5G NTN AND 6G, STATUS AND PERSPECTIVES FOR NTN AT THE 3GPP

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/// Overview of 3GPP activities on Non-Terrestrial Networks (NTN)

/// Technical insights

/// Roadmap and 3GPP 6G activities

Overview of 3GPP activities on NTN

2017

Rel-15

study phase

› Initial Study item on NR to support Non-Terrestrial Networks

› The TSG RAN and RAN WG1 findings and outcome: TR 38.811

study phase

Rel-16

2018

› Study a set of necessary features and adaptations enabling the operation of NR protocol in NTN

› With a priority on satellite access

› Outcome : TR 38.821

2020

Rel-17

Work item on 5G NR to support NTN

› Specification of NTN

› Specs : TS 38 series

Enhancements on NTN

Rel-18

2022

› Work completed in Dec23

› Specs : TS 38 series

2024

Rel-19

Further enhancements on NTN

› Work completed in 3Q25

› Specs : TS 38 series

NTN in 6GR from day 1

Rel-20

2025 → 06-2027

› 5GA: Further enhancements on NTN: GNSS resilient operation

› 6GR: Harmonized TN & NTN

› Work started in 3Q25

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Overview of 3GPP activities on NTN

RAN1: Physical layer

- Timing relationship (Timing Advance)
- UL time and frequency synchronization (Doppler shift)
- Enhancements on HARQ
- Polarization signaling for VSAT/ESIM
- Uplink capacity enhancements (OCC)
- Uplink coverage enhancements (repetitions)
- Downlink coverage enhancements (beam-hoping support)

RAN2: Higher layers

- User Plane: extended latency support for protocols (MAC, RLC, PDCP)
- HARQ disabling and 32 HARQ processes
- NTN system information broadcast (SIB19, SIB25)
- Control Plane: Tracking Area Management UE Location Service
- Mobility aspects : feeder link switchover, RACH-less handover, location and time-based handover, Inter-RAT mobility support
- Discontinuous coverage (IoT)
- Geofencing for MBS broadcast and PWS

RAN3: Access network architecture

- Transparent and regenerative architectures
- Network Identity handling
- Registration Update and Paging Handling
- Cell Relation Handling (Mapped Cell ID)
- Feeder Link Switch-Over (NGSO)
- Aspects Related to Country-Specific Routing (AMF re-selection)
- OAM for NTN

RAN4: RF & RRM performance

- New bands
  - L-, S-, Ka-, Ku bands
  - TN/NTN coexistence
  - Satellite Access Node, UE
- RRM: e.g. timing compensation (idle, connected mode), GNSS accuracy
- VSAT support

SA2: System level

- Mobility management with huge cell size
- UE location and support of regulated service : network verified UE location
- QoS class for satellite links
- Impact of satellite backhauling
- Store-and-Forward (IoT)
- UE-Sat-UE communication (Mesh)

CT1: Network protocols

- PLMN (re)selection
- NAS timers
- NAS overhead reduction

NOTE: IoT NTN and NR NTN are treated separately and solutions might be different or specific to one technology or the other

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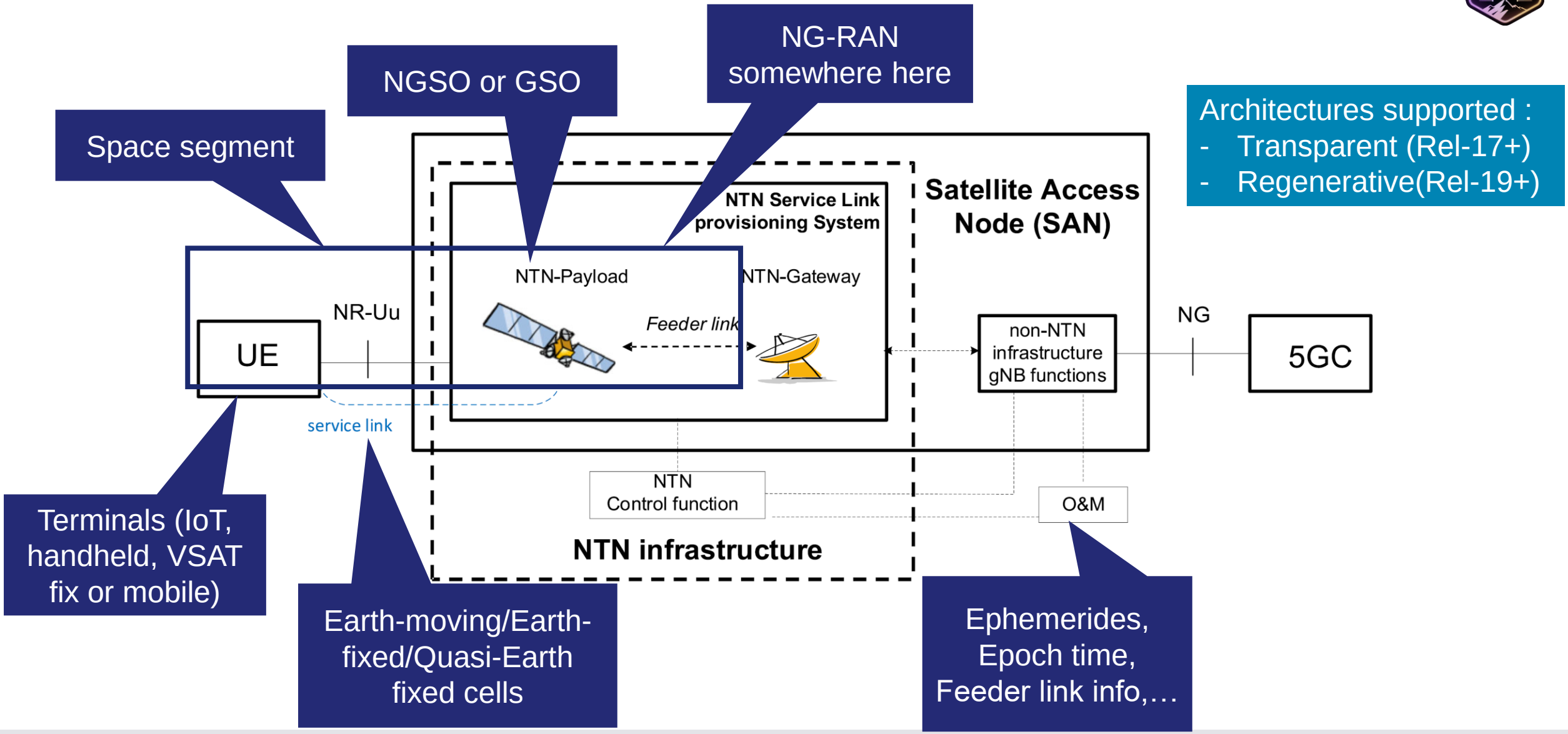
Technical insights – Architecture



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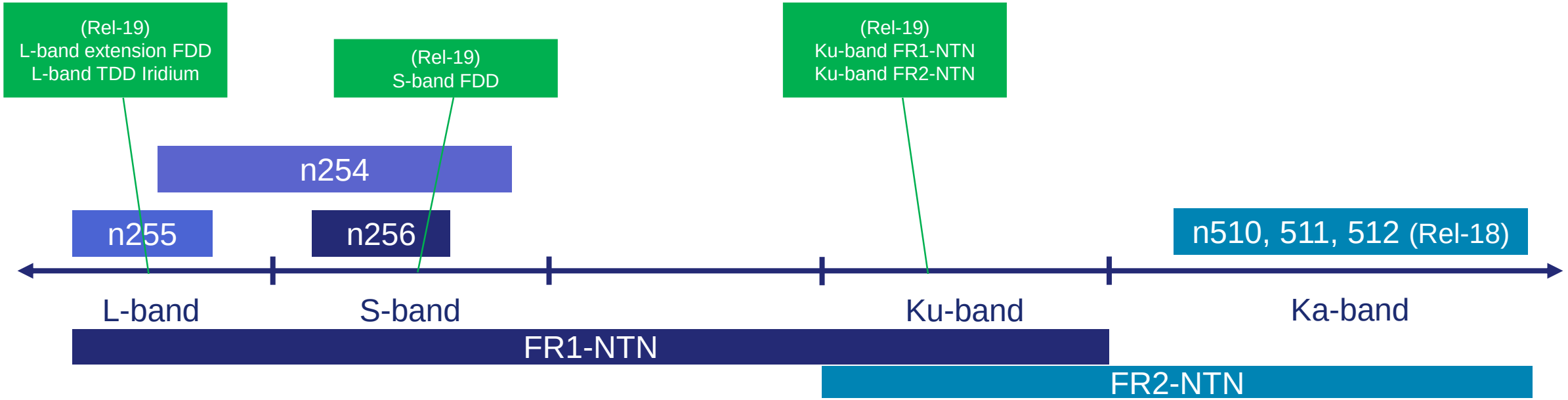
Technical insights – Spectrum



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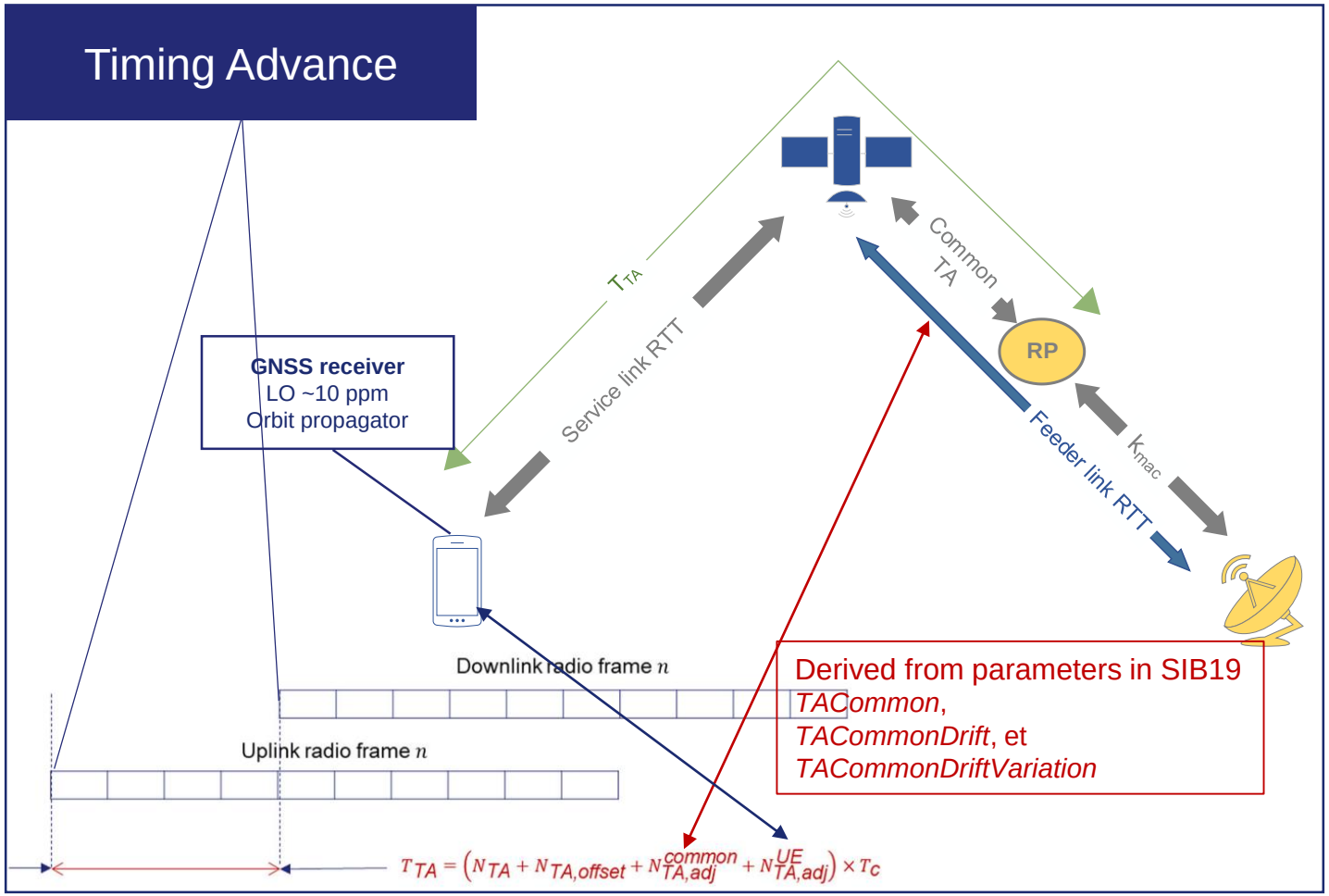
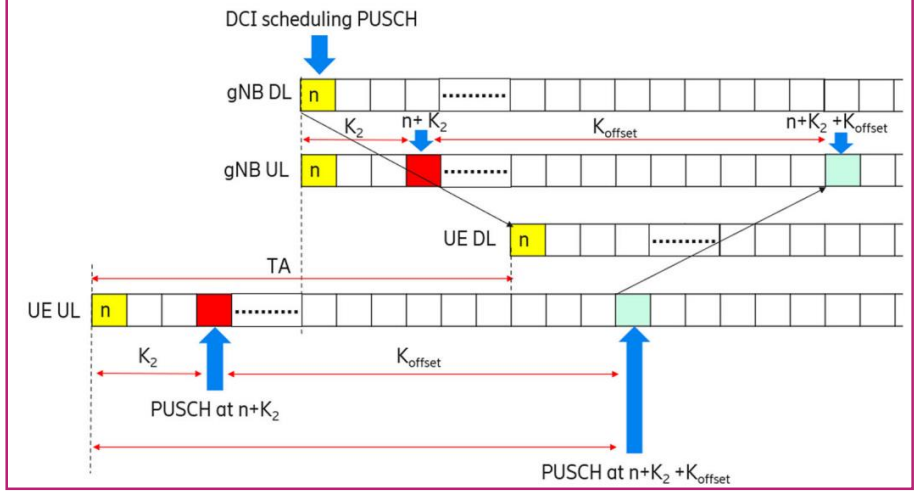
Technical insights – Delay compensation

Timing Advance

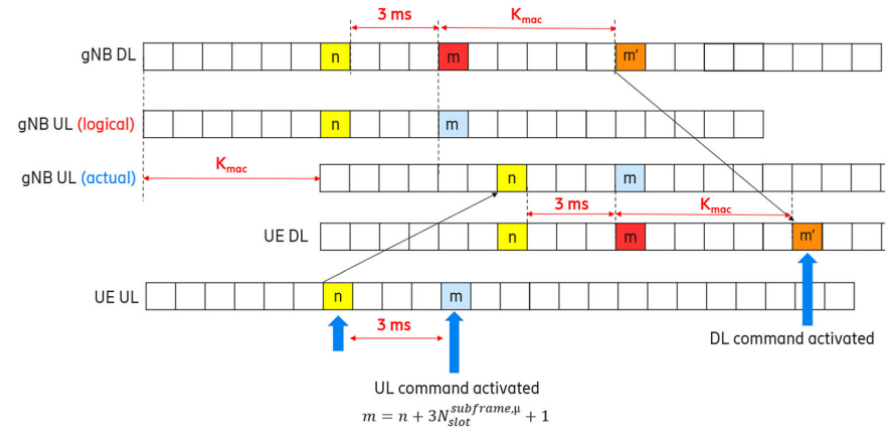


Derived from parameters in SIB19
TACommon,
TACommonDrift, et
TACommonDriftVariation

Koffset



Kmac



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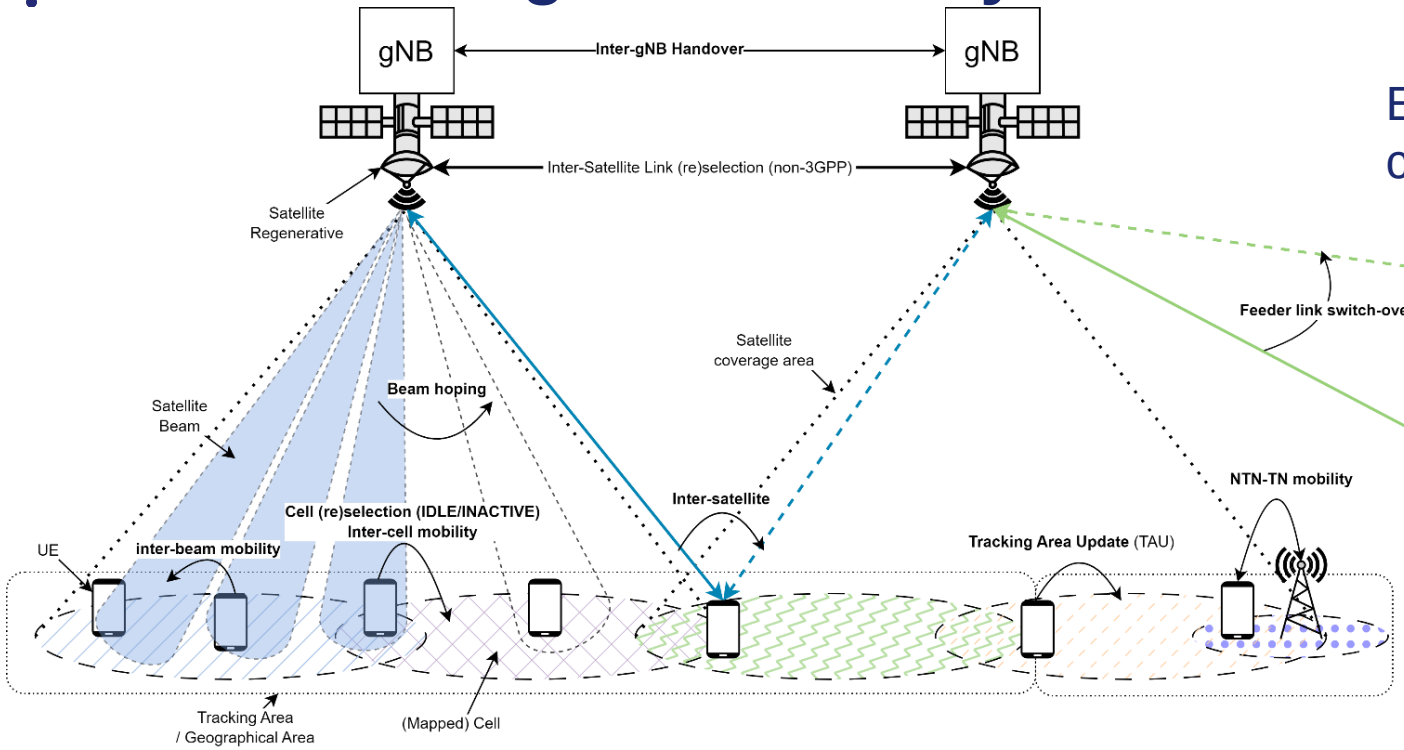
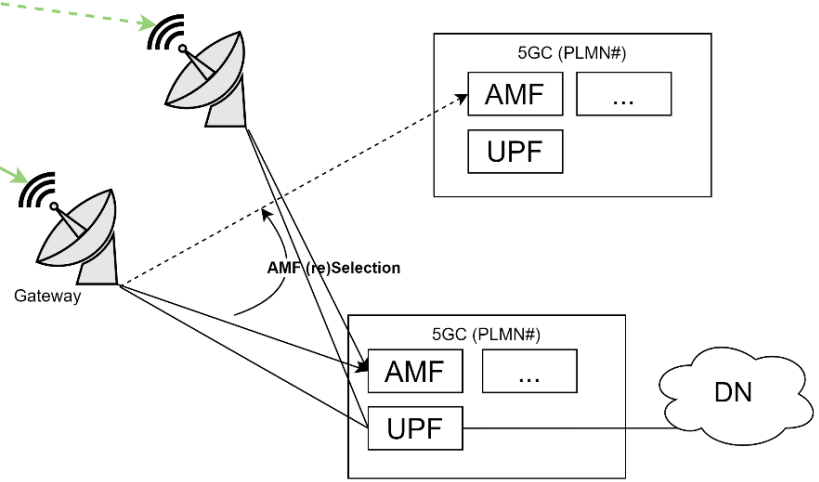
Technical insights – Mobility



Example with regenerative case with full gNB onboard



/// Mobility mechanisms introduced for NTN

- Conditional Handover (Location or Time-based)
- RACH-less handover
- Feeder link switch over and satellite switch with re-sync (for transparent architecture)
- TN-NTN mobility (redirection, cell (re-)selection, assistance information)

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5G and IoT NTN in Rel-20

/// GNSS-resilient operations

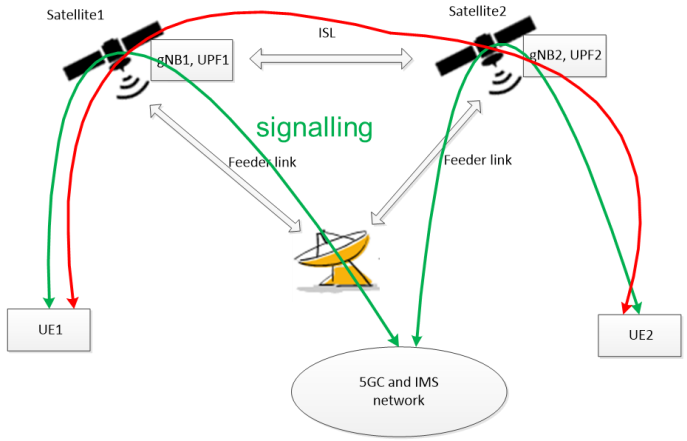
/// Voice over GEO via IoT NTN access

/// RAN4

- High Power UE IoT NTN
- Half-Duplex FDD for Ka/Ku-band VSAT
- DL intra-band intra-SAN CA

/// LTE TN to NR NTN handover and remaining inter-RAT mobilities

/// IP and Ethernet UE-Sat-UE communications



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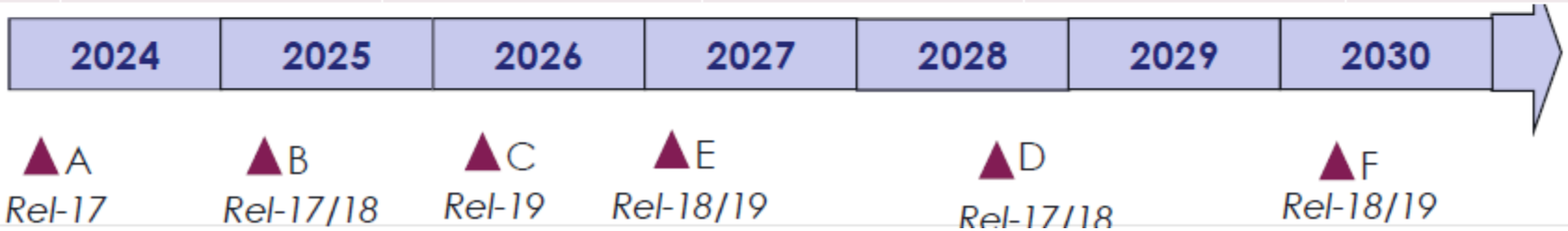
5G NTN, a near future reality ?

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*

IRIS2

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



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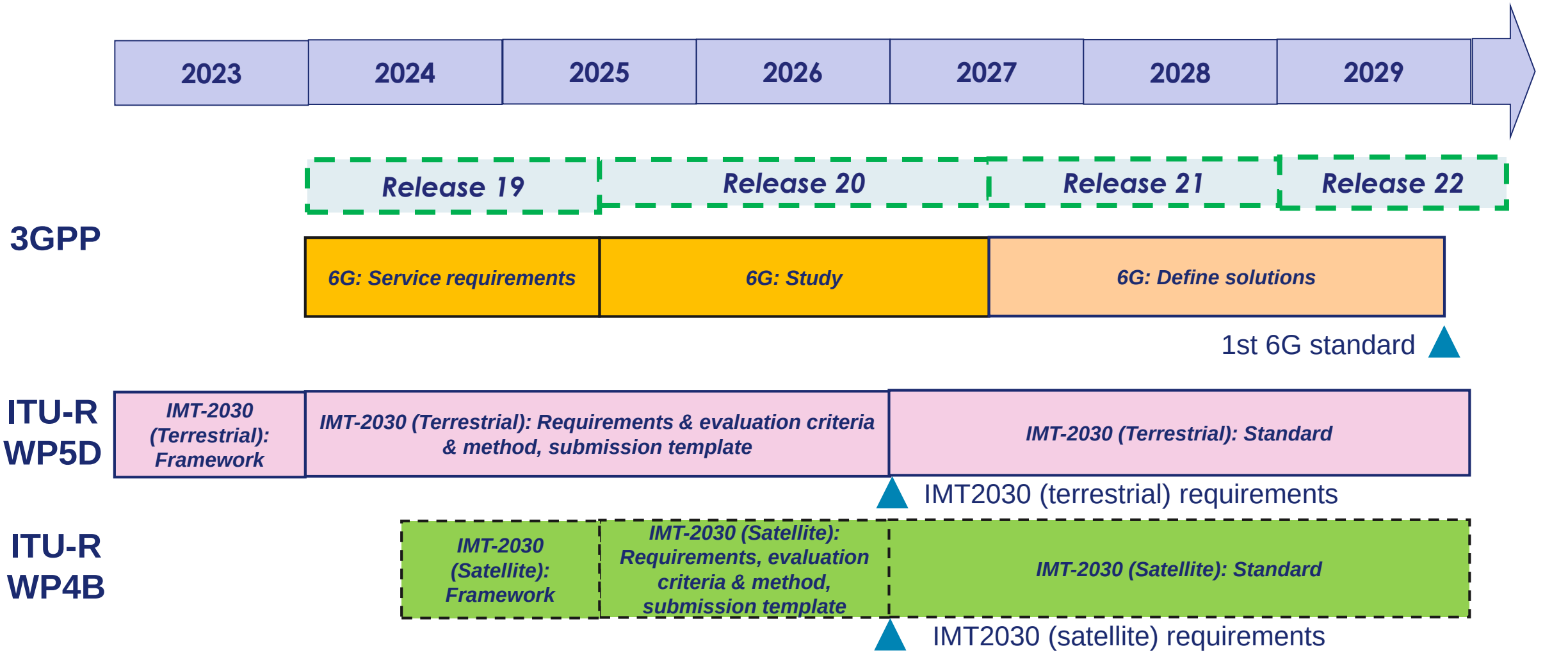
Roadmap and 6G NTN 3GPP activities



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Firsts 3GPP outcomes

/// SA1 use cases (see 3GPP TR 22.870)

/// RAN/SA Study Item descriptions (see RP-252912 and SP-250806)

/// RAN service requirements (see 3GPP TR 38.914)

/// RAN1 first meeting in August and first technical agreements :

- *“For harmonized 6GR design for TN and NTN, RAN1 studies to identify the technical aspects affected by NTN characteristics, as well as lessons learned from NR/IoT NTN”*
- Waveform
  - *“CP-OFDM and DFT-s-OFDM waveforms as defined in 5G NR are supported as the basis for 6GR for uplink”*
  - *“CP-OFDM waveform as defined in 5G NR is supported as the basis for 6GR for downlink”*
- *Bands from sub 6GHz to 52.6 GHz*
- Modulation
  - *“For 6GR DL, 5G NR uniform QPSK, 16QAM, 64QAM, 256QAM and 1024QAM are supported as basis for study for data channel”*
  - *“For 6GR UL, 5G NR uniform QPSK, 16QAM, 64QAM, and 256QAM are supported as basis for study for CP-OFDM for data channel”*
  - *“For 6GR UL, 5G NR pi/2 BPSK, uniform QPSK, 16QAM, 64QAM, and 256QAM are supported as basis for study for DFT-s-OFDM for data channel”*
- Energy-efficiency
- AI/ML in 6GR interface

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END.

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3GPP normative activities

Releases	15	16	17	18
Completion date (Core part)	June 2018	Dec 2019	June 2022	June 2024
Service requirements	5G NTN Use cases and service requirements			
System architecture		Study key issues	Definition of the enables for the support of Satellite	-
Radio Access network aspects	Channel model for 0.5 – 100 GHz	Study key issues	Support of NGSO/GSO, Earth fixed/moving beams,	Verified UE location, UL coverage enh, mobility enh
Targeted terminals	-	-	Handheld/Smart phones (23 dBm)	Fixed VSAT for GSO/NGSO, Mobile VSAT only for GSO
Frequency bands	-	-	S, L bands in FDD mode	Ka band in FDD mode

3GPP normative activities

Releases	19	20
Completion date (Core part)	December 2025	
Service requirements	Mesh connectivity	SA1 led Rel-20 SID 5G advanced: • Emergency communication (text based via GEO) • Multi orbit : need to identify potential use cases • Resilient notification (previously robust notification alert) : use case approved • IMS call via GEO : use case approved
System architecture	SA2 led Rel-19 WID Sat-arch-ph3: Store and forward (S&F), UE-SAT-UE	
Radio Access network aspects	DL coverage enh, broadcast, UL capacity enh, 4G TN/5G NTN mobility, Regen payload (gNB)	GNSS-resilient communications
Targeted terminals	RedCAP UE, Other FR1-NTN UE types: HPUE Other bands: Ku-band	
Frequency bands	Ku band in FDD mode, Extended L band for NR-NTN WID	

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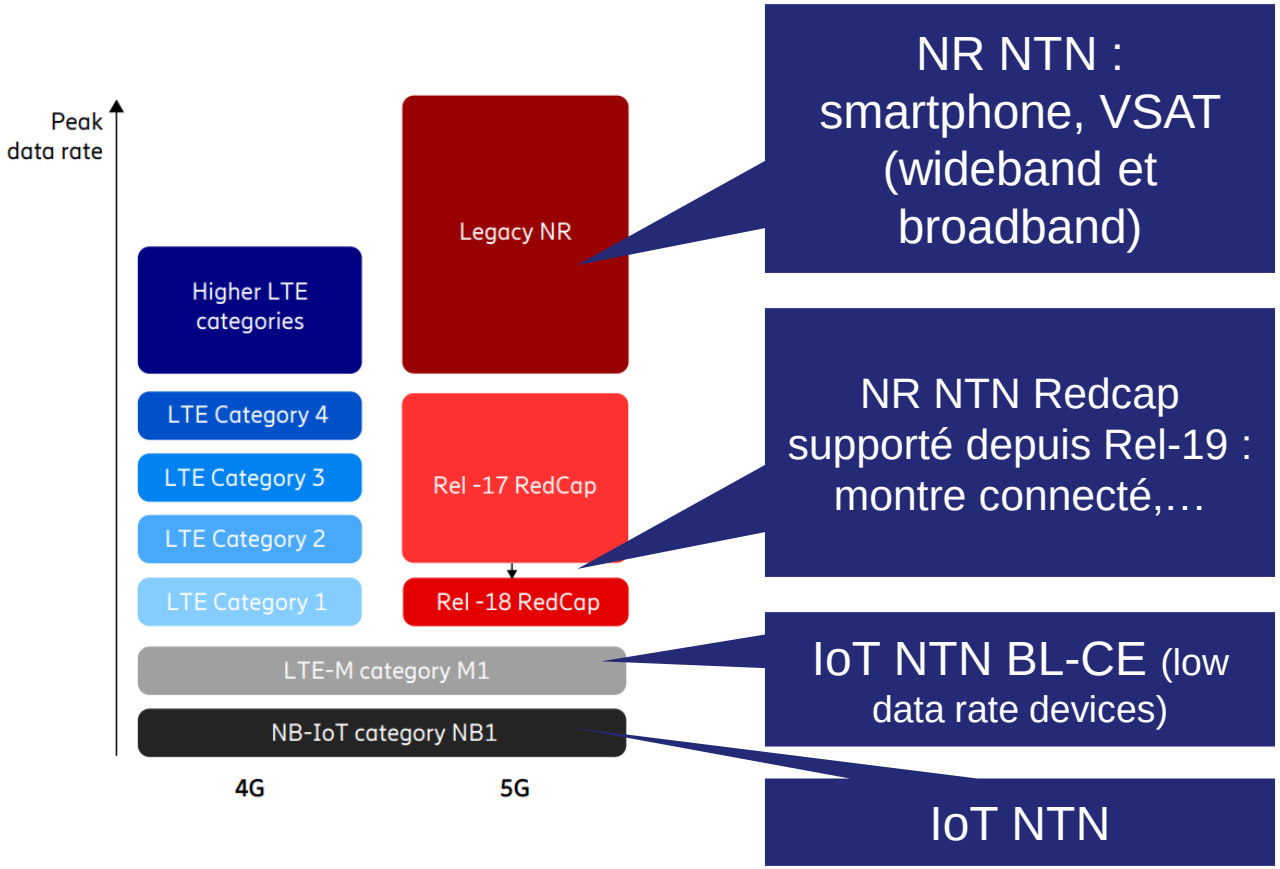
Technical insights - Terminals

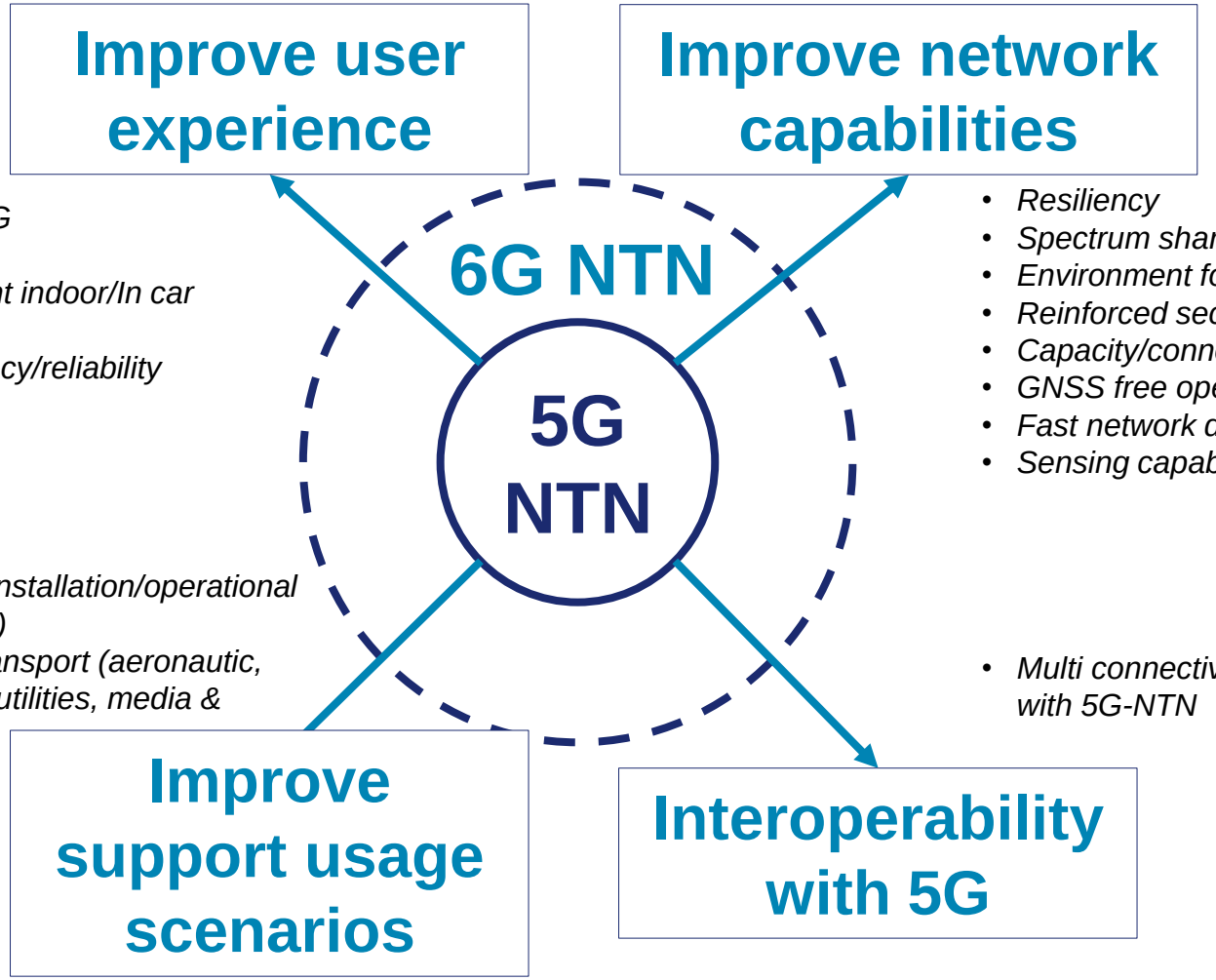


NTN VSAT class	NTN VSAT type	Type description
Fixed VSAT	1	Fixed VSAT communicating with GSO and LEO with mechanical steering antenna.
	2[2]	Fixed VSAT communicating with GSO and LEO with electronic steering antenna.
	3	Fixed VSAT communicating with LEO only with electronic steering antenna.
Mobile VSAT	4	Mobile VSAT communicating with GSO with mechanical steering antenna.
	5[2]	Mobile VSAT communicating with GSO with electronic steering antenna.

NOTE 1: The NTN VSAT types are assuming NTN VSAT has only one antenna beam towards one satellite at a given time in this release.

NOTE 2: NTN VSAT may need power reduction to comply with OFF-axis EIRP requirement defined in clause 9.2.2. There is no requirement for the potential power reduction.

What 6G would be ?



- *Increasing data rate wrt 5G*
- *Increased reliability*
- *Coverage extension to light indoor/In car areas*
- *Increased Location accuracy/reliability*
- *Reduced Latency*

- *Resiliency*
- *Spectrum sharing NTN/TN and across orbit*
- *Environment footprint (energy saving)*
- *Reinforced security*
- *Capacity/connection density*
- *GNSS free operation*
- *Fast network deployment*
- *Sensing capability*

- *Terminal design adapted to installation/operational constraints (vehicles/Drones)*
- *Automotive, public safety, transport (aeronautic, railway, road and maritime), utilities, media & entertainent, defence,*

- *Multi connectivity and mobility across orbit and with 5G-NTN*

6G will leverage and integrate 5G

j) Aim at a harmonized 6G Radio design for TN and NTN, including their integration.

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