



Ordine degli Ingegneri  
della Provincia di Roma



Fondazione  
Ordine degli Ingegneri  
Provincia di Roma



Seminario

# Tecnologie e costellazioni satellitari emergenti

*Costellazioni di Micro-Satelliti Integrati alla Rete 5G*

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*Giampaolo Panariello*

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03 Dicembre 2021

*Sala Caccia Dominioni SMD - Via di Centocelle 301 Roma*

**NOKIA**

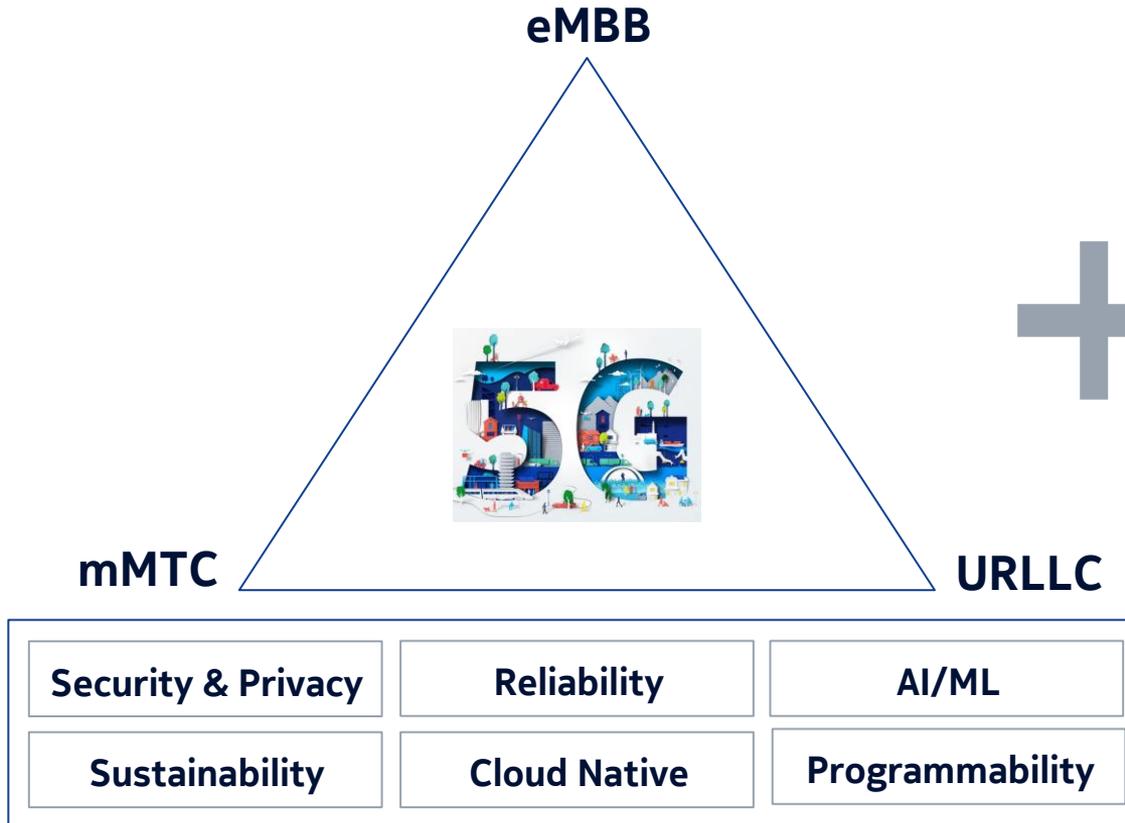
# Costellazioni di Micro-Satelliti integrati alla Rete 5G

Roma, Nov 03th

Giampaolo Panariello  
Nokia



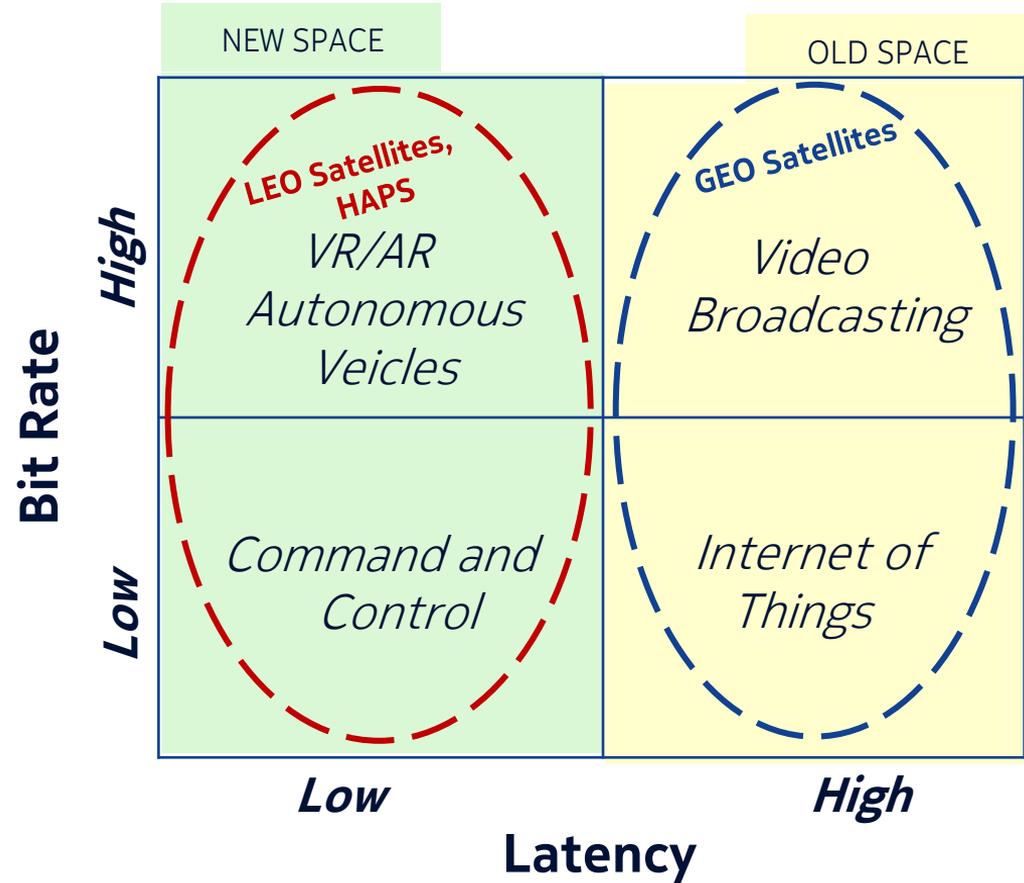
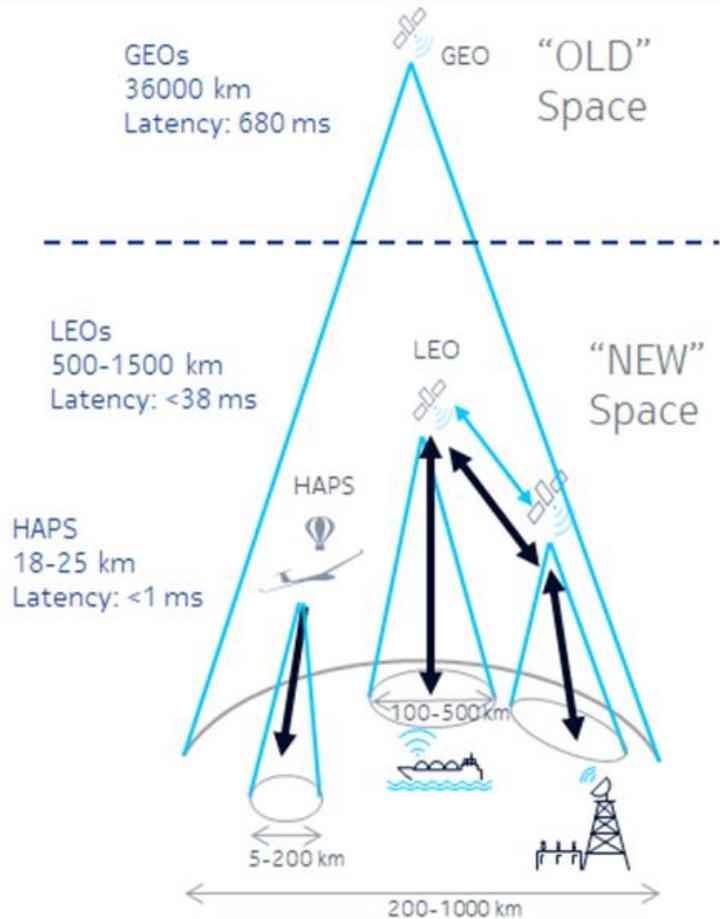
# 5G: Pillars and Use Cases



**Non Terrestrial  
Networks (NTN)**  
*(5G Advanced, starting  
from Rel. 17)*

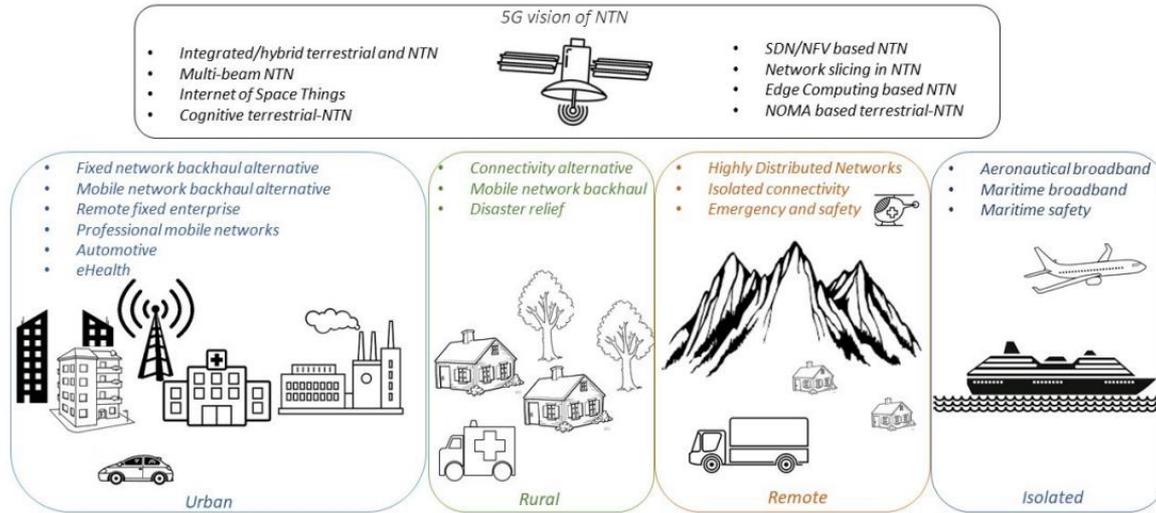


# The «rise» of the «NEW Space»



# 5G NTN Use Cases

## Ubiquity, Continuity, Scalability, Resiliency

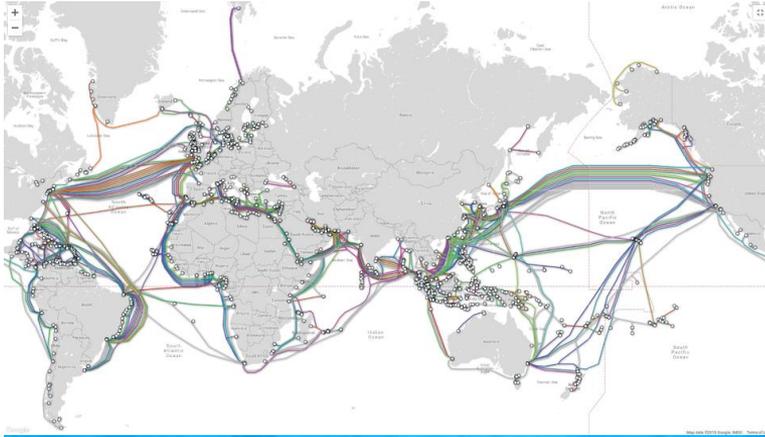


- **Service Ubiquity** to provide NTN access where it is infeasible through terrestrial networks;
- **Service Continuity** to improve NTN availability in case of disasters that lead to the temporary outage or the destruction of terrestrial networks;
- **Service Scalability** to offload traffic from terrestrial networks, above all during busy hours
- **Service Resiliency:** NTN Platforms are not subject to the same weather and man-made disasters that happen to terrestrial communications systems, they bring to the network an important component of resiliency.

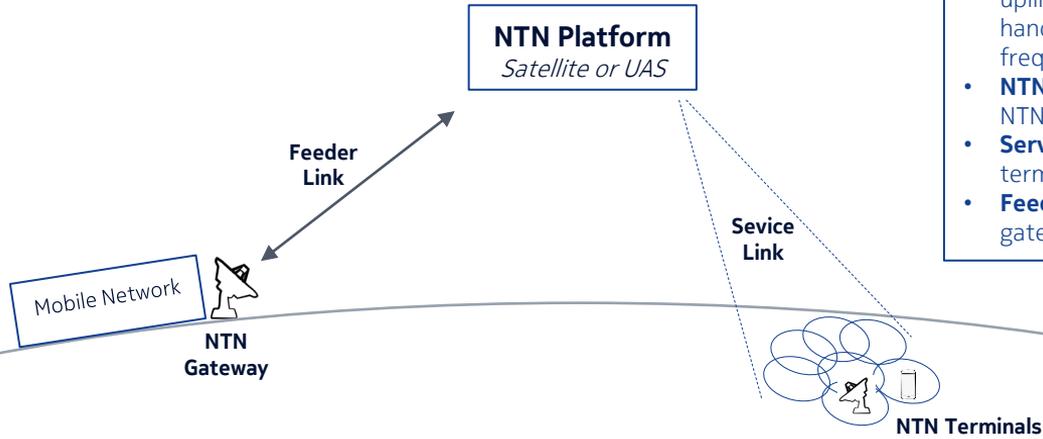
2/3/4G coverage

5G coverage

What could be the effect of an attack to submarine cable?  
NTN could contribute to a back up solution



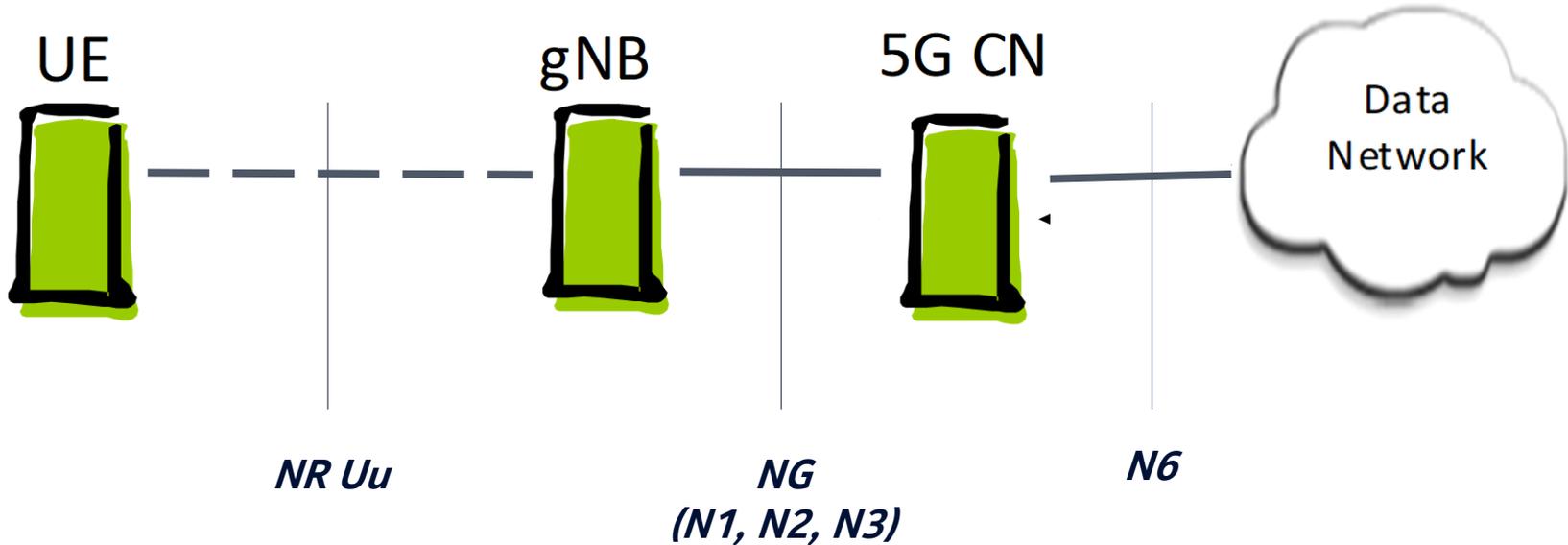
# NTN General Description



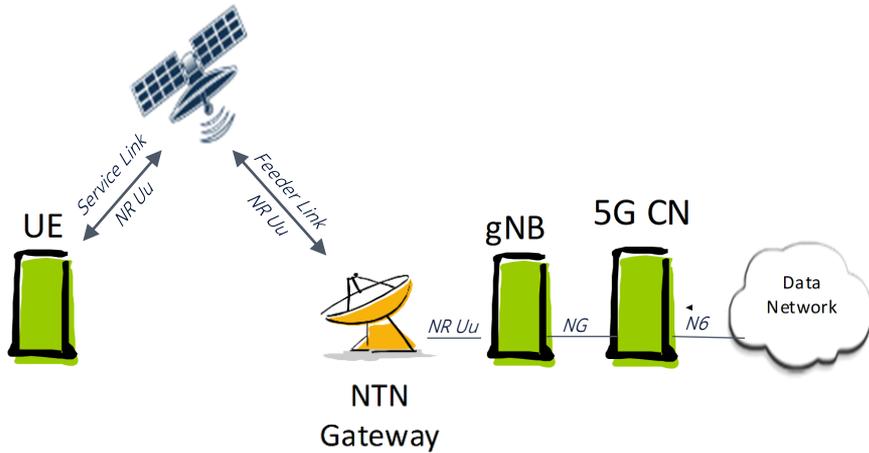
- **NTN terminal** refers to either the 3GPP User Equipment (UE) or a specific satellite terminal. Very small aperture terminals operate in the radio frequency of Ka band (i.e., 30 GHz in the uplink and 20 GHz in then downlink), whereas handheld terminals operate in the radio frequency of S-band (i.e., 2 GHz).
- **NTN gateway** is a logical node connecting the NTN platform with the 5G network.
- **Service link** is the radio link between the NTN terminal and the NTN platform.
- **Feeder link** is the radio link between the NTN gateway and the NTN platform.

Platforms	Altitude Range	Orbit	Beam Footprint Size
GEO satellite	35786 km	Fixed position in terms of elevation/azimuth w.r.t. a given point on Earth	200 - 3500 km
MEO satellite	7000 - 25000 km	Circular around Earth	100 - 1000 km
LEO satellite	300 - 1500 km	Circular around Earth	100 - 1000 km
UAS platform	8 - 50 km (20 km for HAP)	Fixed position in terms of elevation/azimuth w.r.t. a given point on Earth	5 - 200 km

# Simplified 5G Architecture

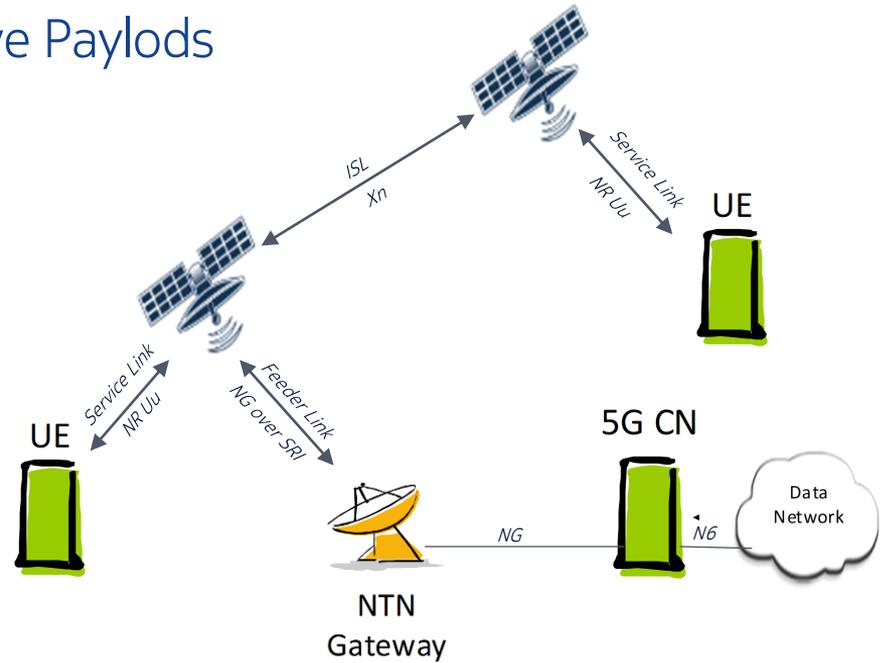


# Transparent (bent-pipe) and Regenerative Payloads



## Transparent

only radio frequency filtering, frequency conversion, and amplification are done on board the satellite. HAPS/LEO amplifies, translates frequency and forwards the Uu signals. Uu interface = service link (SL) + inter-HAPS/Satellite link + feeder link (FL).



## Regenerative

NTN platform effectively implements all the gNB functions on board

SRI = Satellite Radio Interface



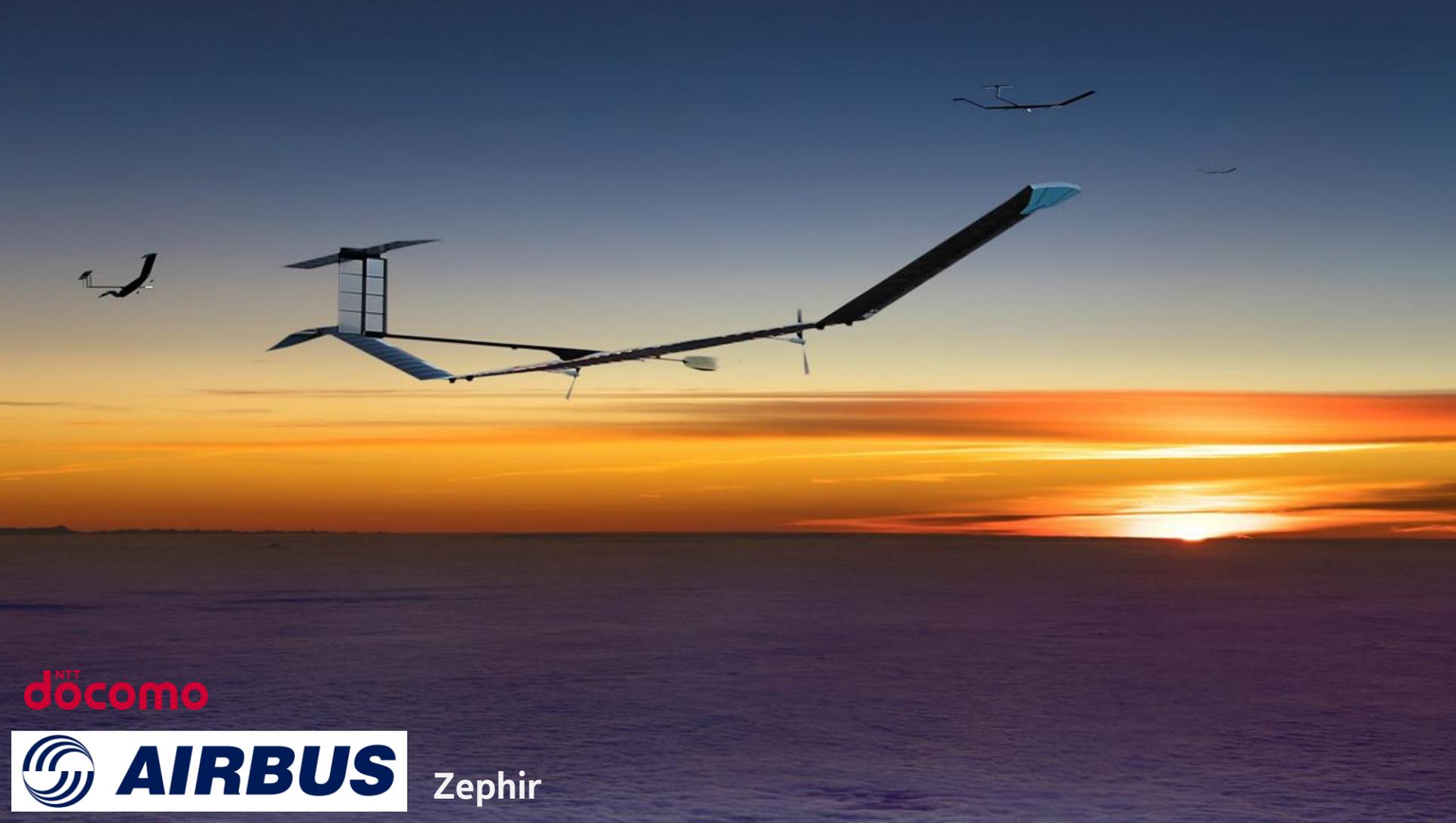
# HAPS MOBILE

— SoftBank



Confidential

Photo credit: NASA/Carla Thomas



<sup>NTT</sup>  
**docomo**



Zephyr

# Pre-Standardization Steps

## **Release 15 Study Item on NR NTN**

- Reference deployment scenarios of NTN (Frequencies, platforms, beams, footprint, Terminals.....)
- NTN channel models based on the terrestrial 3GPP channel models

## **Release 16 Study Item on NR NTN**

- NR adaptations to support NTN
  - For the UP, the main impact comes from the long propagation delays in NTN
  - CP, the focus of the study was on mobility management procedures, due to the movements of NTN platforms (LEO)

The study concluded that the Rel-15 and Rel-16 NR functionalities form a good basis for supporting NTN, despite issues due to long propagation delays, large Doppler shifts, and moving cells in NTN. Some enhancements were proposed.

# 3GPP is active in addressing satellite's role in the overall 5G vision with releases 17, 18 and beyond

## Rel 15-16 (custom approach, Pre NTN Standard)

- Transparent architecture; LEO; Earth Fixed Cells
- Reusing terrestrial spectrum
- Supports LTE, 5G, NB-IoT and eMTC
- Doppler compensation and delay normalization performed by gateway in ground station
- Software modifications to NodeB scheduler for long constant delay

+ Works with existing LTE, 5G and NB-IoT terminals

+ Quick time to market

- Reusing terrestrial spectrum requires regulatory approval

- Performance limitations (#of users, peak rate)

- Requires large satellite (>500sqm)

## Rel 17 NTN support

- Transparent architecture; HAPS, LEO, MEO, GEO; Earth Fixed or Earth Moving Cells.
- Dedicated spectrum in S and L band
- Doppler and delay compensation performed by terminal assisted by network (requires GNSS capable terminal)
- Standardized enhancements to HARQ procedure (increase # of processes and slot aggregation factors)

+ Performance improvements (#of users, peak data rates)

+ More flexibility and architectural choices

- Requires new terminals adopting Rel-17 NTN standards with GNSS support

- Requires satellite controller to provide network assistance information to UE

## Rel 18+ NTN enhancements

- Transparent + regenerative architecture and inter-satellite link (ISL).
- Additional >10 GHz frequency and support of VSAT/ESIM terminals.
- Support of terminals without GNSS
- Coverage enhancement for smart phones
- Mobility and service continuity between NTN and TN

+ Increased feeder link capacity

+ Lower terminal power consumption

+ Enables smaller satellites

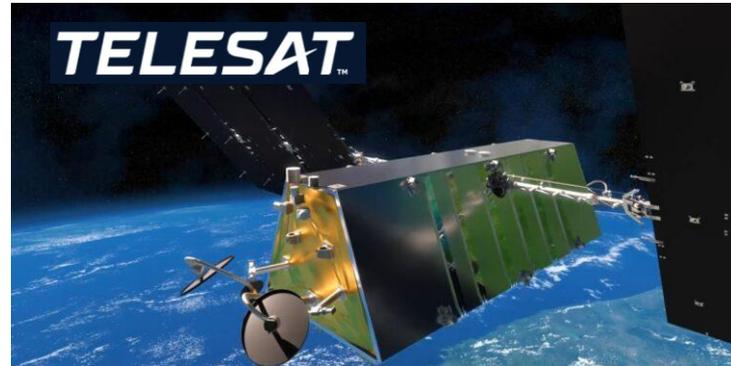
+ Lower CPE costs

- Requires new terminals adopting Rel-18 NTN standards

- Limited reuse of terrestrial hardware for regenerative architecture

**With 3GPP release 18 expected to be completed in the latter half of 2023, standardized 3GPP based LEO deployments at scale are unlikely before 2025**

What about Starlink, OneWeb, Kuiper, Lightspeed.....  
They are NOT NTN Standard and NOT for Mobile Users

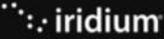


# AST Spacemobile

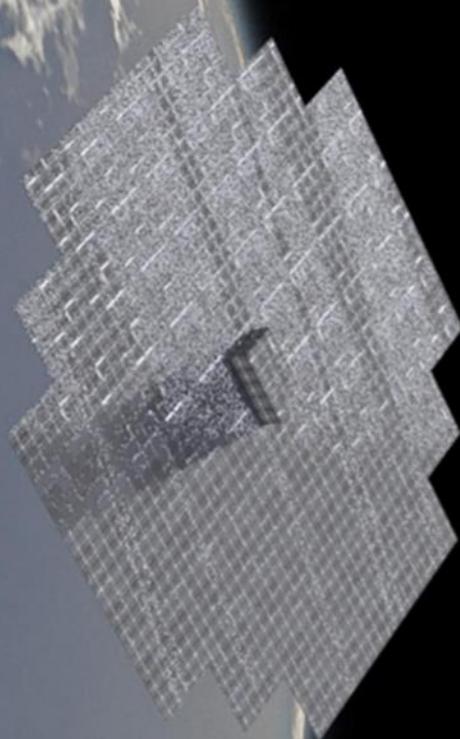
## An example of Pre-NTN Standard Solution

# AST SpaceMobile



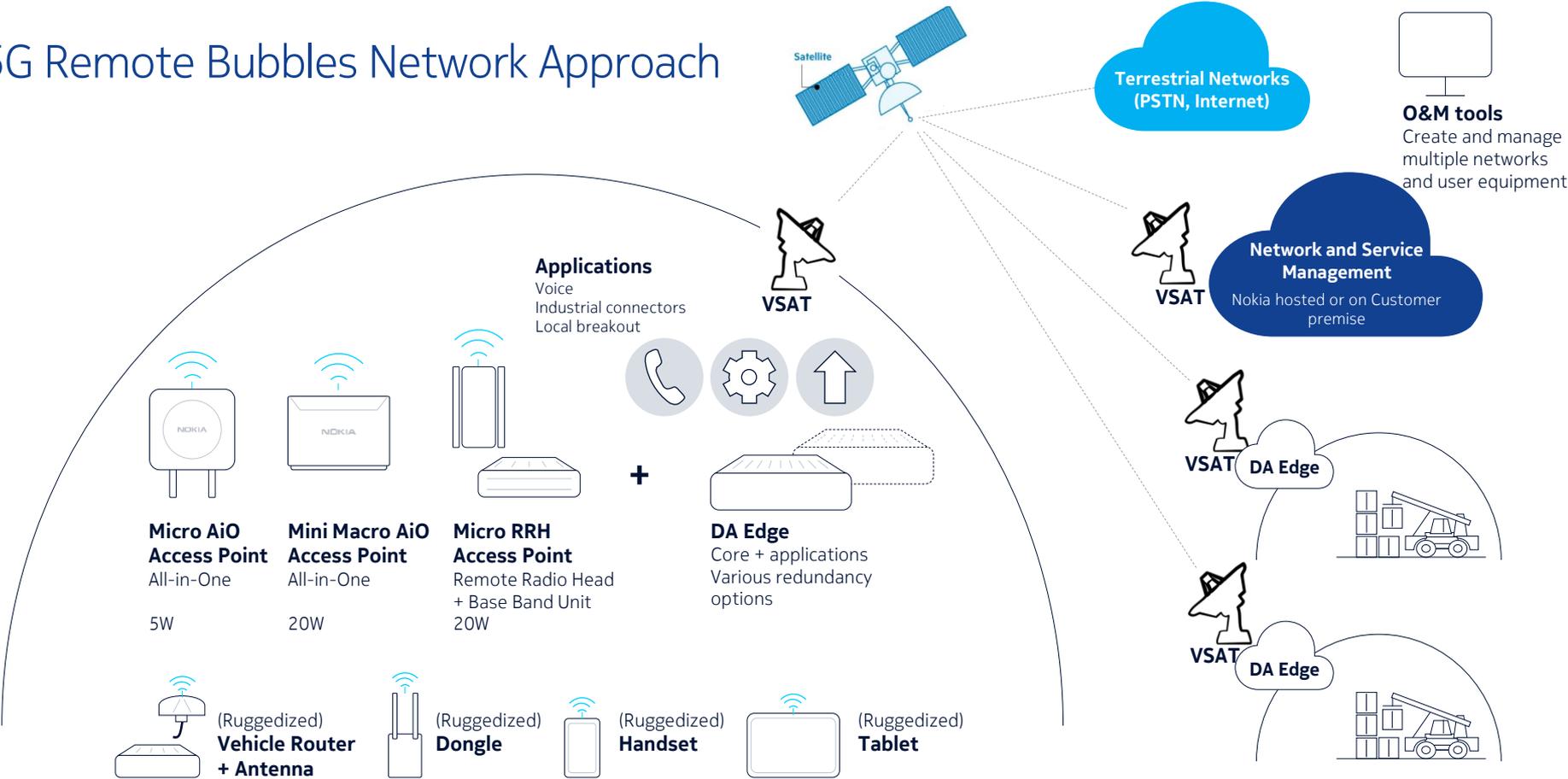
	Direct via Specialized Mobile Phones	Indirect via Complex, Expensive Hardware	First & Only Direct Broadband To Mobile Phones				
							
	Provider-specific satphones (~\$1K)	Provider-specific antennas mounted on planes, ships, vehicles, buildings (~\$1K-\$200K+)	Any standard mobile phone				
Providers	  	<table border="1"> <thead> <tr> <th>Today</th> <th>Coming</th> </tr> </thead> <tbody> <tr> <td>         </td> <td>      </td> </tr> </tbody> </table>	Today	Coming	     	  	
Today	Coming						
     	  						
End Users	Narrowband service on satphones	Enterprise, Maritime, Aviation, Government, Residential	Mass market mobility and the unconnected				
Market Size <sup>1</sup>	< \$1.5 billion revenue	< \$15 billion revenue	> \$1 trillion revenue				

# BlueWalker 3 in-orbit plan



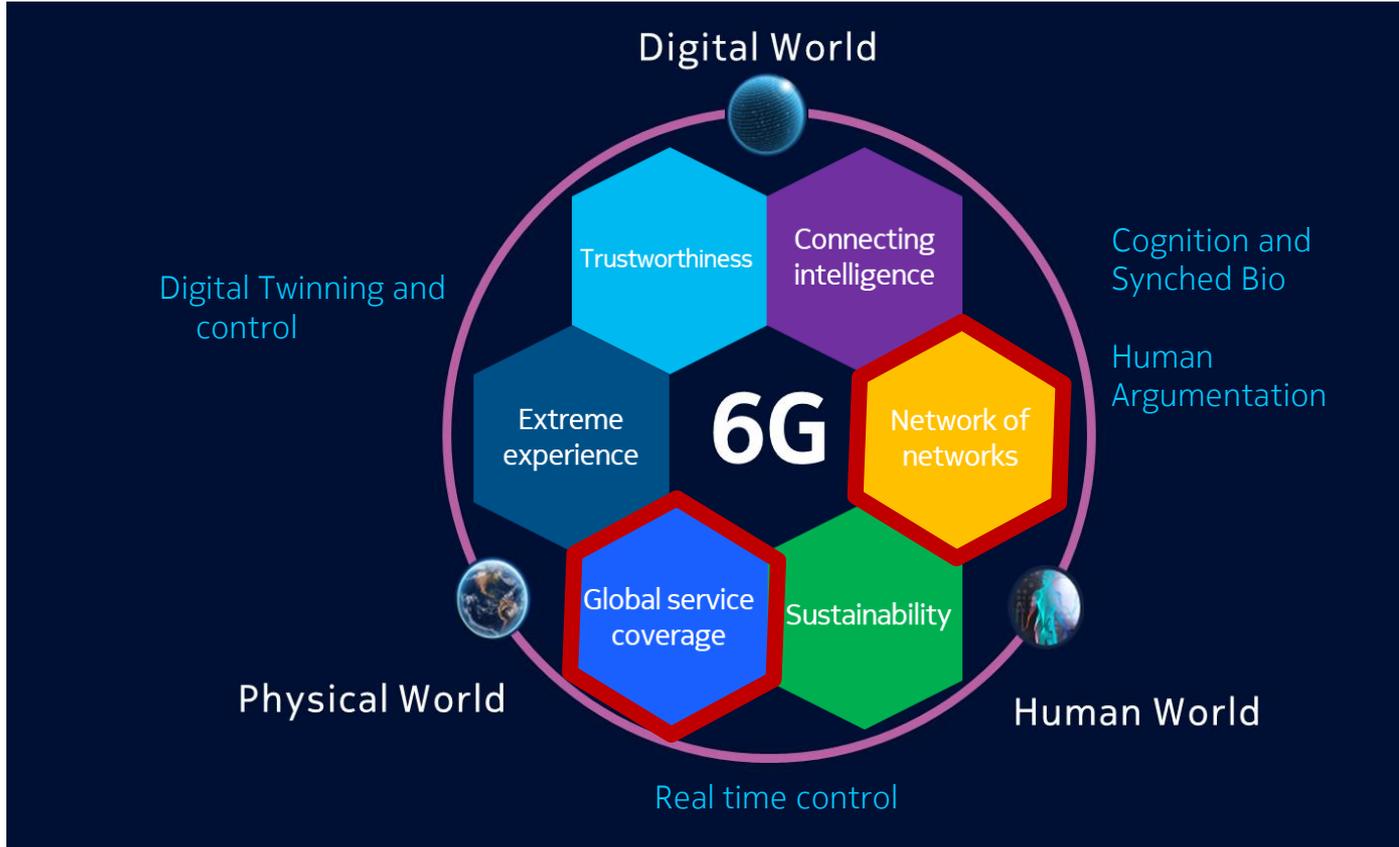
- Size: 693 square-foot phased array
- We believe BW3 will be one of the largest phased array antenna deployed into low Earth orbit
- Altitude: ~400 kilometers (~250 miles)
- Orbit: 53 degrees inclined
- Speed: ~25,000 km/h (~17,000 mph)
- Circle the Earth every ~90 minutes

# 5G Remote Bubbles Network Approach



# What's Next.....6G!!!!

NTN is an integral part of 6G



Update: We are going to the Moon South Pole!!!!!!

NASA confirmed that will send the Intuitive Machines' Nova-C lander, including the **first Extraterrestrial mobile network by Nokia**, to the lunar South Pole on a ridge not far from Shackleton crater. Mission timeline is late 2022

The era of Extraterrestrial Mobile Networks is Starting!!!!

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