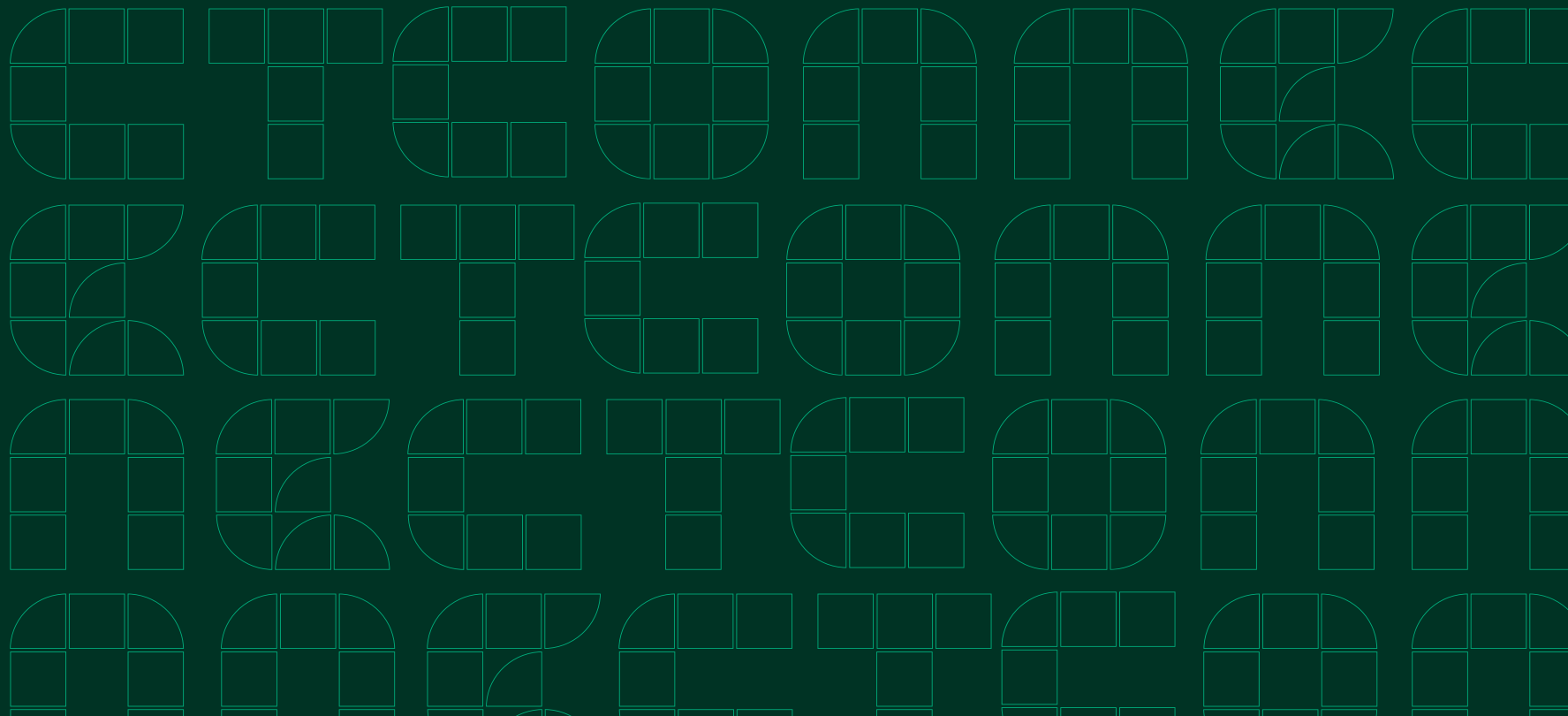
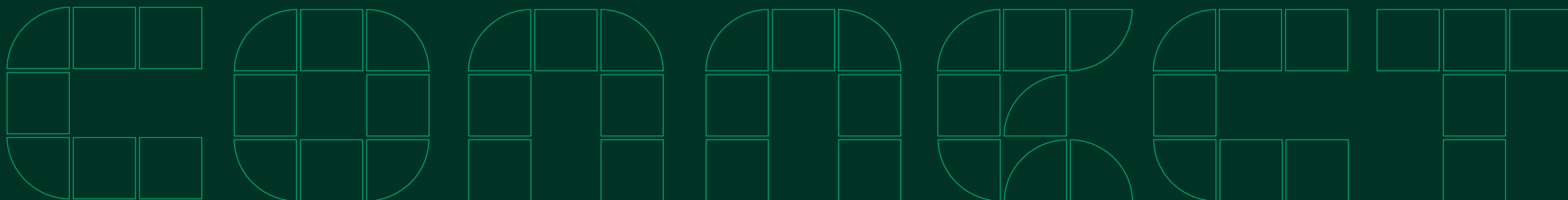


connect





Commercialization of Space: Market Survey of Non- Terrestrial Networks for Cellular Communications

Gerardo Orozco
Chief Systems R&D Engineer for
Semiconductors and Electronics

Commercialization of Space

Communication technologies driving this commercialization

Challenges for convergence with cellular networks

Identified space communication trends

2	0
2	4

3rd



Welcome to the age of
commercial Non-
Terrestrial Networks
NTN

Content credentials
Generated with AI

EMERSON | 

MediaTek Powers World's First Satellite 5G NTN Smartphone Communication

MediaTek's collaboration with Rohde & Schwarz demonstrates the potential of this technology to bring fast, reliable 5G connectivity everywhere via satellite

<https://corp.mediatek.com/news-releases/mediatek-powers-worlds-first-satellite-driven-5g-ntn-smartphone-connection>

Aug 16, 2022 - 9:00 PM

HSINCHU, Taiwan – August 16, 2022 – MediaTek (TSMC) has reached a new 5G milestone by powering a smartphone with a 5G Non-Terrestrial Network (NTN) in a lab environment for the first time. The test involved the transfer of data to ITRI's Next Generation NodeB network (gNB) test system. The test setup simulated a Low Earth Orbit (LEO) satellite channel emulated in combination with Rohde & Schwarz, MediaTek has demonstrated a world-first and showcased the capability of supporting 5G NTN communications with its 5G hardware.

WIRELESS

T-Mobile, SpaceX 'end of the world' dead zones' with satellite connectivity

By Monica Allevan • Aug 25, 2022 09:49pm

T-Mobile SpaceX satellites FCC

<https://www.fiercewireless.com/wireless/t-mobile-spacex-satellites-fcc>

WIRELESS

Apple iPhone 14 will have emergency satellite connectivity

By Linda Hardesty • Sep 7, 2022 04:27pm

Apple Globalstar iPhone satellite broadband

<https://www.fiercewireless.com/wireless/apple-iphone-14-will-have-emergency-satellite-connectivity>



Samsung Electronics Introduces Standardized 5G NTN Modem Technology To Power Smartphone-Satellite Communication

Korea on February 23, 2023

Audio



Share



<https://new.s.samsung.com/global/samsung-electronics-introduces-standardized-5g-ntn-modem-technology-to-power-smartphone-satellite-communication>

Standardized 5G NTN technology simulated on Samsung's Exynos Modem 5300; Demonstrates two-way text messaging as well as image and video sharing



Amazon's concept of ULA's Vulcan Centaur rocket, one of Amazon's contracted launch vehicle for its Kuiper system of satellites. (Image: Amazon via BusinessWire)

<https://www.rcwireless.com/20230109/spectrum/amazon-to-test-kuiper-prototype-system>

Amazon to launch, test Kuiper system

By Kelly Hill January 9, 2023

Featured Policy Spectrum

Qualcomm Introduces Snapdragon Satellite - World's First Satellite-Based Solution Capable of Supporting Two-Way Messaging for Premium Smartphones and Beyond

JAN 5, 2023 | LAS VEGAS

Qualcomm products mentioned within this press release are trademarks of Qualcomm Technologies, Inc. and/or its subsidiaries.

<https://www.qualcomm.com/news/releases/2023/01/qualcomm-introduces-snapdragon-satellite>

Highlights:

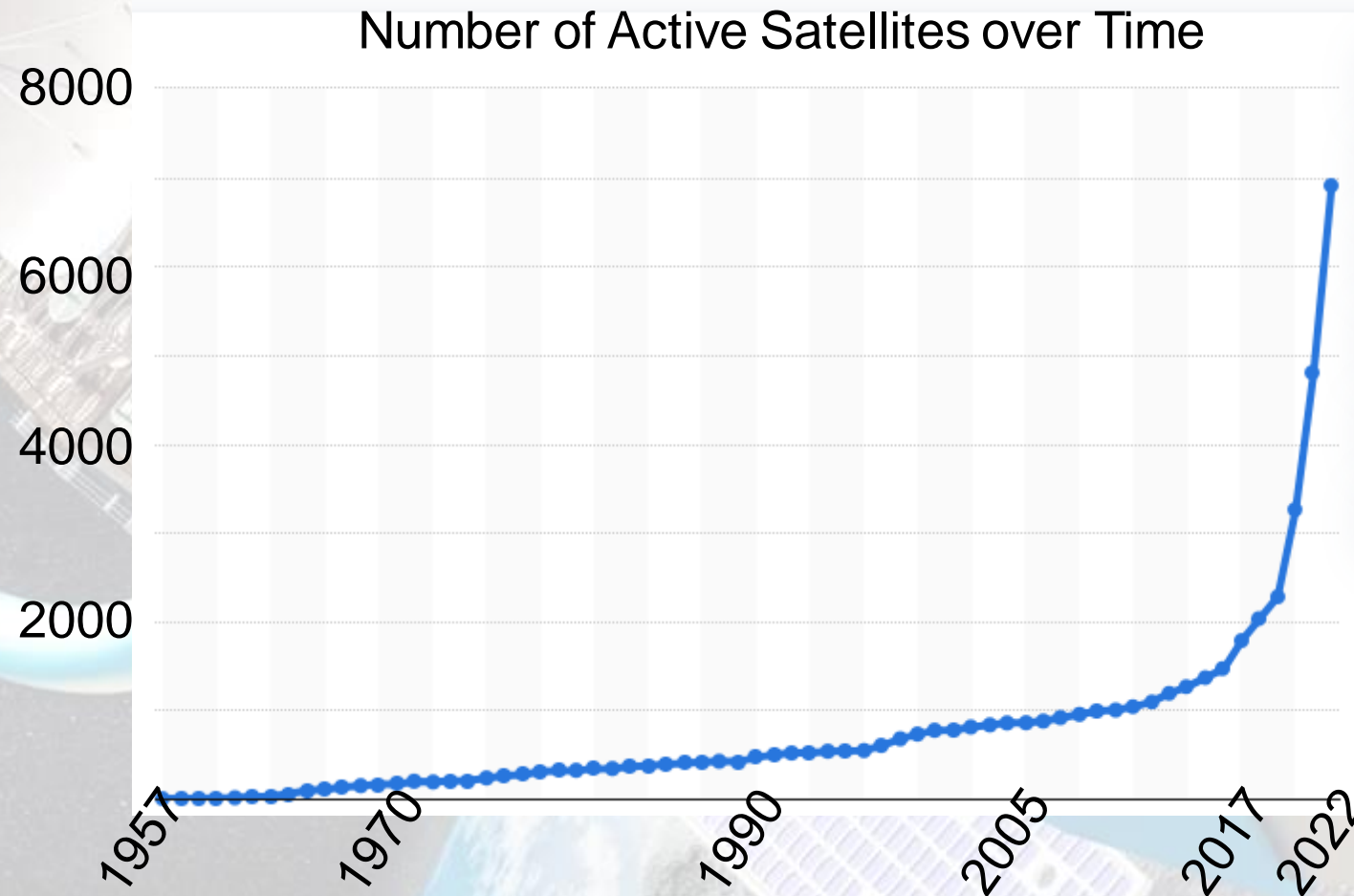
- Qualcomm and Iridium entered into an agreement to bring satellite-based connectivity to next-generation premium Android smartphones; Garmin looks forward to collaborating with support for emergency messaging.



The Number of Active Satellites

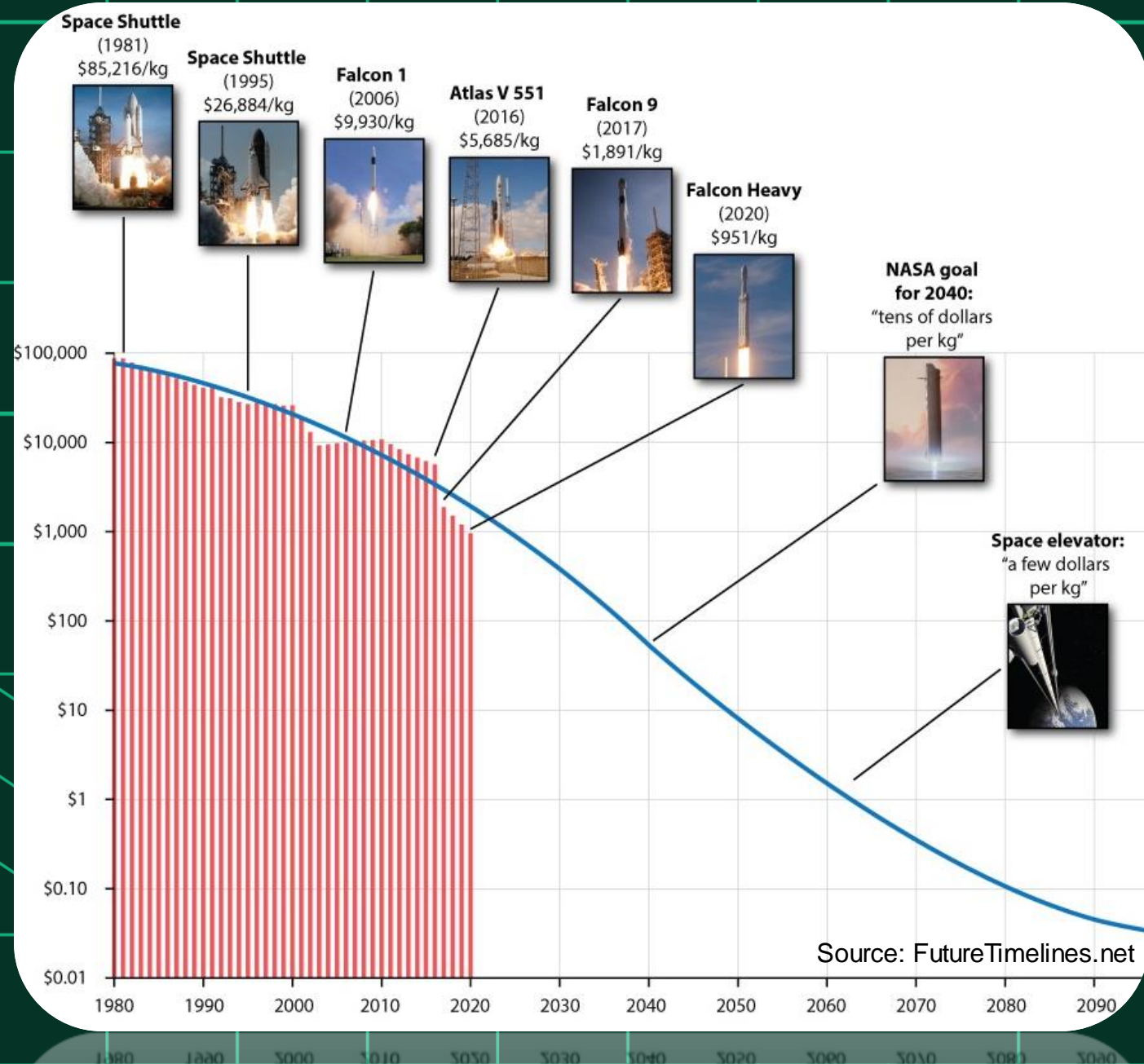
CONNECT

- Deployments growing exponentially
- Very large pipeline of planned satellites



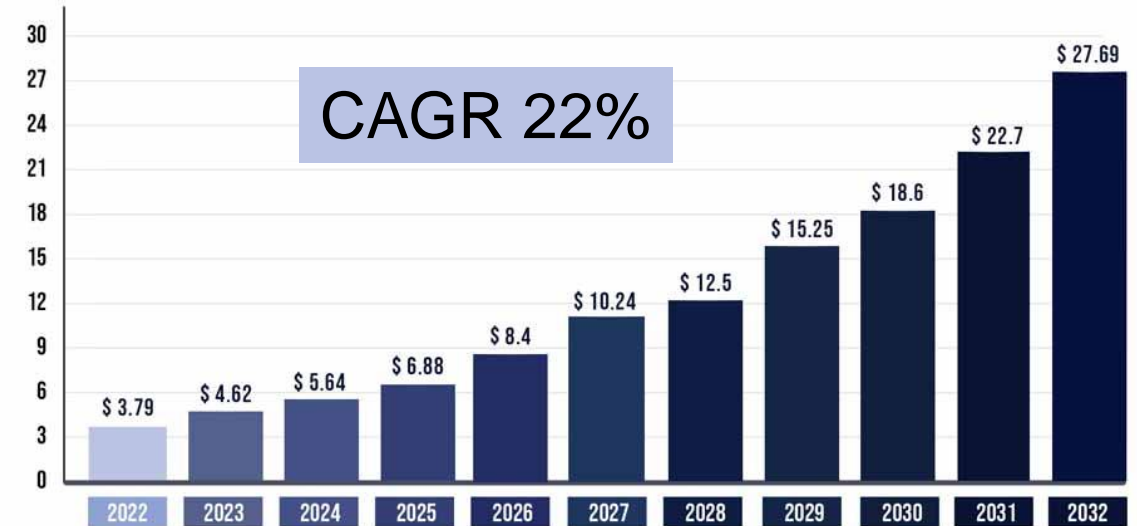
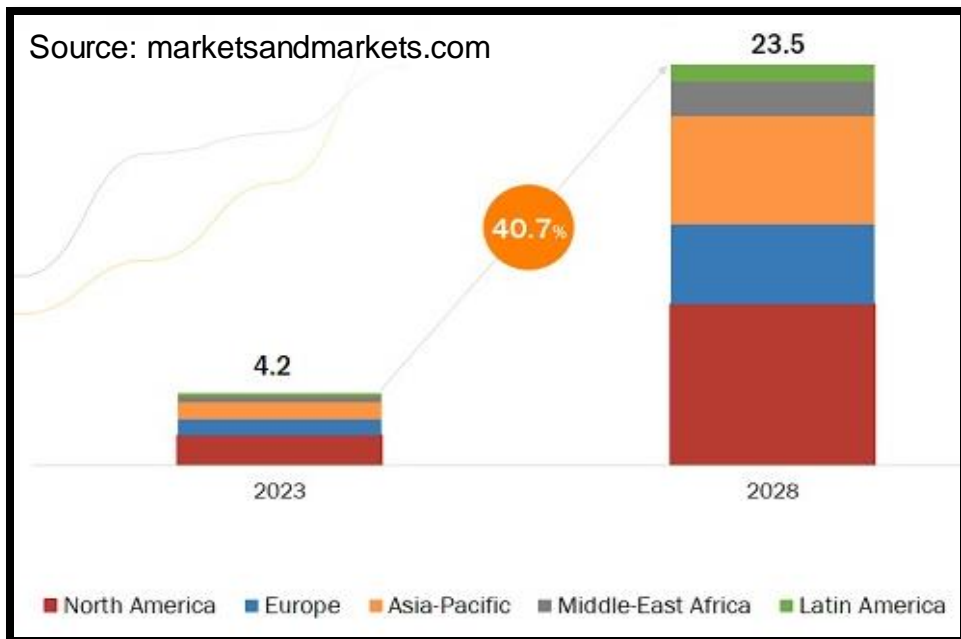
- The cost of placing 1 kg into LEO orbit has dropped dramatically.
 - \$10K/kg in 2006
 - \$1K/kg in 2020
 - <\$50/kg in 2040
- The weight and cost needed for a given functionality has also dropped dramatically.
 - Advances in:
 - Electronics
 - Phased array antennas
 - Solar cells
 - Batteries
 - Attitude control

Satellites have achieved economies of scale



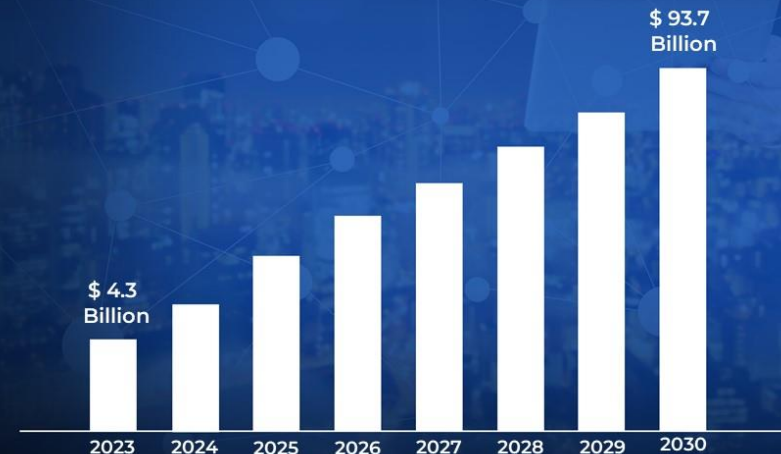
NTN Market Size

- The rising need of service continuity
- The always need of servicing large underserved (usually rural) populations
- Increasing digitalization across various sectors



Source: www.precedenceresearch.com

Global 5G NTN Market



Three main categories of commercial NTN



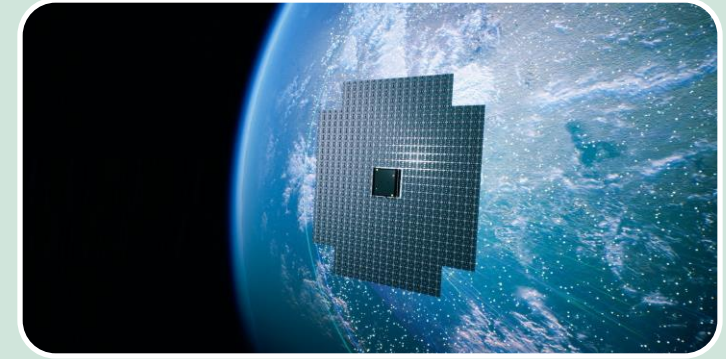
Broadband Data

- Need special ground equipment
- Kuiper/SpaceX/OneWeb



Narrowband Data Expansion (IoT and SOS)

- Existing networks providing more services to more users
- Voice and data with special ground equipment
- New cellphones
- Iridium/Inmarsat/GlobalStar



Networks designed to connect to existing UE

- Unmodified phones voice and data
- AST SpaceMobile/Lynk

5G and LTE Adoption

9The goal is to connect all existing and new commercial devices

12% of current satellites are GEO

Geostationary (GEO)



35,786 km

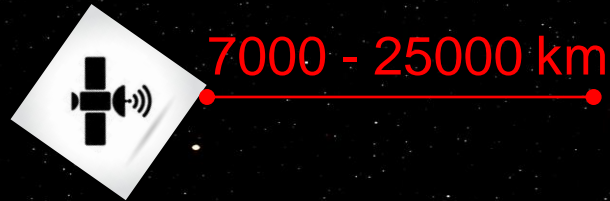


Rotates with earth, thus always
in same location in sky (as seen
from earth)

- Large earth coverage (42%)
- No doppler (frequency shifts)
- Large delays (~240ms)
- Large pathloss (signal attenuation)
- \$\$\$ to get up there

3% of current satellites are MEO

Medium Earth Orbit (MEO)

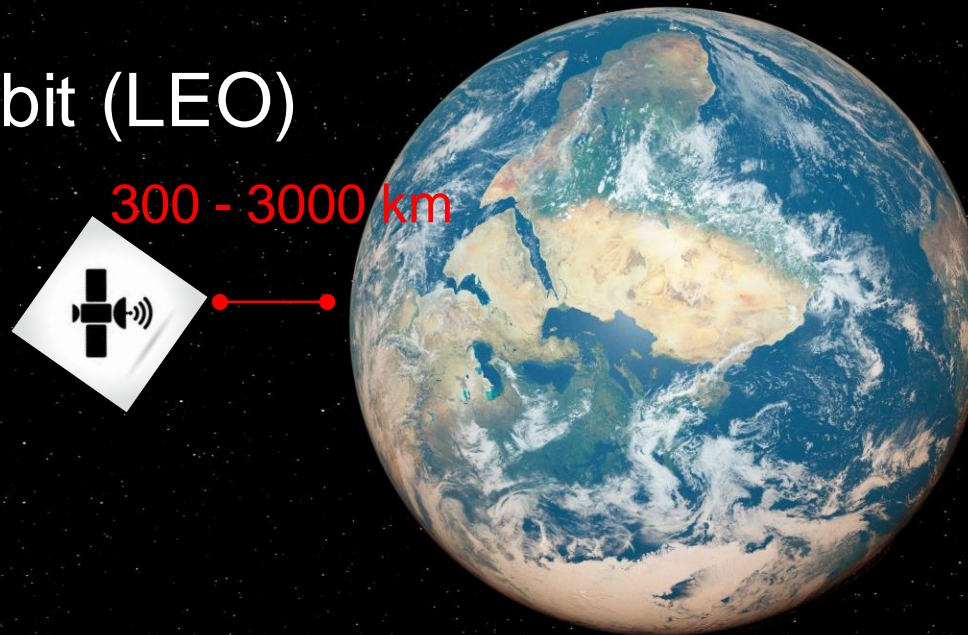


Smaller earth coverage
Doppler (51 – 33 kHz)
Delays (47 – 167 ms)
Less pathloss (signal attenuation)
\$\$ to get up there

GPS

84% of current satellites are LEO

Low Earth Orbit (LEO)



Smaller earth coverage

Doppler (61 – 72 kHz)

Delays (2 – 20 ms)

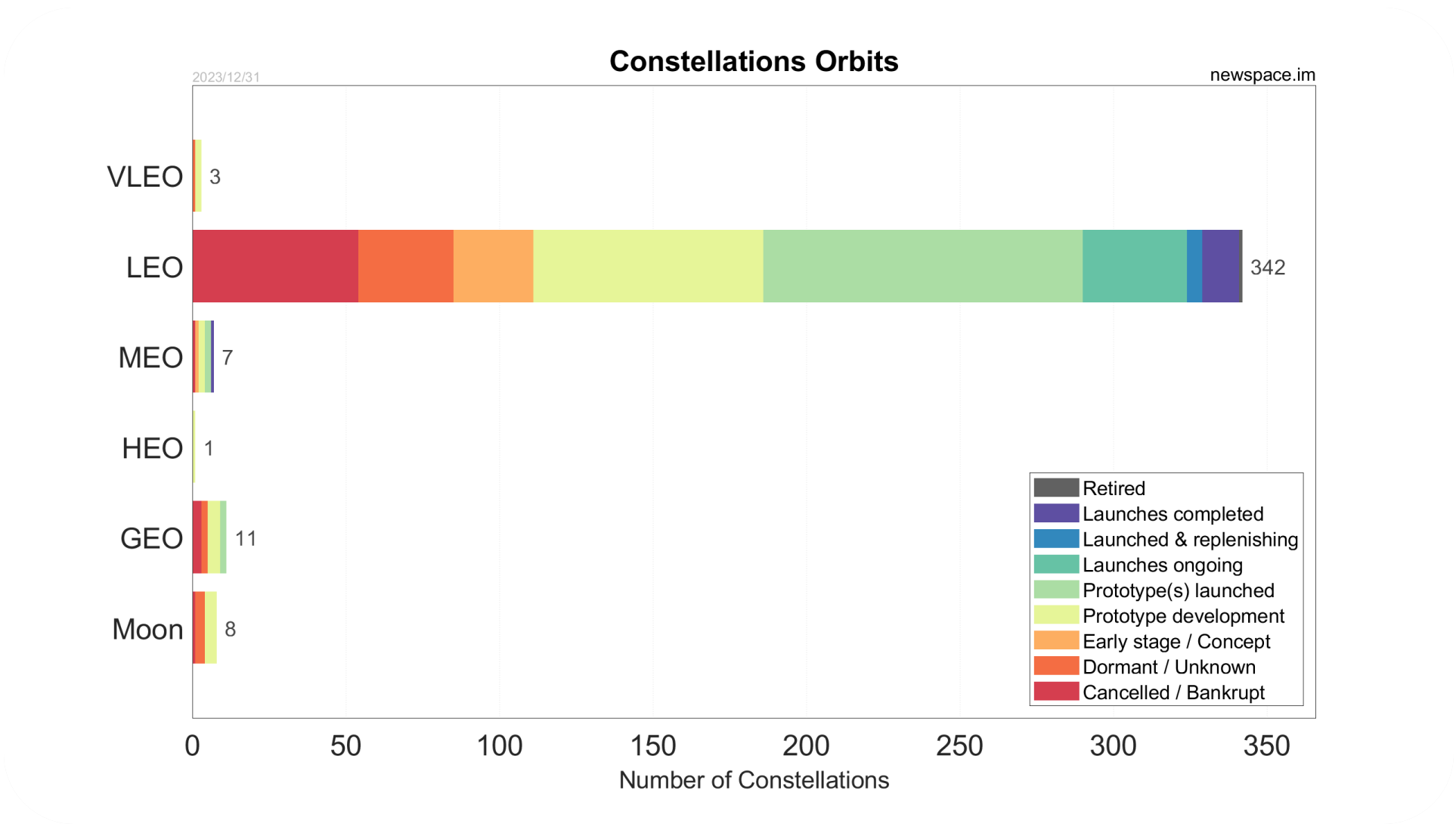
Less pathloss (signal attenuation)

\$ to get up there

Satellite Orbits Summary

Orbit	Altitude from Earth Surface [km]	Orbit Period [min]	Round-trip Min. delay [ms]	Velocity [km/s]	Doppler 2 GHz, 45 deg elevation [kHz]	Average Satellite Lifespan [years]	Beam Footprint [km]
LEO	300 - 3,000	91 - 151	2 - 20	7.7 - 6.5	72.9 - 61.5	5 - 7	50-1000
MEO	7,000 - 25,000	922 - 1,436	47 - 167	5 - 4	51.5 - 33.6	5 - 7	100-1000
GEO	35,786	24·60	239	~ 0	0	10-15	200-3500

Commercialization is in the LEO orbit



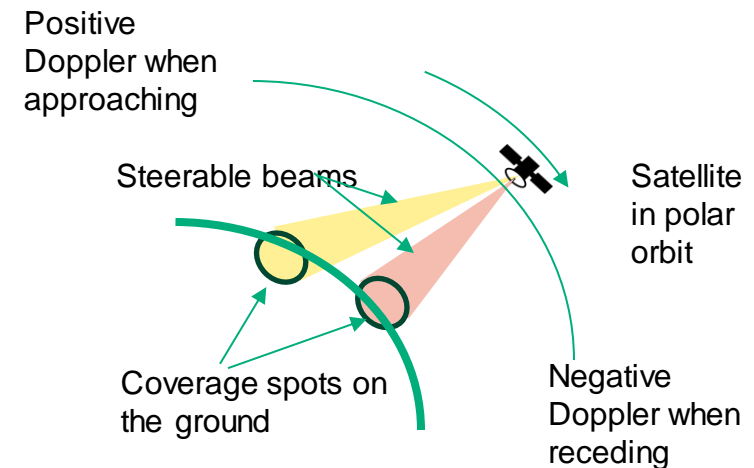
Overcoming the Challenges of Phone Communication

Speed of the Satellite (“base station”) 30,000 km/hr

1. Causes large variable frequency shifts (doppler) → Broadcast the ephemeris of the satellite so that the UE can compensate for this before transmitting.
2. Causes the antenna beam to move very quickly → Proposed to keep beam on same spot in earth “earth-fixed-beam”

Multiple Satellites Serving one Spot

1. Network must constantly handoff from one satellite to the next → Also estimated base on location (with base stations is done with signal strength).
2. Base station to satellite or satellite to base station



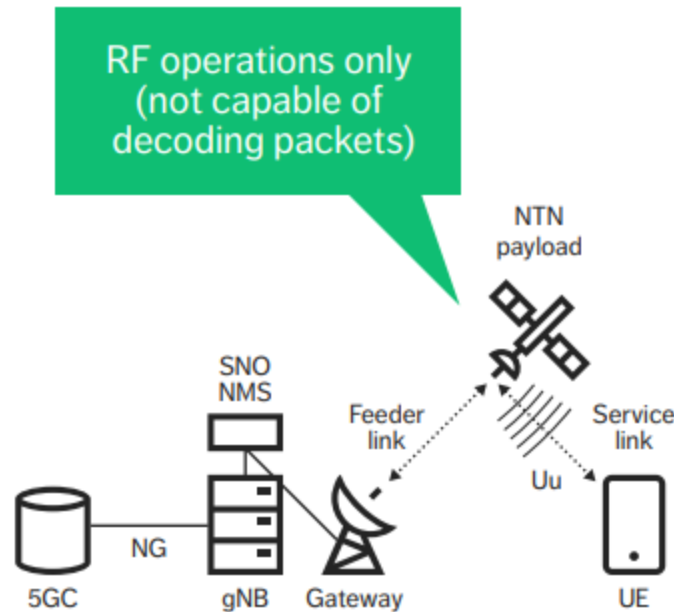
What does the Satellite Actually Do?

Initial architectures for NTN will use the satellite as a repeater.

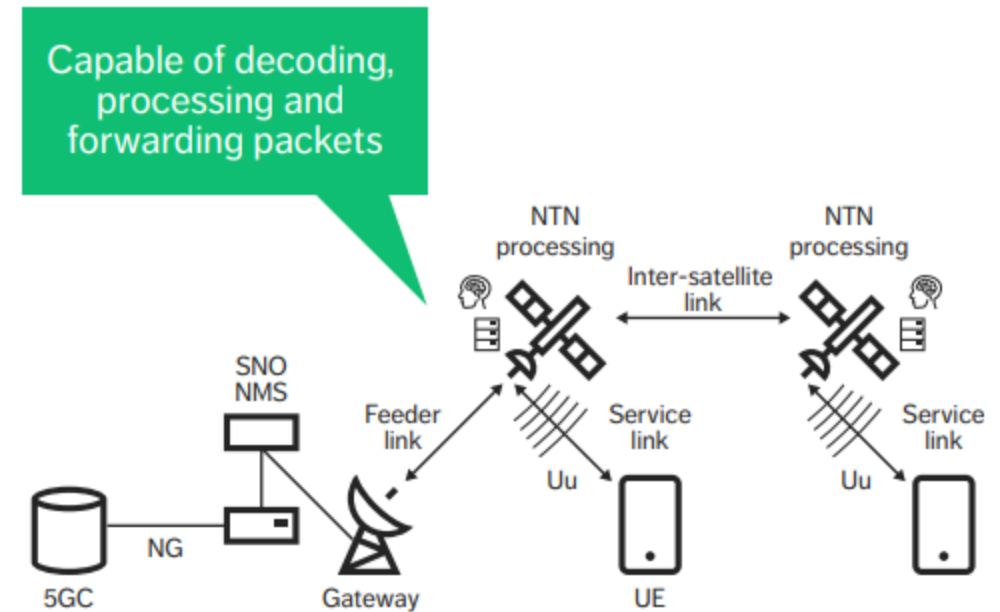
Much of the processing including Modulation, Doppler, time advance, scheduling, error correction, etc. is done on the ground.

Increases adoption even on older type of satellites

Transparent payload

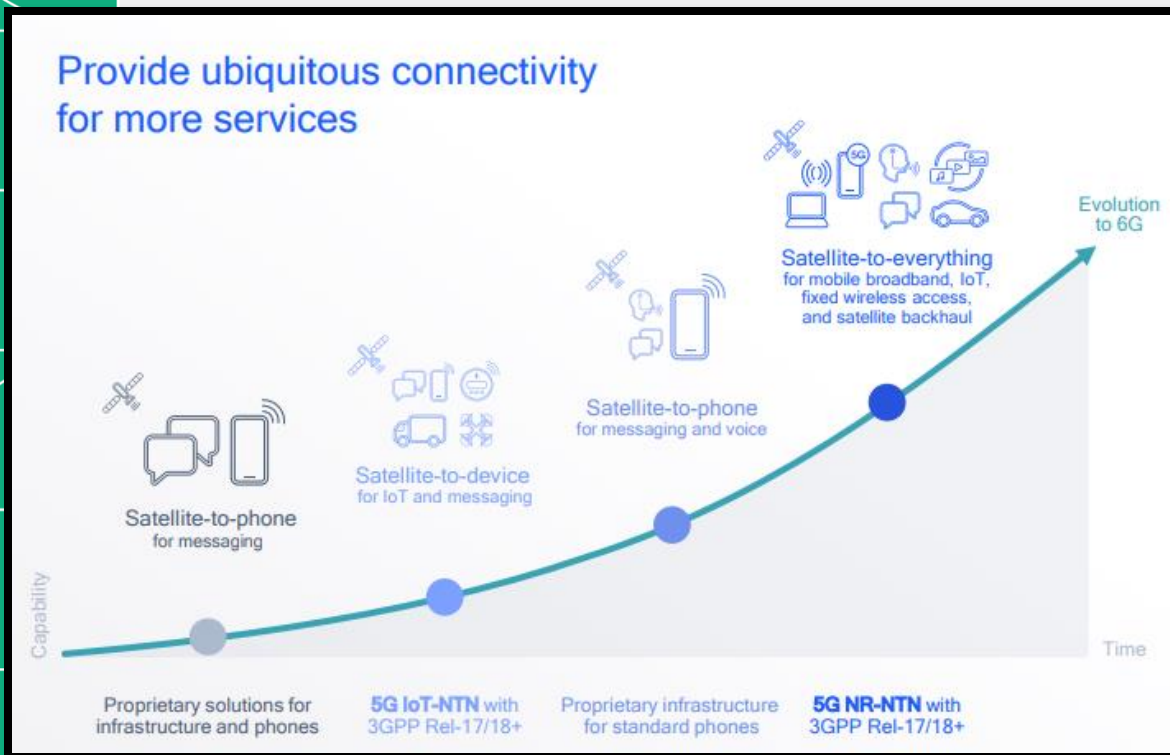


Regenerative payload

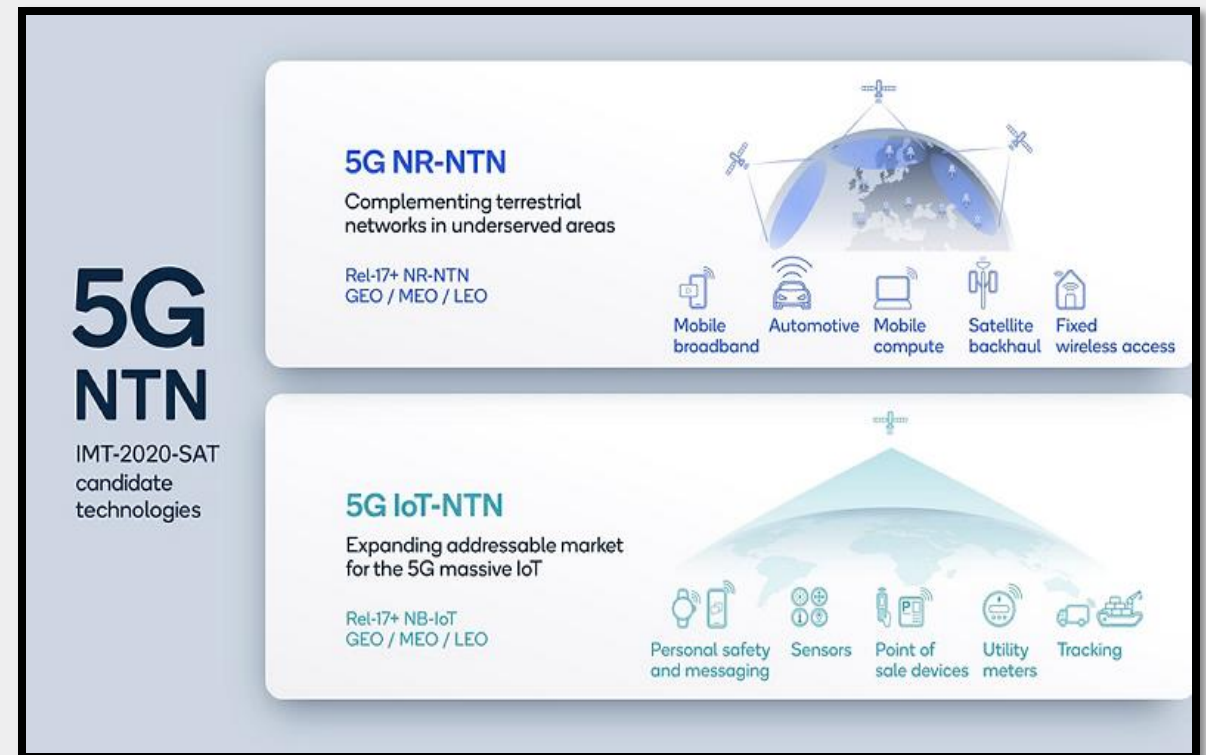


Standards adapted to overcome challenges

The capability increases with standards



Technologies adapted for NTN



Examples of New Satellites: AST SpaceMobile

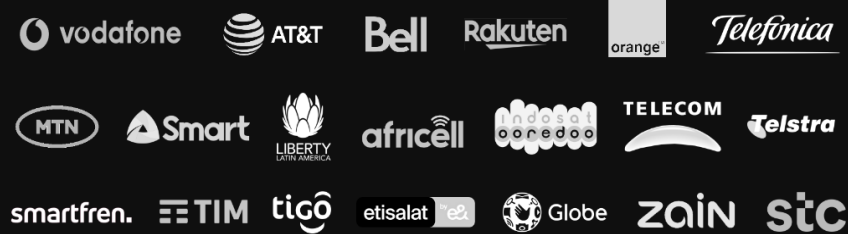


- Startup founded in 2017; HQ in Midland, TX

Strategic Investors

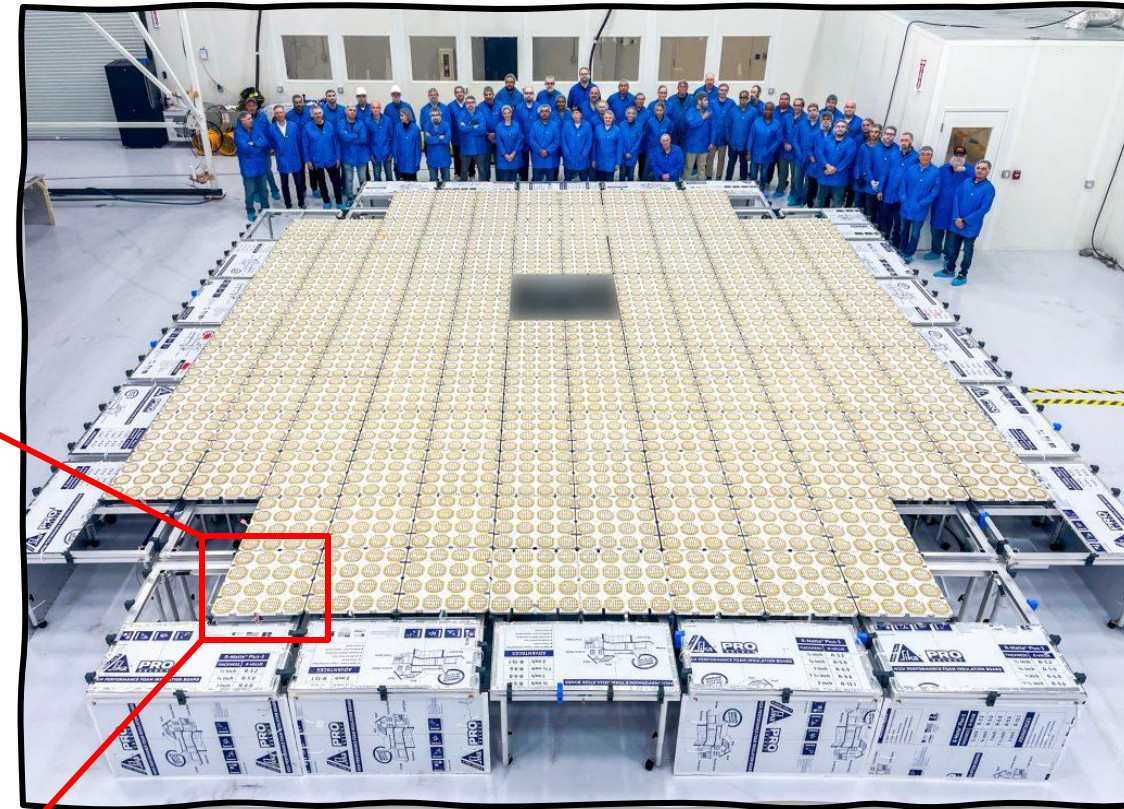
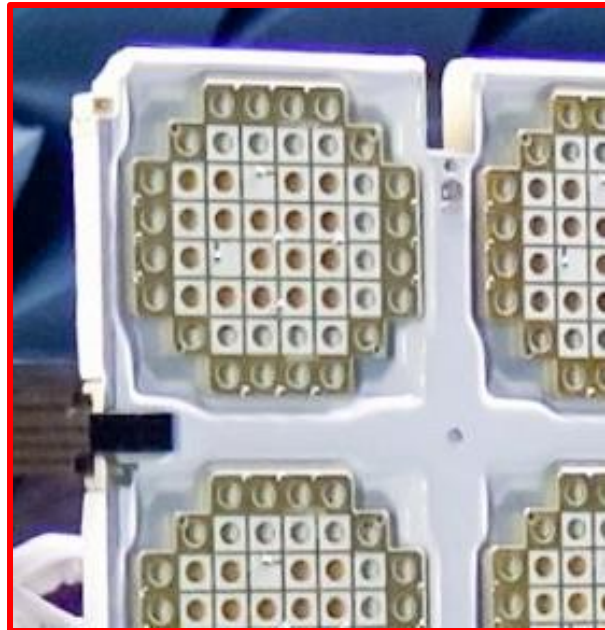


Select MNO Partners



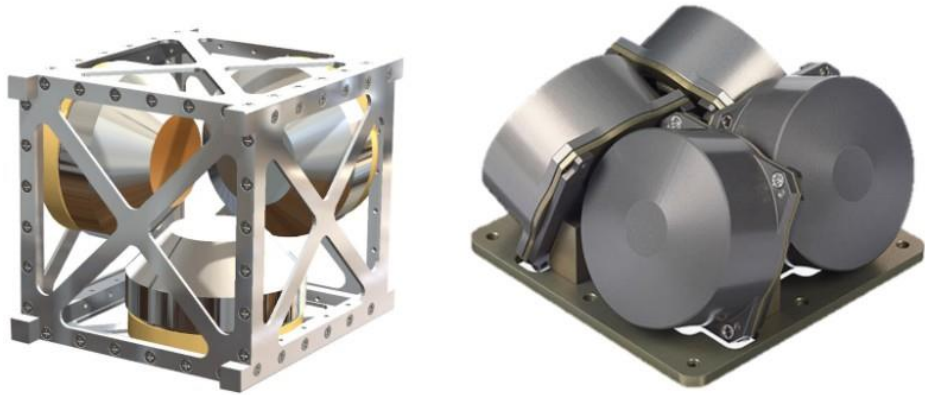
- Provide data and voice for current unmodified phones
- In-house manufacturing
- LEO constellation

- Largest phased antenna array in LEO: 64 m² area
- Launched satellite BlueWalker 3 in Sep 2022

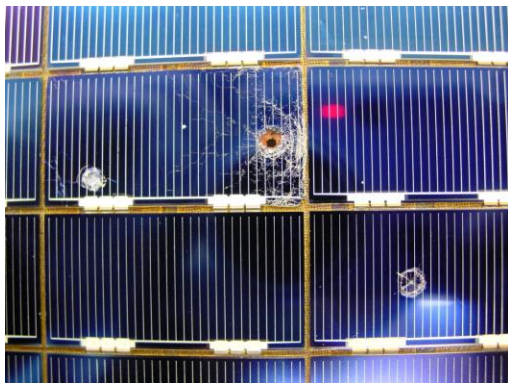


ni Useful Life of LEO Satellites → Space Debris

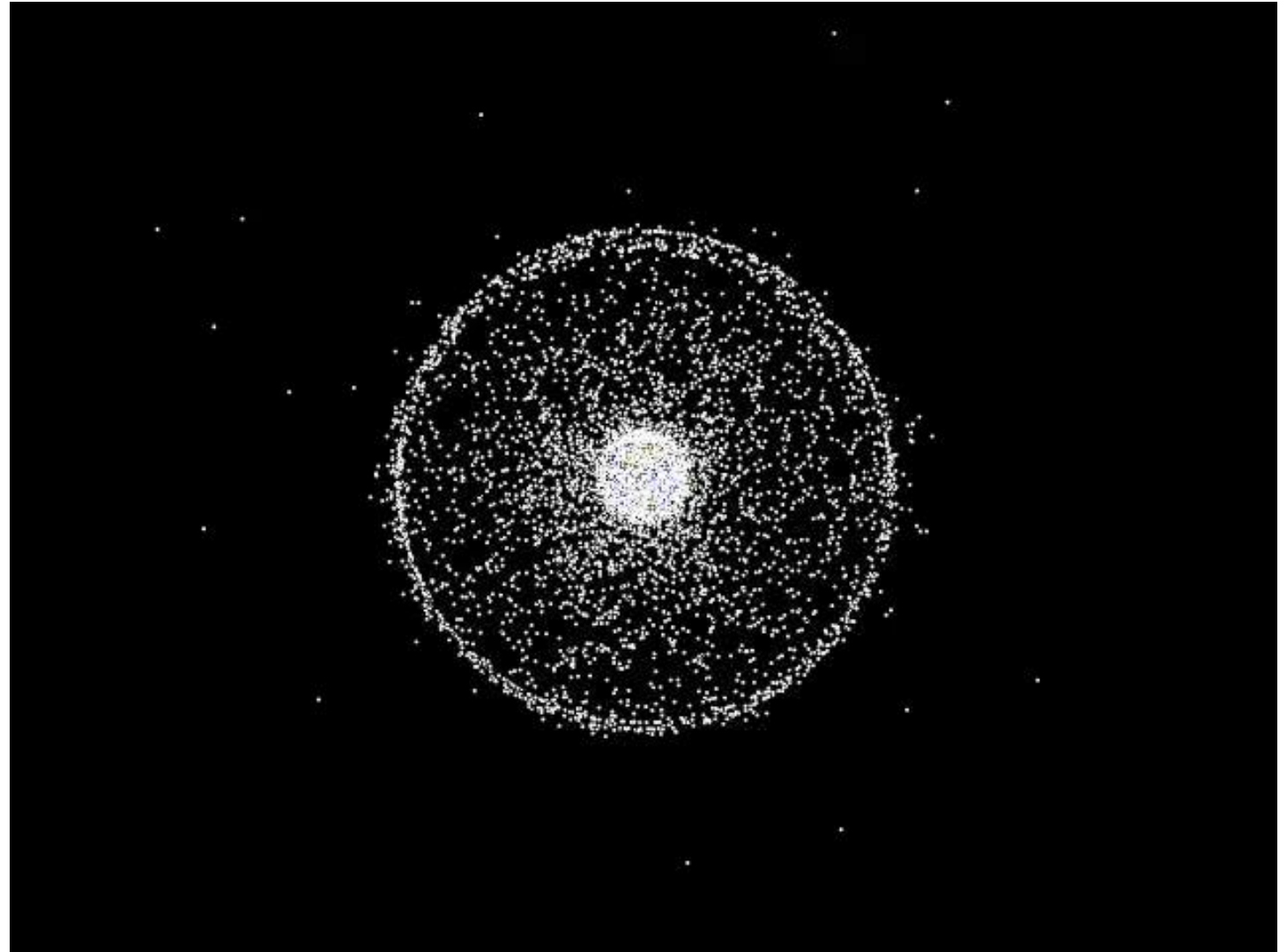
Useful life of LEO satellites is 5 years
Limited by fuel



Control Moment Gyro assemblies



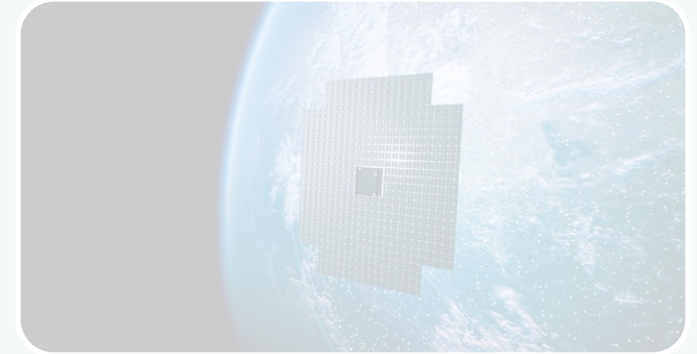
ni.com Damage to solar cell array caused
by space debris.



Source: <https://orbitaldebris.jsc.nasa.gov/photo-gallery/>

All Satellites Categories are Using Aspects of NTN

Some attributes of the 3GPP Compatible NTN networks



- Mostly Low Earth Orbit (LEO)
- 100's to 1000's of satellites
- Very large antenna arrays in orbit

Broadband Data

- Need special ground equipment
- Kuiper/SpaceX/OneWeb

Small antennas in ground units (little to non modification of devices)

- Preemptive compensation of doppler and delay
- All satellite antennas are phased array antennas
 - Dynamic beam steering and multi beam
- Expected satellite useful life ~5 years
- Pass through (repeater) satellite architecture

Expansion

- Existing networks providing more services to more users
- Voice and data with special ground equipment
- New cellphones
- India/Inmarsat/GlobalStar

New Satellites to connect to existing UE

- Unmodified phones voice and data
- AIS SpaceMobile/Lynk

Frequency ranges usually used for satellite communication:

Band	Downlink		Uplink	
	Frequency Range [GHz]	Bandwidth [MHz]	Frequency Range [GHz]	Bandwidth [MHz]
L	1.525 – 1.559	34MHz	1.6265 – 1.6605	34
S	2.170 – 2.200	30MHz	1.980 – 2.010	30

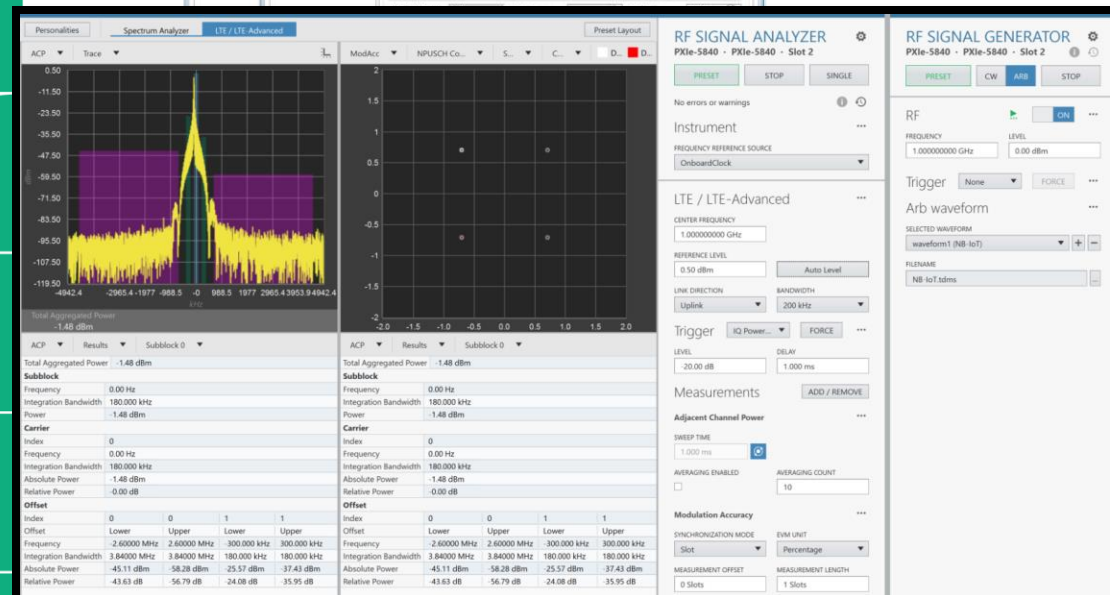
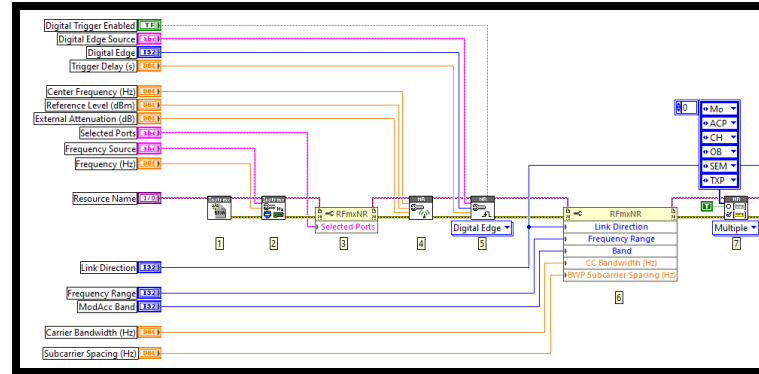
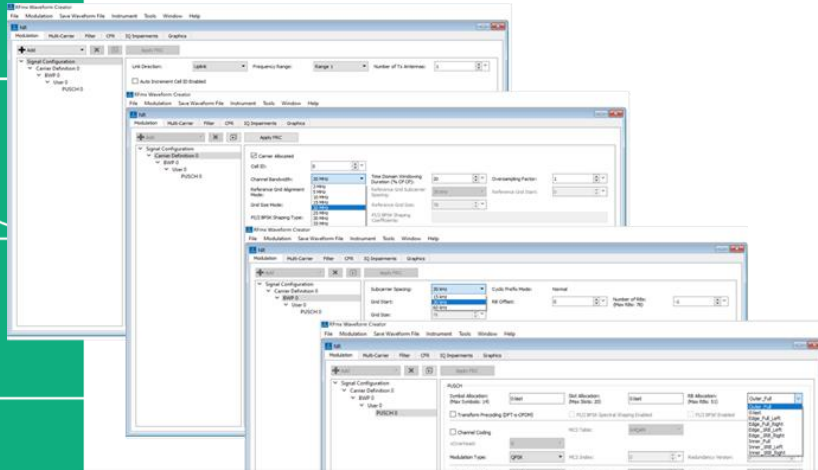


Ku	10.7 – 12.7	3GPP Proposed Bands	Band	Up link	Down Link	Duplex
		First 3GPP NTN FR1 bands for L-Band and S-Band (IoT)	n255	1,626.5MHz - 1,660.5 MHz	1,525MHz - 1,559 MHz	FDD
Ka	17.3 – 20.3		n256	1,980MHz - 2,010 MHz	2,170MHz - 2,200 MHz	FDD
		n510	17.7 - 20.2 GHz	27.50 - 30 GHz	FDD	
E	71.0 – 76.0	Proposed 3GPP NTN FR2-0/FR2-1 bands * for K-Band and Ka-Band (VSAT)	n511	17.7 - 20.2 GHz	28.35 - 30.00 GHz	FDD
			n512	17.7 - 20.2 GHz	27.50 - 30.00 GHz	FDD

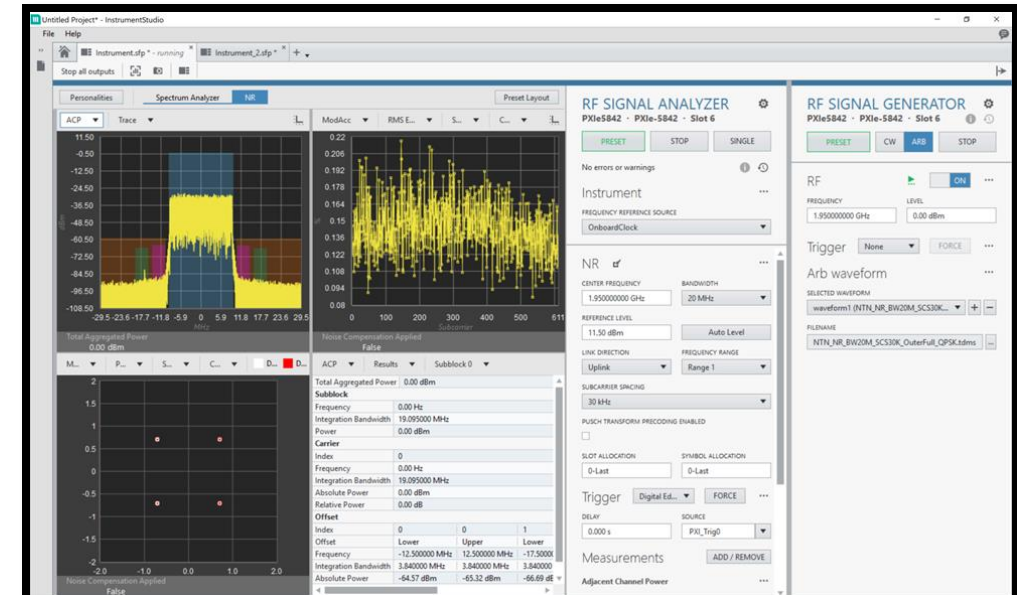
24

Coverage and flexibility are needed in this space

Automated API in LabVIEW, C, C#



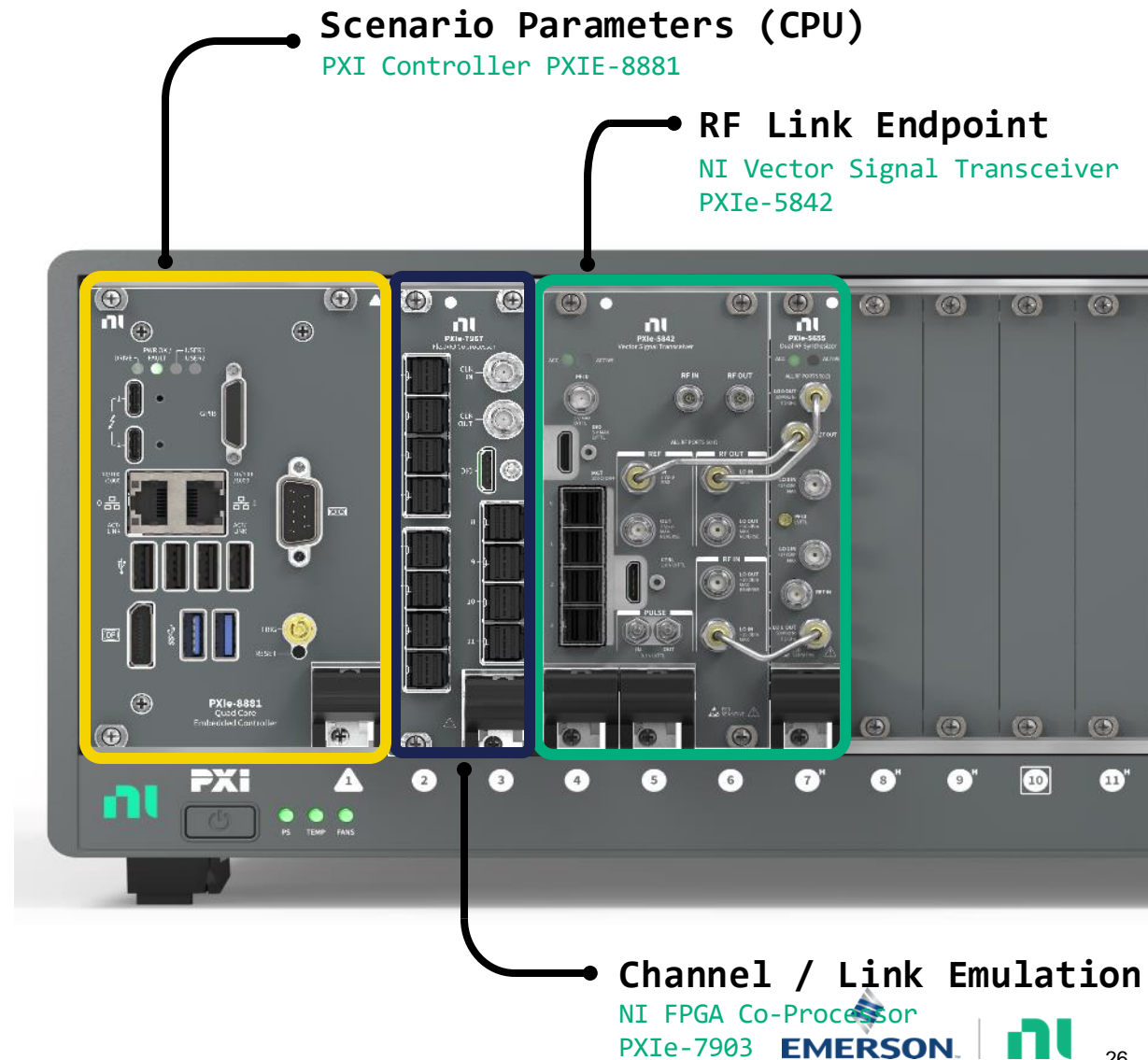
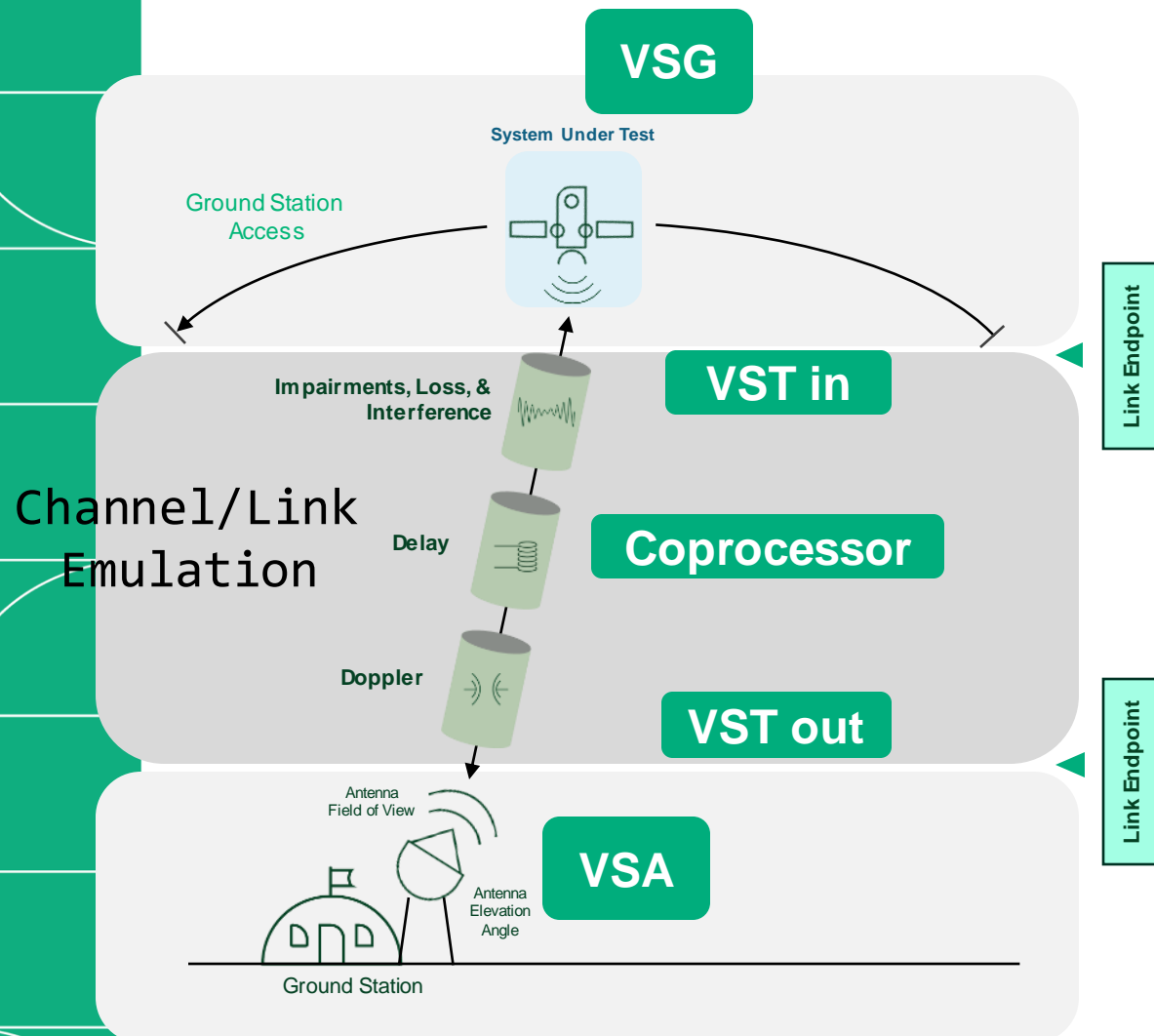
NB IoT Measurements



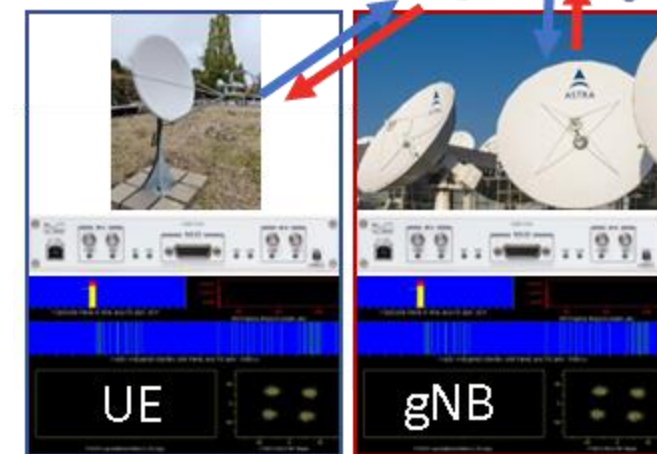
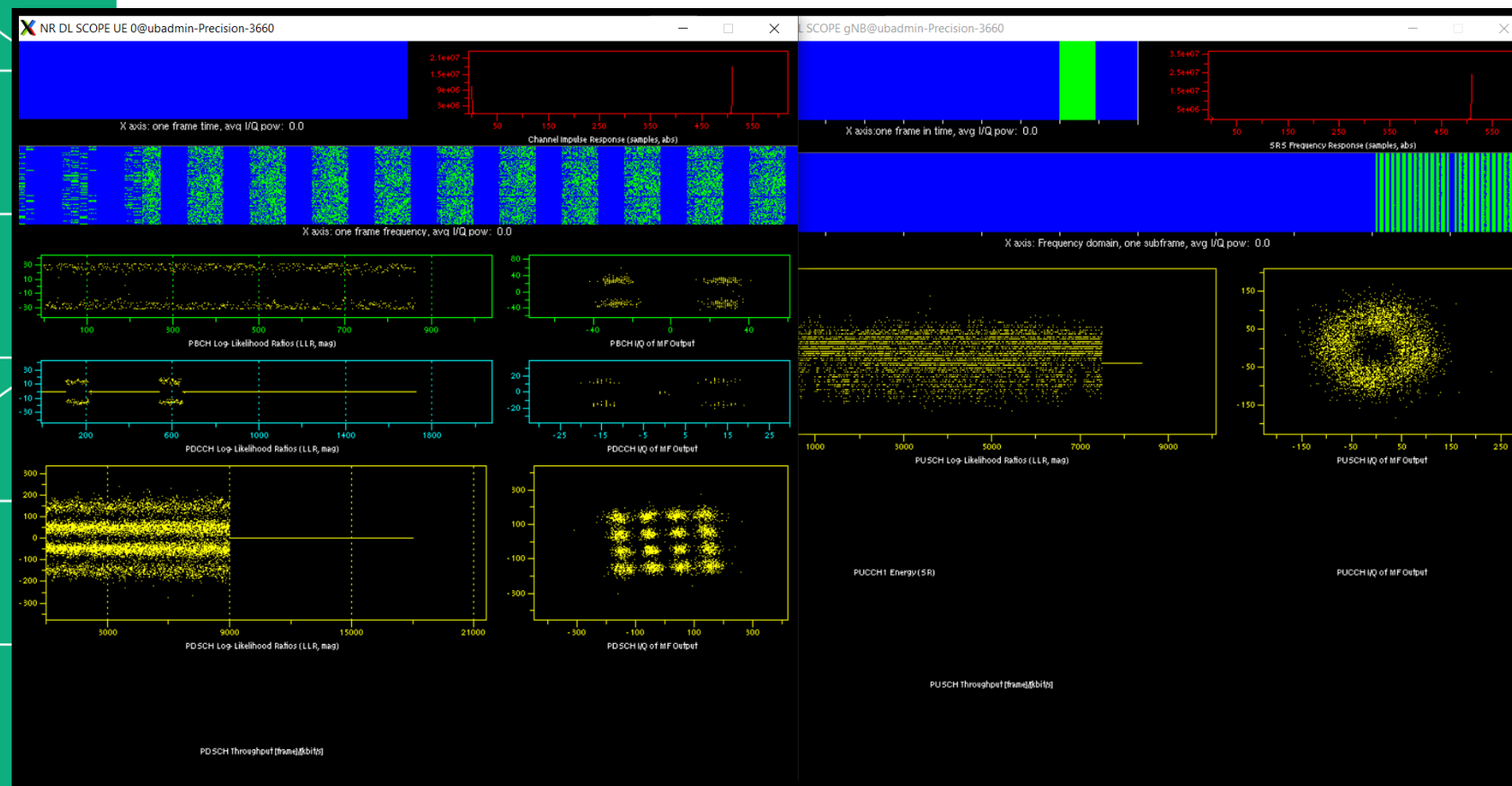
NR Measurements Release 18th



Satellite Link Emulator | Hardware Architecture

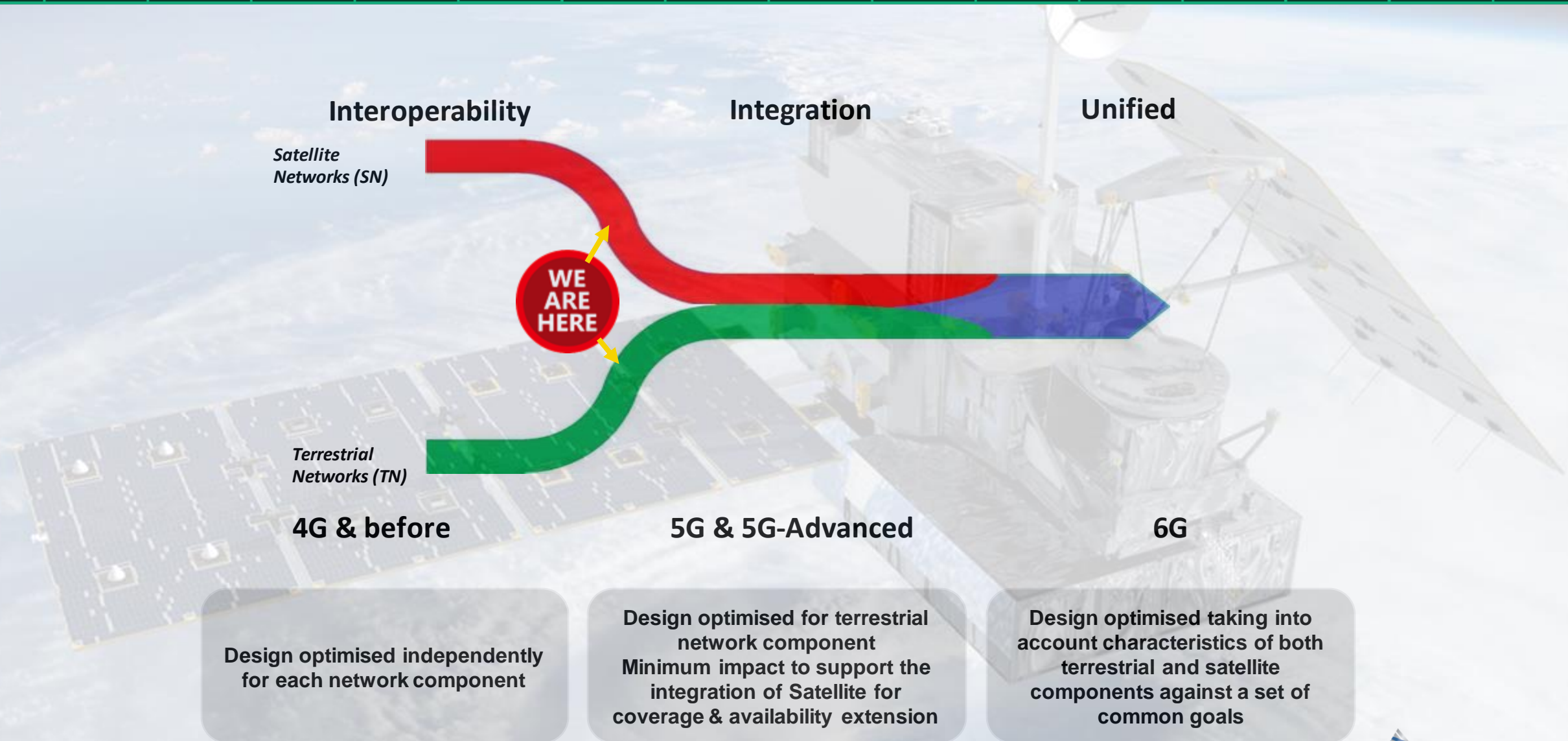


5G Non-Terrestrial Network Using Open Air Interface (OAI)



Source: [University of Luxembourg](https://www.univ.lu.lu/en)

Roadmap to support a vision for satellite in 3GPP



A Race to be a Space Wireless Carrier

Musk's SpaceX and T-Mobile plan to connect mobile phones to LEO satellites in 2023

During a live media event Thursday afternoon, T-Mobile's Mike Sievert and SpaceX's Elon Musk announced a new partnership that's intended to connect T-Mobile sold phones to a new constellation of SpaceX's Starlink satellites. The result, according to the company, is putting a lot like

Vodafone teams up with Amazon's Project Kuiper to extend 5G reach

By Reuters

September 5, 2023 1:04 AM MDT · Updated 8 months ago



FCC approves direct-to-smartphone regulatory framework

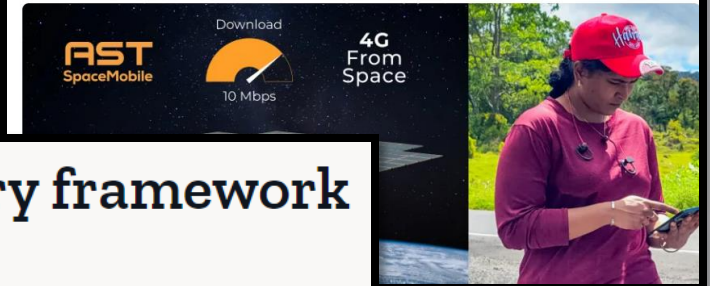
Jason Rainbow March 14, 2024

AT&T and AST SpaceMobile seek permission for spectrum leasing deal

Jason Rainbow May 11, 2024

Cellular satellite test successfully beams 4G data from space to a regular phone

AST SpaceMobile recently completed a two-way voice call.



More phones will connect to satellites this year. Here's what it means for you.

Qualcomm and Iridium say at CES the



By Chris Velazco

Updated January 6, 2023 at 1:57 p.m. EST | Publish

Qualcomm ends partnership for connecting Android phones to Iridium satellites

Jason Rainbow November 10, 2023

FEBRUARY 27, 2024 BY JEAN-LUC AUFRANC (CNXSOFT) - NO COMMENTS

Qualcomm unveils Snapdragon X80 5G modem with NB-NTN satellite connectivity, AI Hub, and FastConnect 7900 WiFi 7 chip

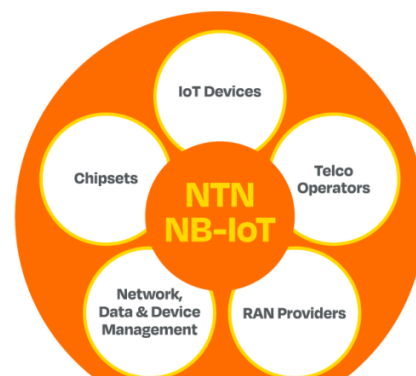
According to AST SpaceMobile, download rates of around **14 megabits per second** were achieved during tests with ordinary phones in September using BlueWalker-3, the Texas-based venture's 1,500-kilogram prototype that has been in LEO for nearly two years.

Growing Support for 5G NTN



The Globalstar NTN NB-IoT ecosystem

- Globalstar will adopt 3GPP Release 18 NB-IoT
- Strategic partnerships between terrestrial and non-terrestrial service providers enables new and innovative solutions and applications



PROJECT STARDUST:

Iridium's NB-IoT NB-NTN service program, developing 3GPP 5G standards-based global IoT and D2D connectivity using its existing satellite network.

The service will offer satellite connectivity to standard smartphones and IoT devices.

www.iridium.com/project-stardust

The diagram illustrates the Project Stardust ecosystem. At the top, an Iridium satellite is shown. Below it, a globe represents the 'INTERNET'. To the left, 'IRIDIUM® AND IRIDIUM CONNECTED™ PRODUCTS' are shown with icons of wind turbines, a person, and a ship. To the right, a 'CELLULAR MOBILE NETWORK' is shown with a tower icon, and an 'IRIDIUM GATEWAY' is shown with a large antenna icon. The Iridium logo is also present.

Who We Serve ▾ Global Network ▾ Wh

Home / **Satellite in a 5G World**

Satellite in a 5G World

Space Telecommunication Trends



Partnership between satellite operators and cellular carriers

Adopting 3GPP Standards

Connect to unchanged phones

Expand to broadband data into phones and smaller terminals



Content credentials
Generated with AI

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**The standard will
keep evolving to
provide ubiquitous
communications**

