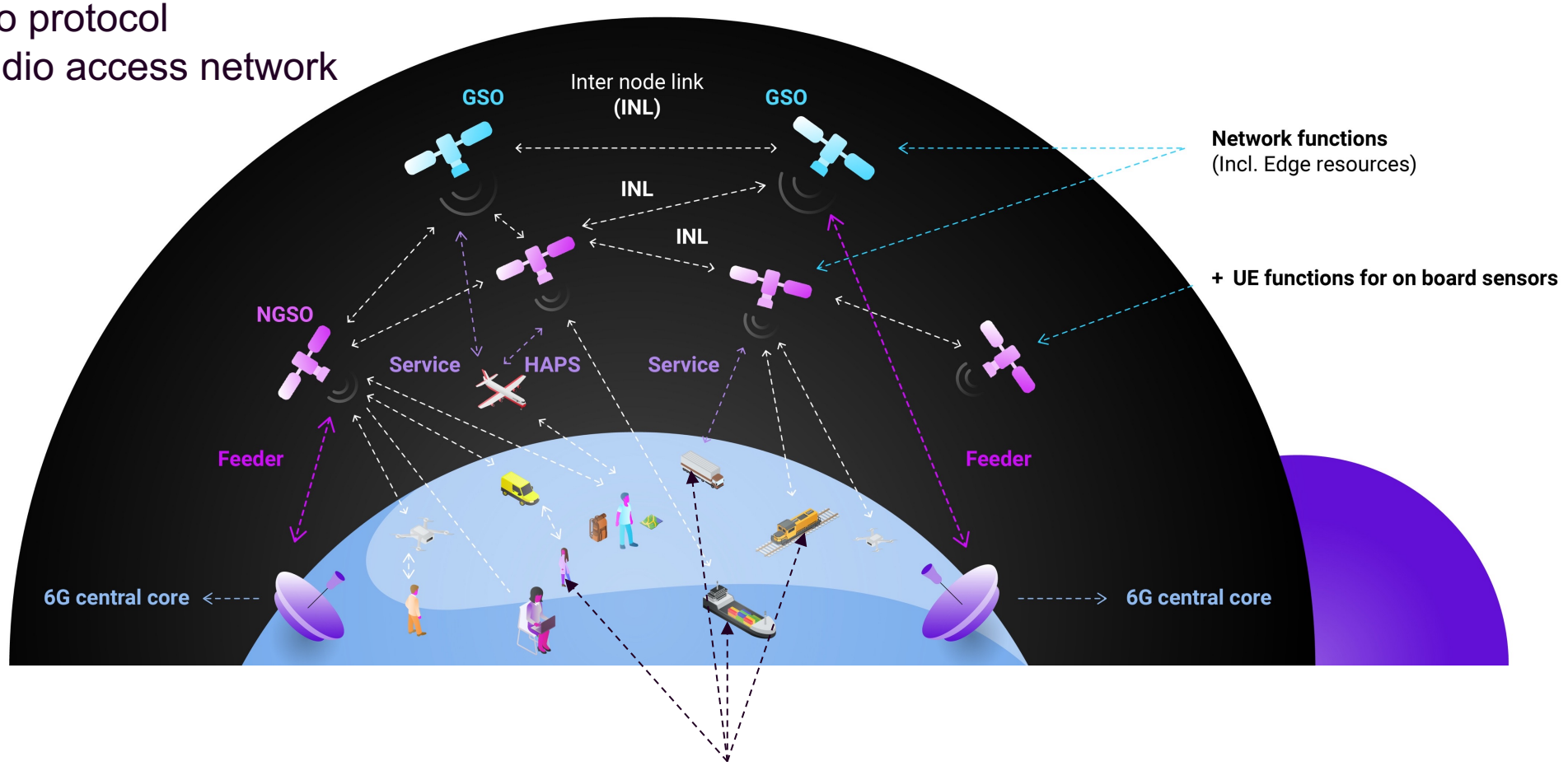
6G-NTN: Vision

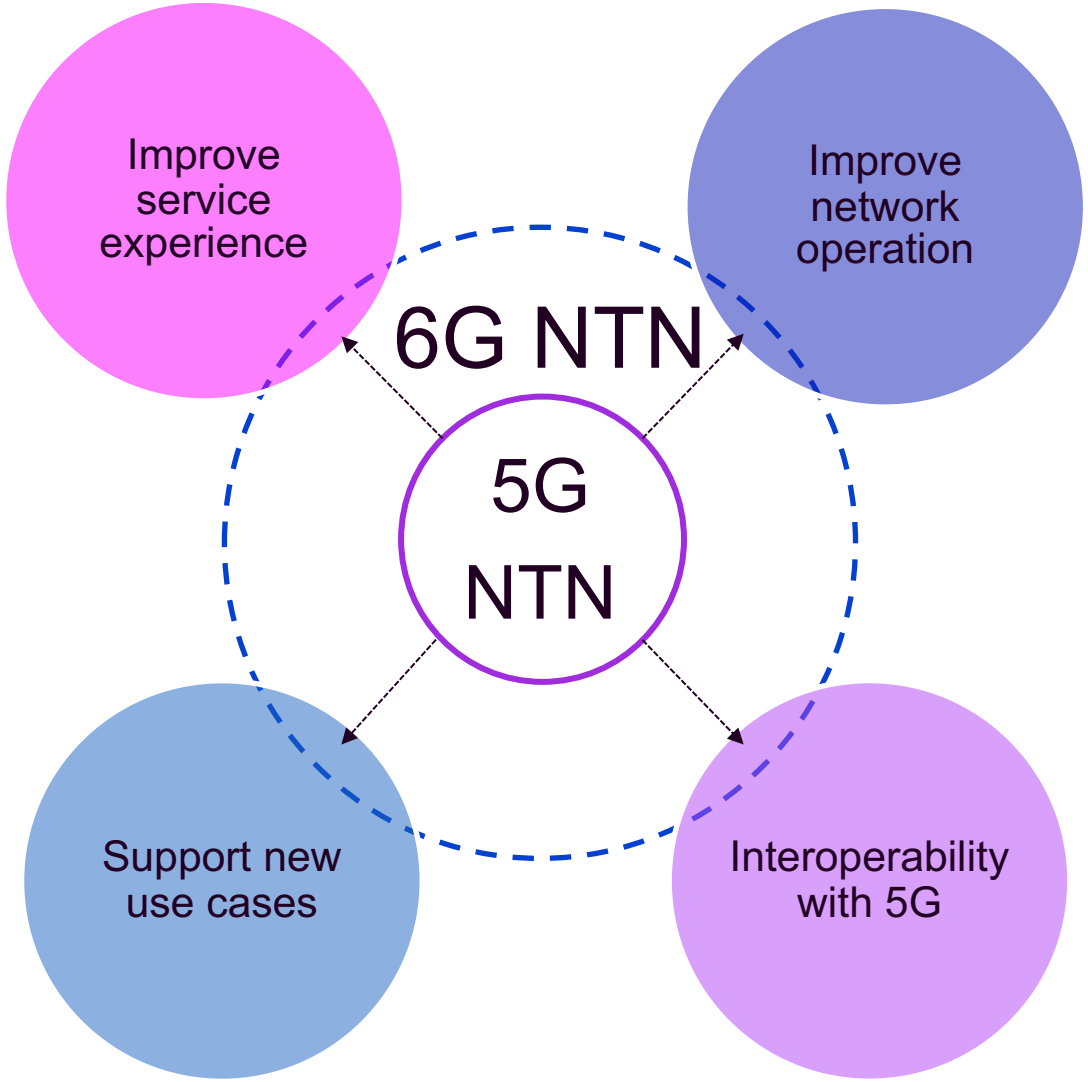
- Multi-dimensional network infrastructure
- Multi-mission radio protocol
- Multi-constraint radio access network



Multi-terminal types and usage conditions

6G NTN objectives

- Increasing data rate x10 wrt 5G
- Increased reliability
- Enabling light indoor/in-car coverage
- Increased location accuracy
- Latency (RTD) down to 10 ms

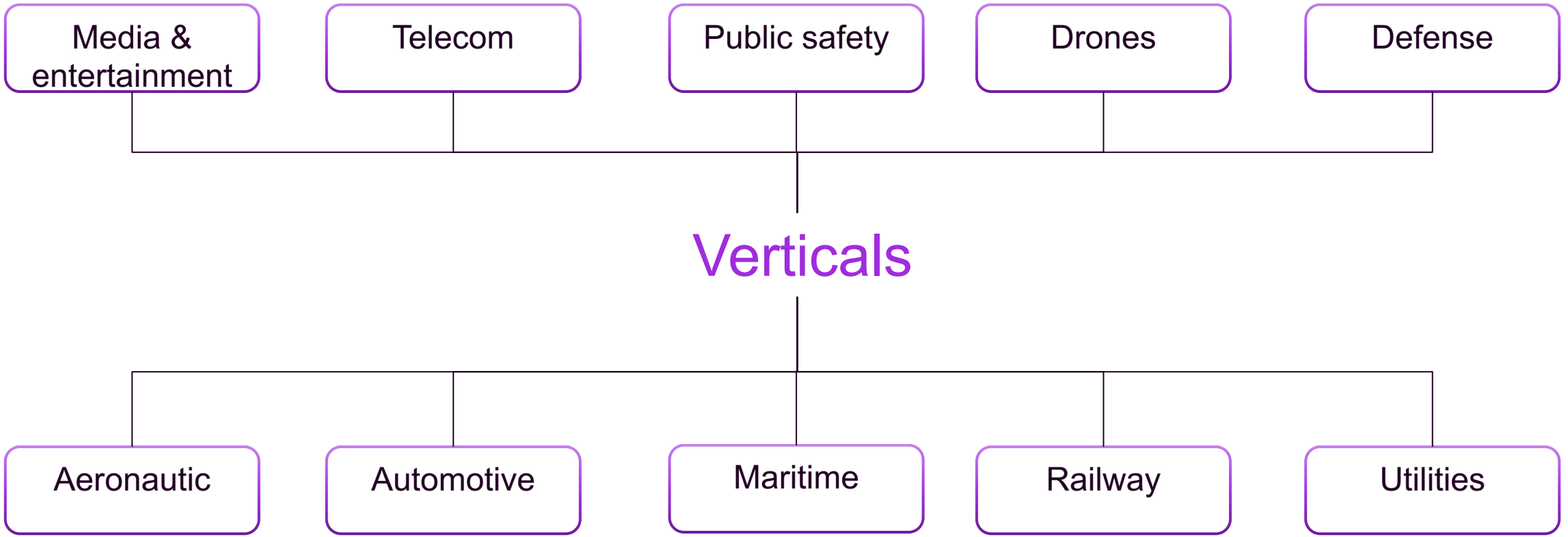


- Resiliency
- Spectrum sharing NTN/TN and across orbits
- Environment footprint (energy saving)
- Reinforced security
- Capacity/Connection density
- GNSS free operation

- Terminal installation/operational constraints
- Crisis response

- Multi connectivity and mobility across orbits and with 5G-NTN

6G-NTN addressed markets



Overview of the use cases

UC 1

Maritime coverage for search and rescue coast guard intervention

Public Safety/Maritime

UC 2

Autonomous power line inspection using drones

Utilities/Drones

UC 3

Urban Air Mobility

Aeronautical

UC 4

Adaptation to PPDR* or temporary events

Public Safety/Media Ent.

UC 5

Consumer handheld connectivity and positioning in remote areas

Telecom (consumer)

UC 6

Continuous bidirectional data stream in high mobility

Automotive

UC 7

Direct communications over satellites

Automotive/Public Safety/ Media/Maritime

* Public Protection and Disaster Relief

System design initial assumptions

Targeted terminals

- Handheld
  - Below 6GH → omnidirectional
- non Handheld:
  - Below 6GH → omnidirectional
  - Above 10 GHz → 10-15 cm aperture antenna (for vehicle/drone mounting set-up)

VLEO/LEO for global broadband connectivity and reliable UE location determination

- Below 6GH: HH + nonHH
- Above 10GHz: non handheld devices and ISL Inter Orbits
- Optical: ISL same orbit (Intra Node Links)

GEO for broadcast and ISL

- Above 10GHz: non-HH and inter-orbit ISL

HAPS for broadband connectivity

- Below 6GH: HH + nonHH
- Above 10GHz: non handheld devices and ISL Inter Orbits
- Optical: ISL same orbit (Intra Node Links)

Drone (as a network node) for local broadband connectivity

- Below 6GH: HH + nonHH
- Above 10GHz: non handheld devices and ISL Inter Orbits
- Optical: ISL same orbit (Intra Node Links)

5G-NTN components

- LEO constellation in L/S bands for wideband connectivity to HH
- LEO/GEO in Ka band for broadcast/multicast & broadband connectivity to non HH

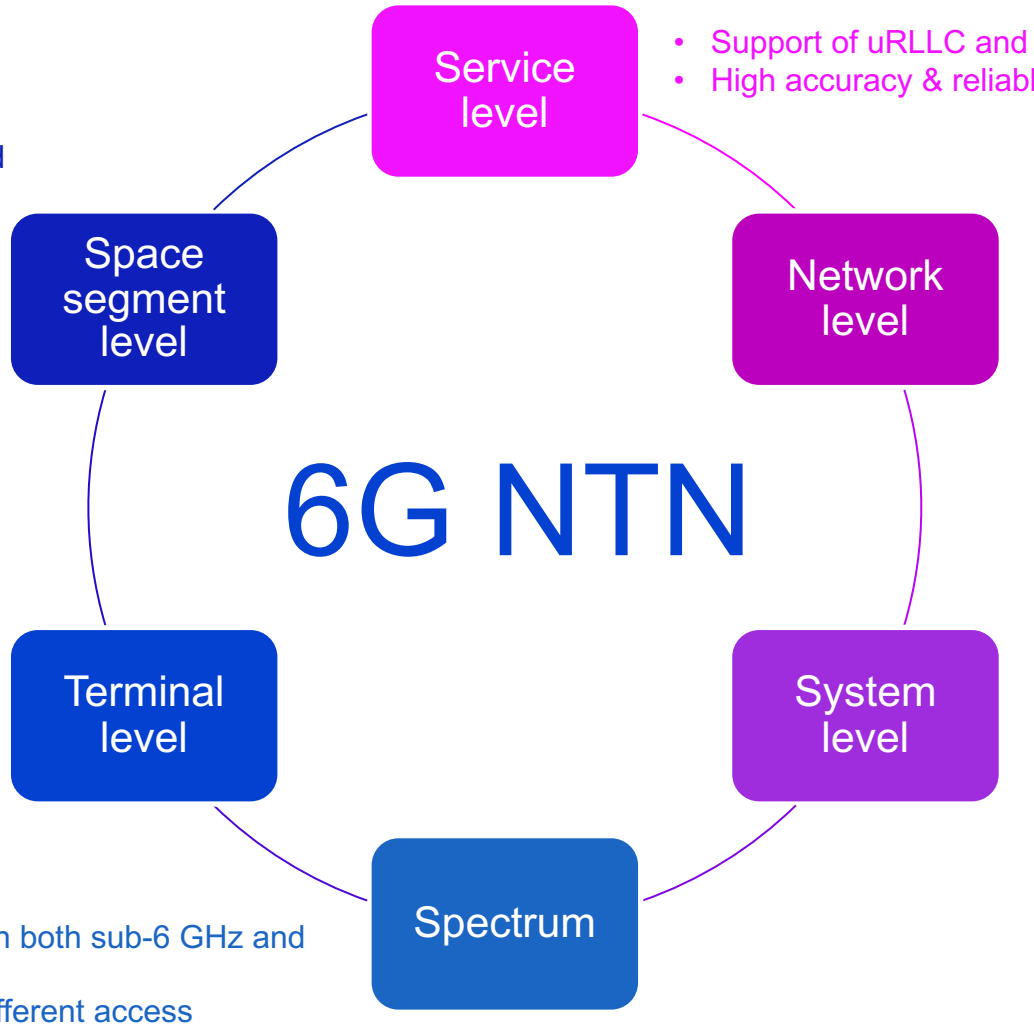
6G NTN versus 5G NTN: performance

User experience data rate (UL/DL) [Mbps] & speed wrt terminal types	6G-NTN	5G-NTN (As per 3GPP & ITU-R spec)
HH	Tens of Mbps (Outdoor only) @ 20 km/h At least SMS capability in light indoor/in car conditions @ 250 km/h	1/0.1 Mbps (Outdoor only) @ 3 km/h
Vehicle or drone (flying and surface) mounted	Hundreds of Mbps (Outdoor only) @ 250 km/h (with <20 cm equivalent aperture	[50/25] Mbps @ 250 km/h (with 60 cm aperture)
Large aeronautic, maritime platforms	Thousands of Mbps (Outdoor only) @ 1200 km/h (with >60 cm equivalent aperture)	[50/25] Mbps @ 1000 km/h

Other performance	6G-NTN	5G-NTN
Location service	Accuracy < 0.1 m Acquisition time < 1 s (95% reliability with Network positioning method)	Accuracy < 1 m Acquisition time < 100 s (reliability with Network positioning method)
Coverage	Light indoor/In car (able to accommodate up to 20 dB building penetration loss)	Outdoor only
Reliability and latency	Up to 99.999% and down to 15 ms (RTD)	Up to 99.99% and down to 35 ms
Connection density	> 1000 per km^2	Up to 400 per km^2

Research areas

- Software-defined payload implementing:
  - RAN functions
  - possibly some CN functions (e.g., UPF)
  - edge computing resources for value added services
- Inter node links (↑, →)
- Lower orbit satellite constellation



- Support of uRLLC and advanced eMBB services
- High accuracy & reliable location service

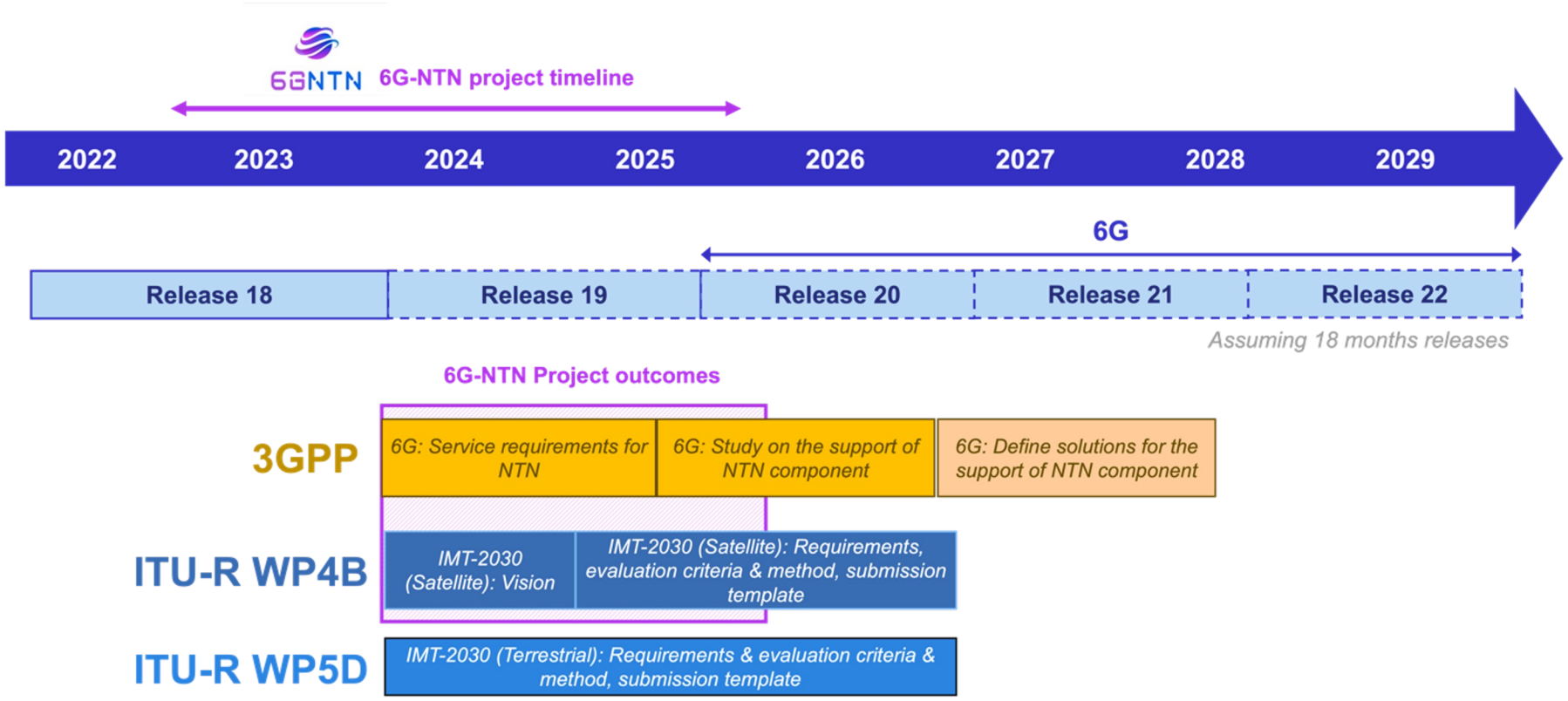
- Mobility/multi connectivity
- Smart routing in multi-orbit NTN + terrestrial component

- Waveform
  - Extended flexibility for additional deployment scenarios TDD and FDD via satellite
  - Multiplexing with navigation signaling/measurements bursts
  - GNSS-free operation
  - Reinforced interface mitigation capabilities (towards Transec)
  - Sensing capabilities
- AI-driven radio access network (i.e., for RRM)
- Dynamic orchestration of virtual network functions in a 3D network

- Broadband terminals optimized to the constraints of vehicle/drone mounting installation
- Smartphone also in light indoor/ in car conditions

- New frequency bands in both sub-6 GHz and mmWave spectrum
- Sharing between the different access technologies (TN and NTN)

6G-NTN Timeline with 3GPP schedule



The 6G-NTN project will define a roadmap for the development of the building blocks needed for enabling integrated NTN service provisioning and disruptive market offer in the 2030-35 timeframe.

Conclusions

6G-NTN objectives:

- Identification of the target service and operational requirements for 6G NTN component
- Design/sizing of a 3D NTN to meet the target user requirements
- Design, trade-off, and assessment of compact terminals targeted by the 3D NTN component
- Design of flexible software-defined payload across flying platforms and frequency bands
- Design of key characteristics/features of a flexible waveform for 6G's integrated radio access network
- Design and evaluation of AI data-enhanced multi-orbit multi-connectivity radio intelligent controller
- Design and development of dynamic orchestration of Virtual Network Functions in a 3D network for 6G
- Design of a reliable and accurate positioning functions for the 6G system with a precision below 10 cm
- Design of enabling features for spectrum usage optimization between the different network nodes
- Maximization of the impact of 6G-NTN and strengthening Europe's industrial leadership in the sector

6GNTN

THANKS

6g-ntn.eu

info@6g-ntn.eu

@6G-ntn

@6Gntn

alessandro.vanelli@unibo.it

6GSNS

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Use cases: from NTN to 6G NTN

From current 3GPP Use Cases to 6G-NTN

Coverage extension through Backhauling ⟹ Direct to device

Multi-connectivity ⟹ Service versatility

Mobility in idle mode or roaming ⟹ Mobility in connected mode

		UC1	UC2	UC3	UC4	UC5	UC6	UC7
Targeted verticals								
1	Consumer					x		
2	Automotive			o		o	x	x
3	Public Safety & Defense	x		o	x	o		x
4	Utilities / Energy / IoT		x			o		x
5	Media and Entertainment				x			
6	Railways transportation		o	o				o
7	Maritime transportation	x				o		x
8	Aeronautic / drone sector		x	x				o
10	Road transportation / Smart cities			x		o	o	o
Service category								
1	Service Continuity	x	x	x		x	x	
2	Service Ubiquity	x		x	x	x		x
3	Service Scalability				x			

X = explicit link with vertical/market service
o = link with vertical/market service with small modification

Initial assumptions

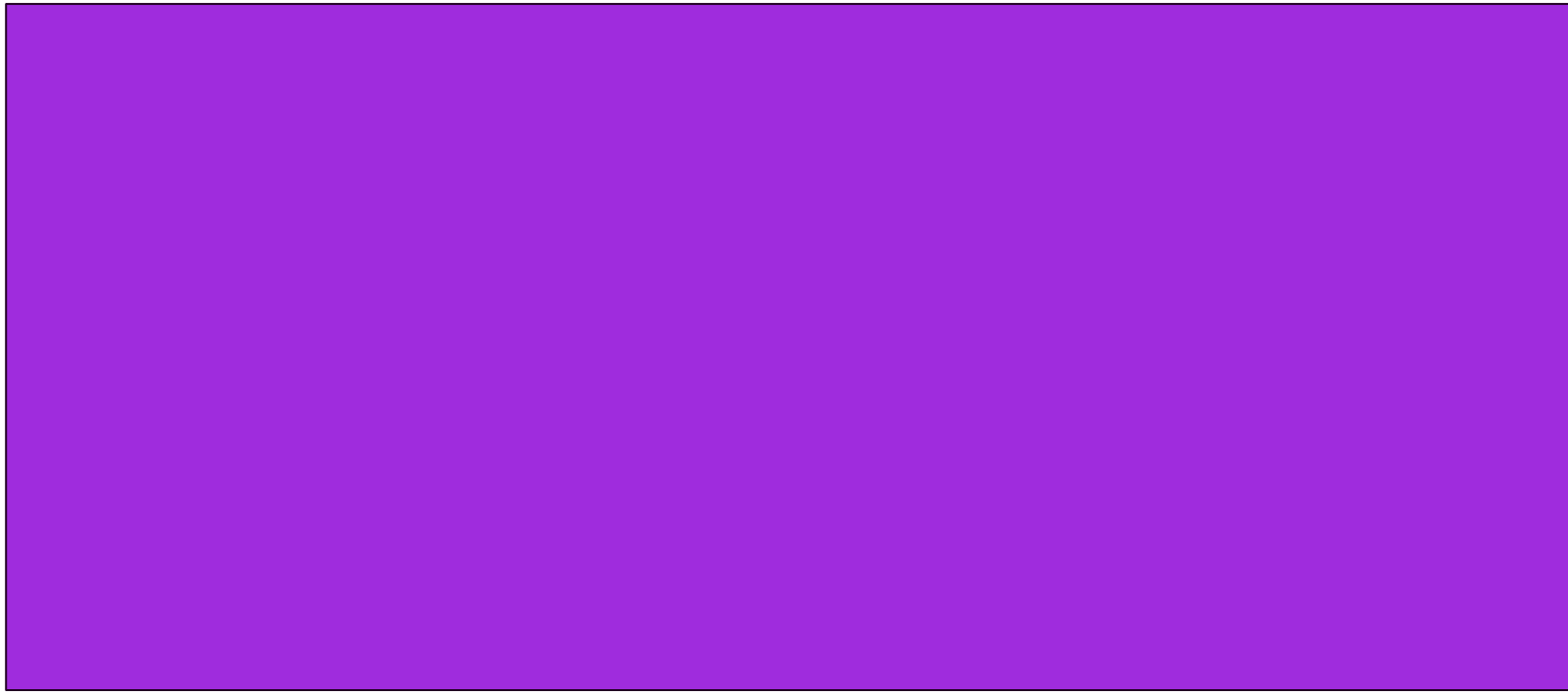
- Target terminals:
  - Handheld: sub 6 GHz (Omni)
  - Non-Handheld: sub 6 GHz (omni) and above 10 GHz (~10/15 cm aperture)

- Orbits:
  - vLEO/LEO: global broadband connectivity and reliable UE location determination
  - GEO: inter orbit ISL + broadcast (above 10 GHz, only non-handeld)
  - HAPS: for broadcast connectivity
  - Drone: network node for local broadband connectivity

- Frequency and links:
  - LEO, vLEO, HAPS, drones: sub 6 GHz for both Handheld and non-Handheld
  - LEO, vLEO, HAPS, drones: above 10 GHz for non- Handheld
  - GEO, LEO, vLEO, HAPS, and drones: above 10 GHz for ISL inter-orbit
  - LEO, vLEO, HAPS and Drones: optical for ISL same orbit

- Also integrating 5G-NTN components:
  - LEO constellation in L/S bands for wideband connectivity to HH
  - LEO/GEO space segment in Ka band for broadcast/multicast and broadband connectivity to non-HH

6G-NTN objectives



6G-NTN Methodology