Supplemental Coverage from Space: Extending Rural Connectivity

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NTN Market Trends, Use Cases

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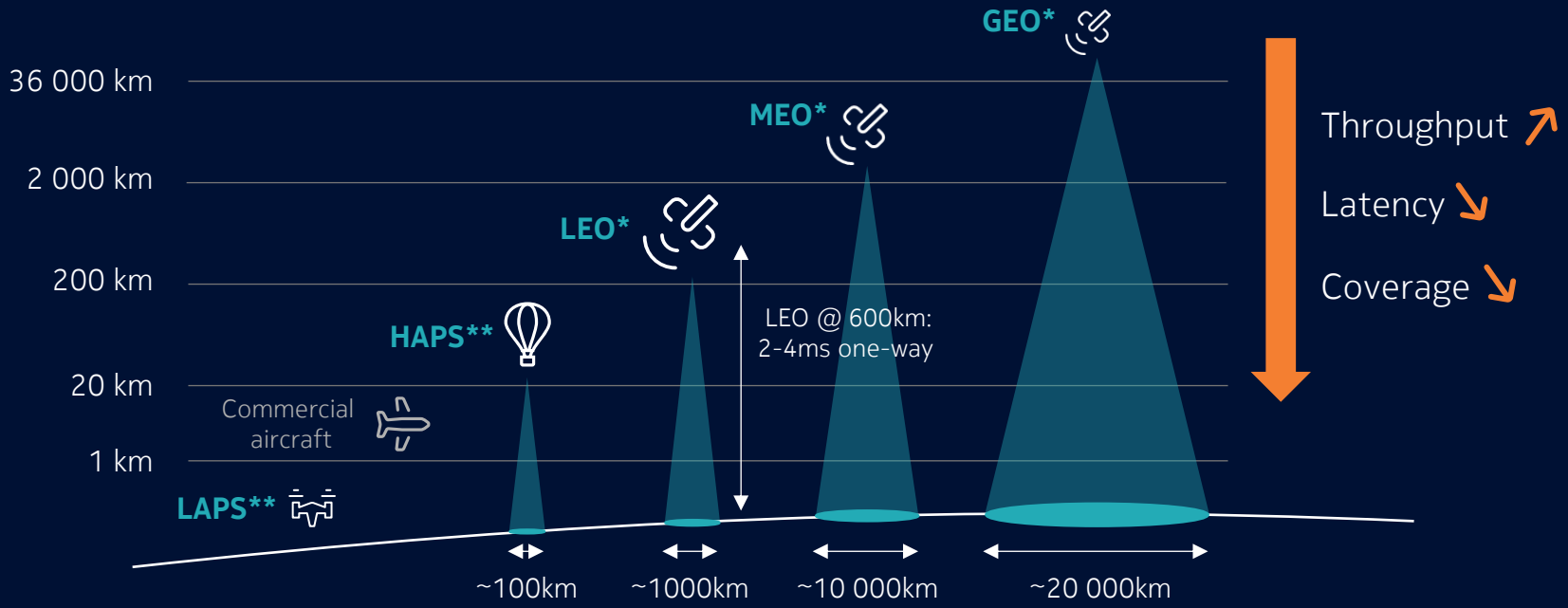
Non-Terrestrial Networks are wireless communication networks

Leveraging satellites, drones, or other aerial platforms



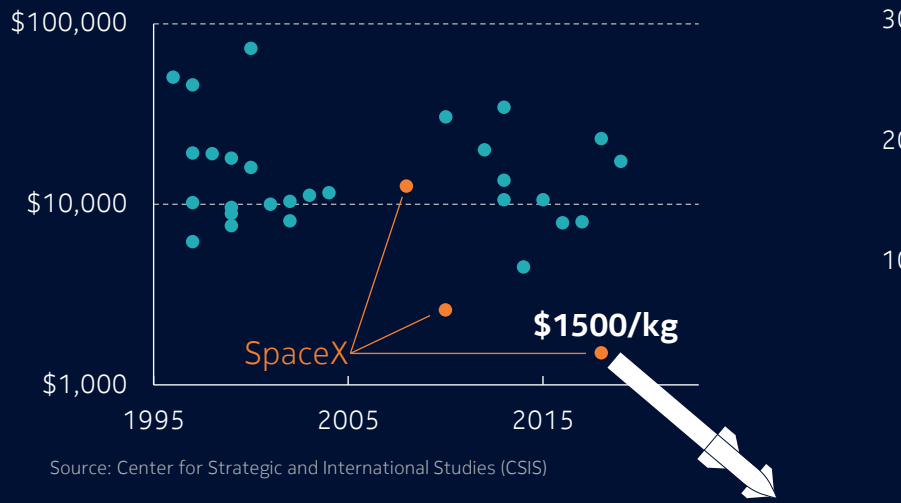
* LEO/MEO/GEO = Low/Medium/Geostationary Earth Orbit
** LAPS/HAPS = Low/High Altitude Platform Systems

Max. Dist: 1932 km Delay (one-way): **6.4 ms** Relative Speed: **~7.5 km/s**	Max. Dist: 14018 km Delay (one-way): **46.7 ms**	Max. Dist: 40586 km Delay (one-way): **135.3 ms** Relative Speed: ~0 m/s

We’ve recently entered a new era

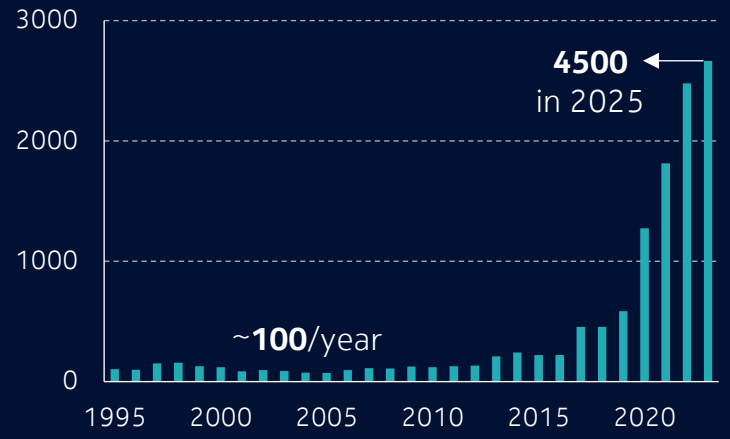
In which space is increasingly being commercialized

Launch cost in $/kg



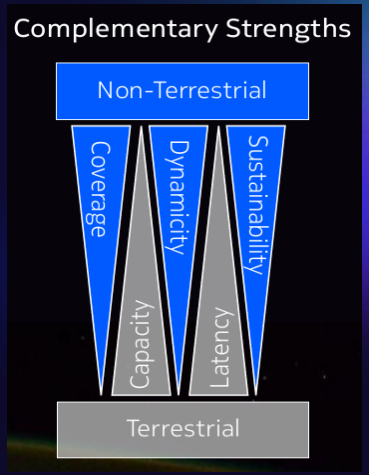
Source: Center for Strategic and International Studies (CSIS)

Annual number of objects launched into space



Source: United Nations Office for Outer Space Affairs – with major processing by Our World in Data

Advantages of NTN over Terrestrial Communication Networks



Global Connectivity

NTN provides seamless coverage across the globe, including remote and hard-to-reach areas that traditional terrestrial networks struggle to serve.

Resilience

NTN infrastructure is less vulnerable to natural disasters (earthquakes, tsunamis, cyclones) and physical disruptions, ensuring reliable communication even in emergency situations.

Scalability

Scalability refers to the ability of the network or systems to handle increased demand, growth or expansion without compromising on performance, reliability and quality. NTN networks can be easily expanded to accommodate growing demand for communication services by deploying additional satellites or platforms and the need for extensive ground-based infrastructure. Terrestrial networks, on the other hand, face challenges in expanding coverage due to physical infrastructure limitations (e.g., laying new fiber-optic cables)

Non-Terrestrial Networks give rise to a plethora of new use cases

Ubiquitous connectivity

Mobile network expansion (Direct-to-Device or SCS*)

Upscaling IoT connectivity (e.g., asset tracking, agriculture)

Network backup (disaster recovery)

Remote fixed connectivity (VSAT**)

Defense applications (e.g., secure comms)

Space-compatible cloud and Wide-Area Networks

Security applications (e.g., satellite-based Quantum Key Distribution)

* SCS = Supplemental Coverage from Space
** VSAT = Very Small Aperture Terminal (mounted devices with directional antenna's)

Why NTN ?

LEO satellites disrupt space

- Launch cost reduced
- Satellite cost reduced
- Launch intervals reduced
- #satellites per launch increased
- End-to-end latency reduced
- Throughput increased

NTN applies to many use cases

TN backhaul

High gain antennas, potentially in mmWave spectrum

Examples:
AT&T - OneWeb
KDDI – Starlink
Verizon – Amazon

Fixed wireless access

Large antennas, no user mobility

Examples:
Starlink, Amazon, OneWeb, Eutelsat, Viasat

Mobile users

Handheld devices, cars

Pre-rel 17 sat tech: Apple

Pre-rel 17 3GPP: AST, Lynk, Starlink

3GPP rel 17,18, 19

Internet of things

Low-data rate services with long battery life target

Eutelsat, Skylo and many, many others.

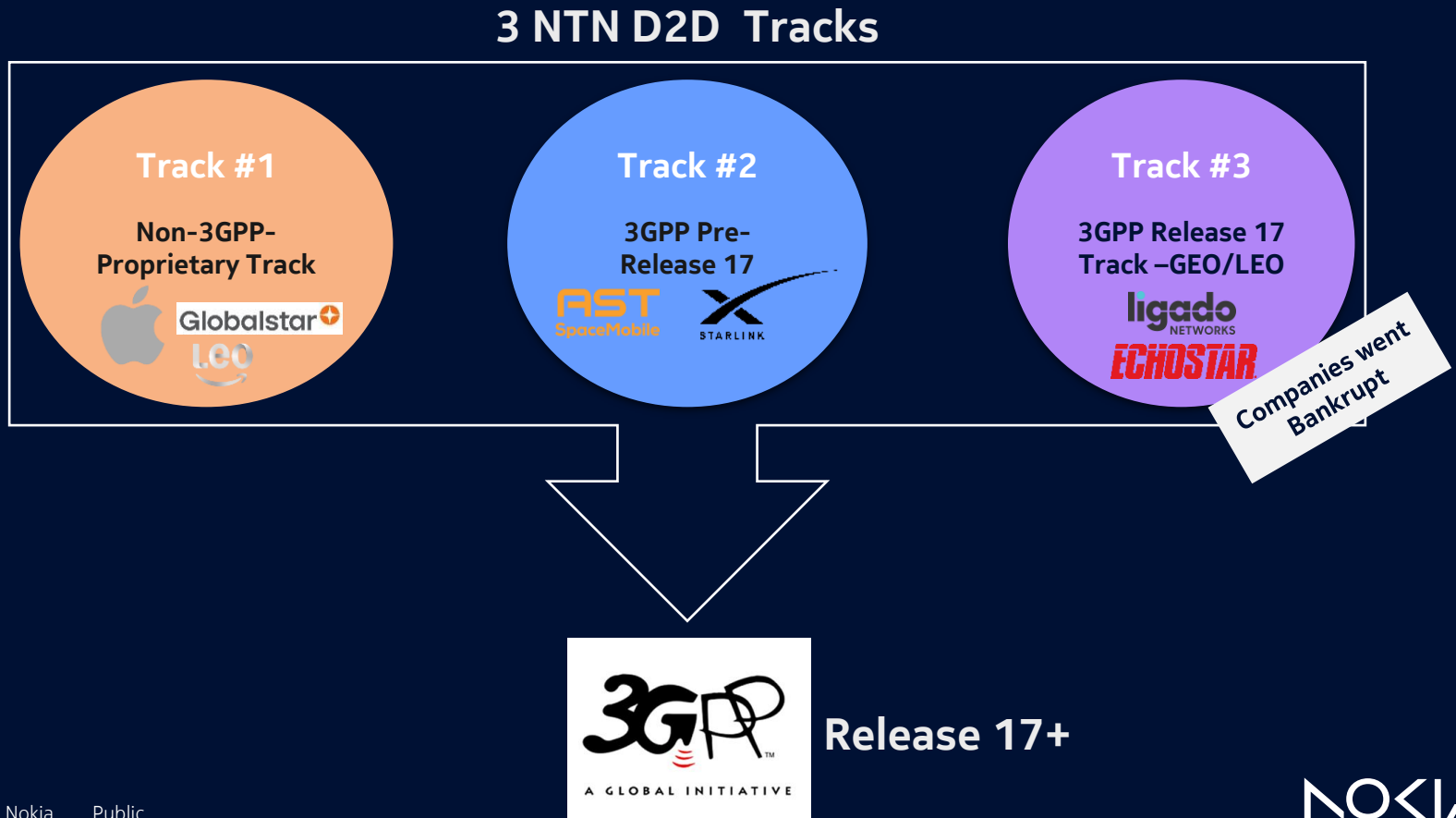
3GPP Rel 17,18, 19

Plus NTN provides resilience

NTN Spectrum and Technology Update

Jad Berberi

NTN Direct to Device D2D Tracks



NTN Partnership and Current Status

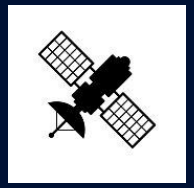
	Track 1	Track2	Track2
	Non-3GPP- Proprietary Track	**3GPP Pre-Release 17 Track**	**3GPP Pre-Release 17 Track**
Driver			
Status	Launched 2023	Launched 2024	Launched 2024
Cellular Partner	NA		
Satellite Partner			
Service	Limited to Uplink Emergency messaging	SpaceX: Messaging, then voice, limited data	AST: Voice, data, Messaging
Device	iPhone 14 and later	Existing Devices	Existing Devices

Performance Comparison

	Cellular Terrestrial 3GPP Networks	LEO NTN (in 2 GHz band)
Cell Peak Speed (theoretical)	Shared Aggregate Speed> 3 Gbps	Shared 100-300 Mbps (for 20 DL+20 UL MHz BW)
User Peak throughput	>3 Gbps in good radio conditions	14-20 Mbps
Coverage	Rural 20 Km	50-100 Km radius on the ground service beam
Link Budget	Max Allowed is 65 dBm/ MHz for 2/3 GHz band	Same for AWS4, Pathloss is 20 dB less
Latency	5-20 ms	20-30 ms
Reliability	High	Low – impacts on atmospheric conditions
QoS	High	Low
Scalability	Support for both FWA and Mobility	Need to change the satellite to accommodate new bands
Lifespan of System	Medium 10-20 yrs	Short 3-5 yrs

LEO NTN can be a good complementary solution at the fringe of suburban areas for non sensitive application

D2D NTN Spectrum Types



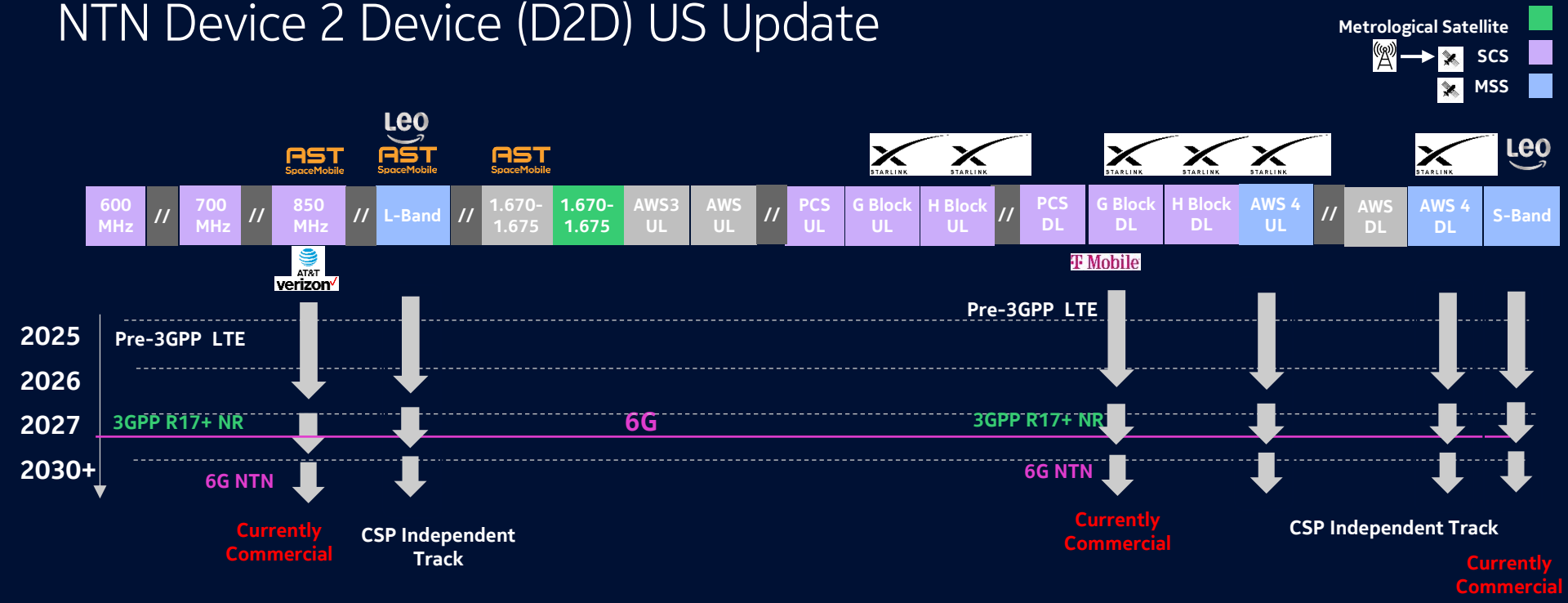
Mobile Satellite Station Spectrum (MSS)

1. Use spectrum allocated for Mobile Satellite to communicate with UE devices (Phones)
2. Requires Devices Chipset to support the MSS Spectrum
3. Clean implementation that is no interference with Terrestrial networks (TN)
4. In 12 GHz this spectrum is used to deliver competing services with Fixed Wireless Access

Supplementary Coverage from Space (SCS)

1. Use spectrum allocated for Terrestrial networks (TN) for satellite to Device
2. Defined by FCC as a TN that can be used by Satellite
3. Does not Requires Devices Modification
4. Coordination is required between TN and NTN to mitigate interference

NTN Device 2 Device (D2D) US Update



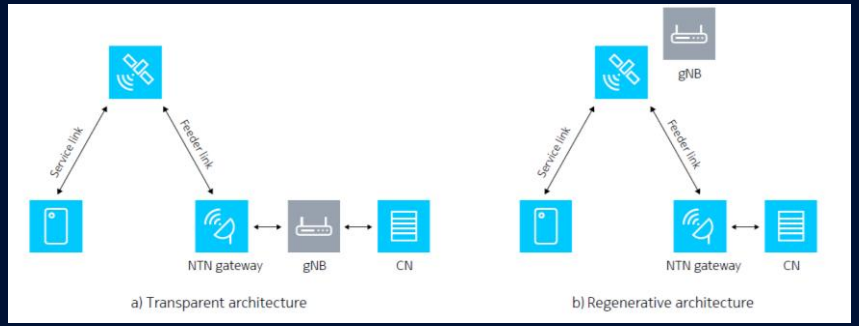
- NTN will provide complementary service in rural areas and at the fringe of the suburban areas
- NTN will converge in the coming years to 5G 3GPP NTN R17+
- 6G will have more NTN integration

3GPP NTN High Level Capabilities

Spectrum

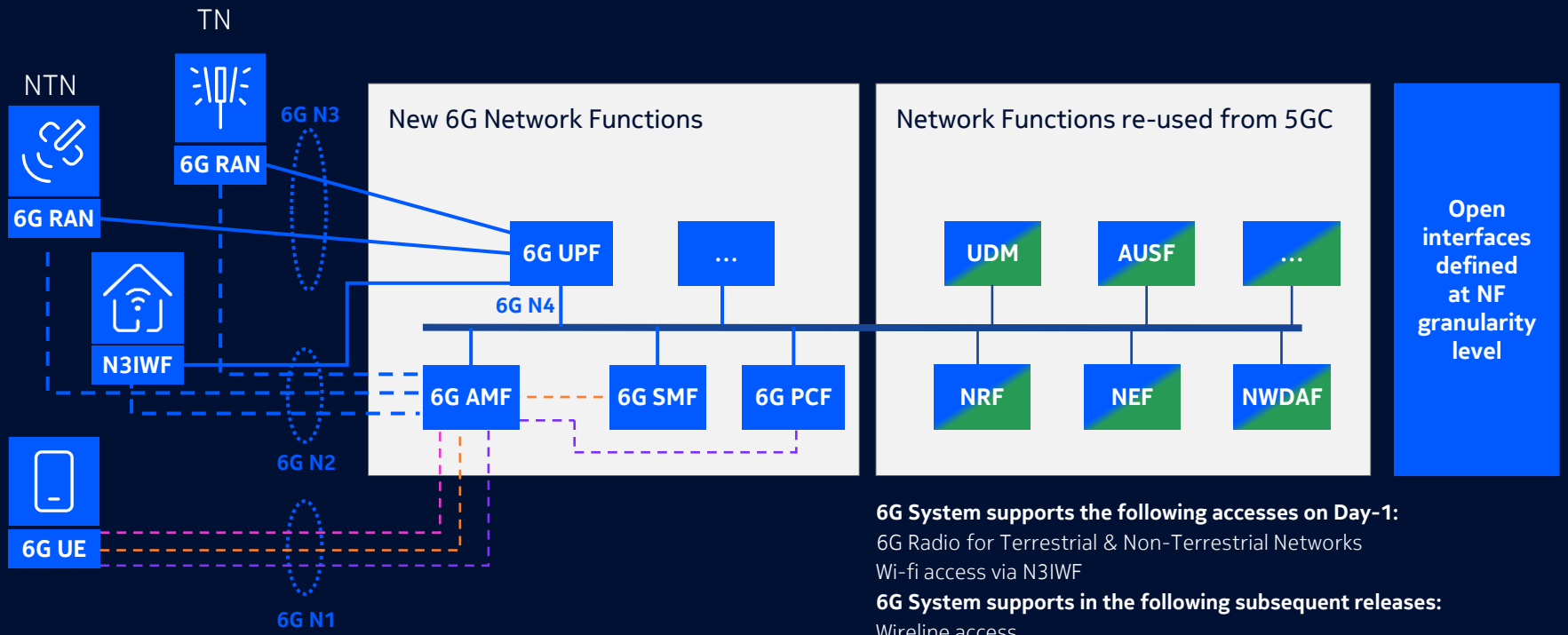
NTN satellite operating band	Uplink (UL) operating band Satellite Access Node receive / UE transmit $F_{UL,low}$ – $F_{UL,high}$	Downlink (DL) operating band Satellite Access Node transmit / UE receive $F_{DL,low}$ – $F_{DL,high}$	Duplex mode
n256	1980MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
n255	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
n254	1610 MHz - 1625.5 MHz	2483.5 MHz - 2500 MHz	FDD
NOTE: NTN satellite bands are numbered in descending order from n256.			

Architecture



- **NTN Spectrum is clean**, does not require interference mitigation
- **3GPP NTN :** provides air interface accommodation for the latency (Delay HARQ)
- Algorithm to **accommodate the Dopler Effect**

6G System Converged networks



6G System supports the following accesses on Day-1:
6G Radio for Terrestrial & Non-Terrestrial Networks
Wi-fi access via N3IWF
6G System supports in the following subsequent releases:
Wireline access

Friends and Foe

Friends?

- **Working together in rural for mobile:** Aligning to provide assisted coverage for rural areas where cost of mobile deployment is high

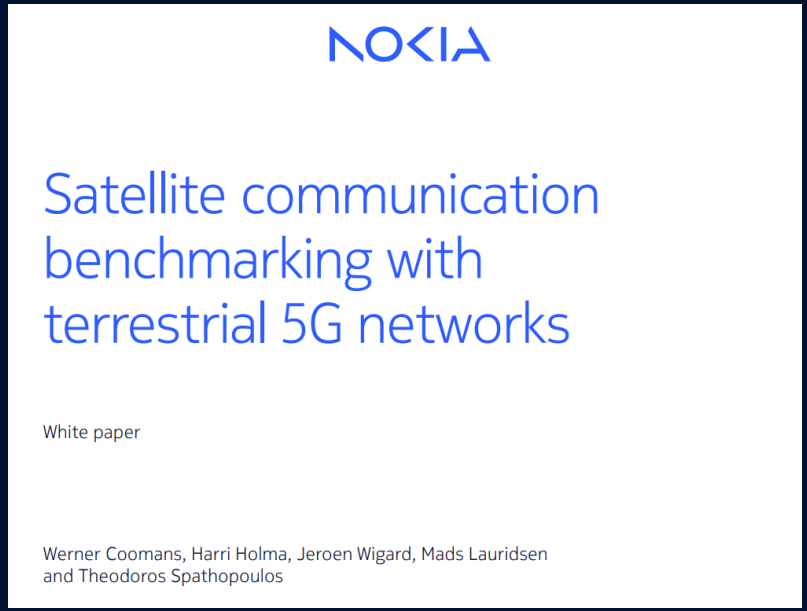
Foes?

- **Competing with Fixed wireless Access (FWA):** Starlink and Leo are already competing with Mobile industry to deliver high speed data in rural areas against Fixed wireless Access solutions (FWA)
- **Could compete using MSS spectrum:** at the fringe of suburban areas

Satellite communication benchmarking with terrestrial 5G networks

White Paper

Due to advances in launch capabilities and increasing production volumes, satellite communications are addressing increasingly wider customer segments. Further cost reductions and access to new spectrum will only increase their relevance, especially to rural and remote users without access to 4G or 5G fixed wireless access (FWA) or fiber. Where FWA is available, however, it remains a more compelling offer than existing satellite broadband services. Satellite-based Direct To-Device (D2D) services are starting to be commercially deployed across the globe, which support low data-rate services for consumers as well as emergency and public safety connectivity services. We argue that D2D can be considered as a solution for mobile operators to complement their terrestrial network coverage and will be an integral part of 6G mobile networks from day one. In this paper, we look closely at current and planned satellite services benchmarking them against 5G FWA services and make recommendations to service providers on how best to respond to this new class of sometimes-competing and sometimes complementary communications services.



Link

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Thank You