“2026 Global Satellite IoT Ecosystem meets Multi-Orbit D2D/D2C Services”

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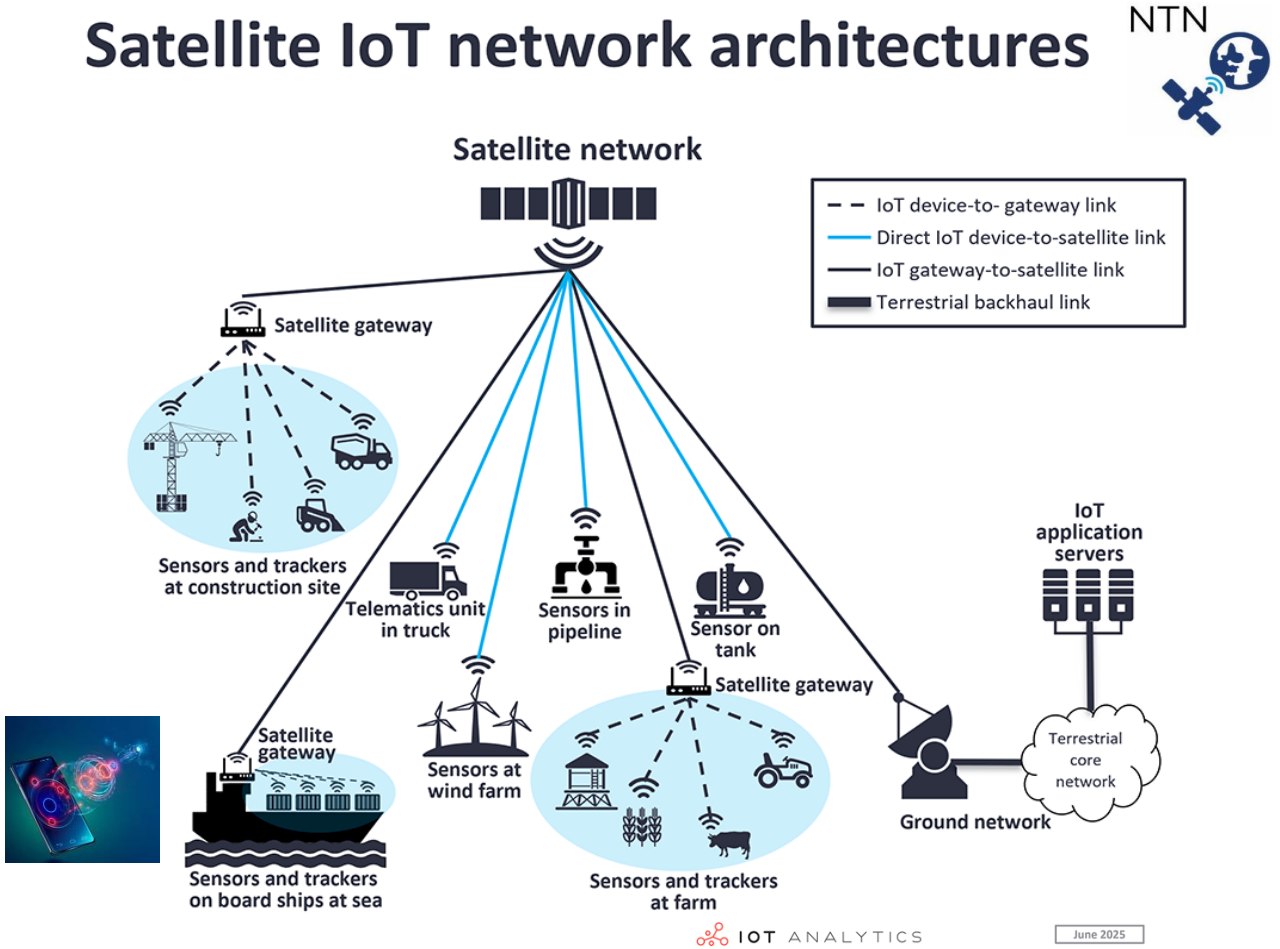
Global Satellite IoT Ecosystem meets Multi-Orbit D2D Services



Source: IoT Analytics Research 2025–Satellite IoT Market Report 2025-2030, Satellite IoT Connectivity Tracker & Forecast.
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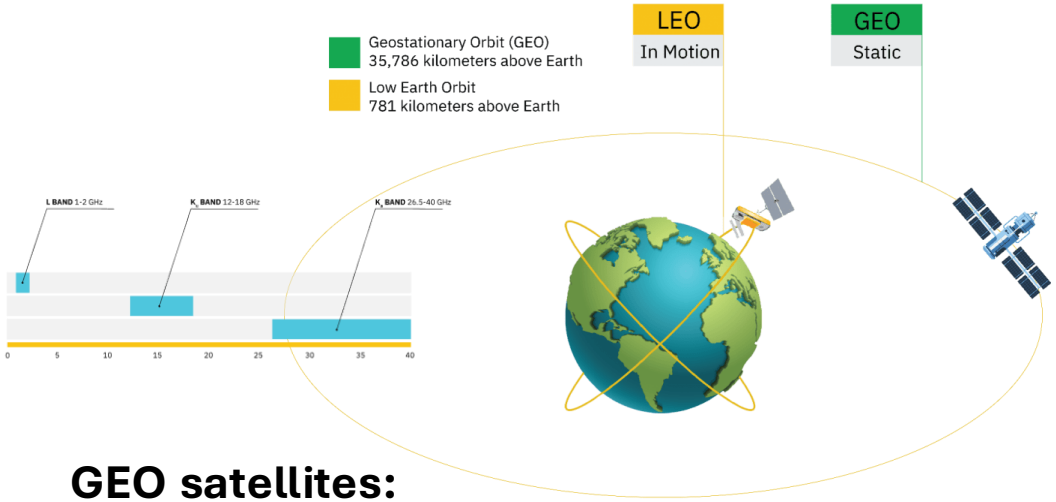
2026 Insights into the Satellite IoT marketplace

- ✓ **Technological shift**: moving toward standardized technologies
  - 3GPP Non-Terrestrial Networks (NTN)
  - Unlicensed/LoRa-NTN
  - challenges to legacy & proprietary Satellite systems
- ✓ **Multi-orbit strategies**: Deploying a multi-orbit strategy
  - Convergence of LEO/GEO constellations with Terrestrial services for enhanced connectivity
- ✓ **New business models**:
  - Entering the private 5G market (specific private enterprise resources, higher security than CBRS)
  - Offering integrated solutions beyond pure connectivity
- ✓ **Competitive landscape**:
  - Key satellite IoT operators include Viasat/Inmarsat, Iridium, ORBCOMM



GEO satellites:

- positioned 36,000 km above the Earth's equator, rotates same direction/speed as Earth.
- provide very high broadband data throughput (50 Mbps downlink/ 5 Mbps uplink, operate in Ka or Ku bands spectrum

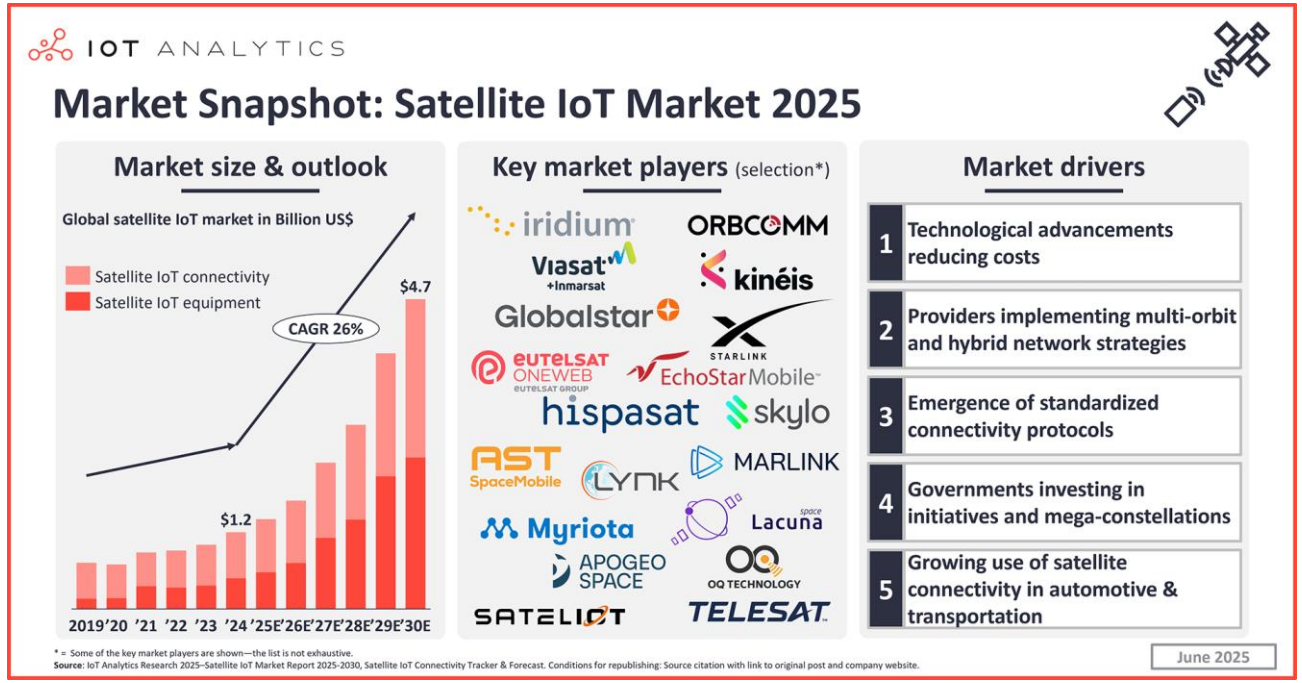
LEO Satellites:

- Position 500-1,500 km above Earth,
- ensures minimal lag (low latency)
- enables real-time voice communications, data transmission, and tracking
- Includes Mesh networking, L-band spectrum

Satellites are the future of connectivity for the IoT Tracking Industry

- **Vodafone & Skylo Partnership:** to trial NTN (Non-Terrestrial Network) Narrowband IoT services. This allows customers to switch seamlessly between cellular and satellite networks using a single SIM
- **Expansion of LEO Constellations:** Both Starlink and competitor Amazon LEO are launching rockets with more frequency to place satellite constellations in the sky
- **Hardware Innovation:** Newer IoT modules are becoming more power-efficient footprints for developers building global tracking devices
- **Direct-to-Device (D2D) Breakthrough:** **Sateliot** achieved the world's first **5G satellite IoT connection** using standard commercial devices

Satellite IoT tracking is growing, driven by the expansion of LEO constellations + 5G standards.



Sensor-to-satellite refers to a direct connection being formed between a ground-based device or sensor and an overhead satellite.

USA & EUROPE SATELLITE CONSTELLATION COMPANIES

& THEIR PARTNERSHIPS WITH MOBILE NETWORK OPERATORS (MNOs)

FULL MARKET LANDSCAPE INCLUDING AMAZON LEO + GLOBALSTAR ACQUISITION & APPLE PARTNERSHIP (2026)

	UNITED STATES						EUROPE			
COMPANY	SPACEX STARLINK	amazon project kuiper (Amazon Leo)	AST SpaceMobile	iridium	Globalstar NOW PART OF AMAZON	Viasat (incl. Inmarsat)	eutelsat ONEWEB	SES	TELESAT LIGHTSPEED	IRIS² (EU INITIATIVE)
CONSTELLATION (TYPE / STATUS)	**Starlink** LEO Mega Constellation (Operational) 7,000+ satellites (growing to 12,000+)	~3,200 LEO satellites (Planned)	**BlueBird** LEO Cellular Broadband (Operational) ~90+ satellites (Phase 1)	**Iridium NEXT** LEO (66 satellites) (Operational)	**Globalstar** LEO (24 satellites) (Operational) L-Band MSS Spectrum (Band 53)	GEO + Hybrid (Operational)	**OneWeb** LEO (~648 satellites) (Operational)	**O3b mPOWER** (MEO) + GEO (Operational)	**Lightspeed** LEO (~198 satellites) (Planned) Launch starts 2026	**IRIS²** LEO Secure Government Network (Planned)
FOCUS / POSITIONING	Direct-to-Device (D2D) Broadband, Mobility Maritime, Aviation Enterprise	**ACQUIRED GLOBALSTAR** Globalstar — April 2025 | $11.57B — Includes spectrum, satellites, ground infrastructure & licenses. **Hybrid: Direct-to-Device + Carrier Backhaul Broadband, IoT, Mobility Enterprise**	Direct-to-Device Cellular Broadband (Works with standard smartphones)	Mission-Critical Voice, IoT Aviation, Maritime Government	Direct-to-Device Messaging, IoT Emergency Services	Aviation, Maritime Enterprise Government Connectivity	Enterprise Government Backhaul, Mobility Connectivity	High-throughput backhaul Cloud connectivity Maritime, Mobility	Carrier-grade LEO broadband Backhaul Enterprise	Sovereign Secure Connectivity Defence, Gov Critical Infra
KEY MNO / PARTNERSHIPS	T-Mobile — Global roaming partners (200+ countries)	verizon — 5G backhaul partnership; AT&T — Network integration & backhaul; **APPLE (STRATEGIC PARTNER)** Continuing support for iPhone Emergency SOS & Satellite Messaging. Apple invested ~$1.5B in Globalstar and holds ~20% in the satellite entity	AT&T, vodafone, Rakuten Mobile	Global IoT & Telecom Operators: vodafone, Telefónica, kpn, others	Apple — iPhone Emergency SOS & Satellite Messaging. Other partners: Government, IoT & Enterprise	Airlines, Maritime operators, Government & Enterprise	orange, airtel, BT	vodafone, orange, Telefónica	Tier-1 Telcos (Backhaul Partnerships)	AIRBUS, THALES, eutelsat GROUP, EU Member States & Partners
KEY DIFFERENTIATORS	Largest LEO network; Vertically integrated (launch + ground + service); Strong consumer brand	✓ Spectrum ownership (Band 53 MSS) via Globalstar ✓ D2D capability + large LEO scale ✓ Deep cloud integration (AWS) ✓ Strategic device ecosystem (Apple)	True cellular broadband from space; No special device or hardware required	100% global coverage; Pole-to-pole; Low latency voice & IoT	Proven D2D service; Licensed spectrum (valuable MSS assets); Global IoT reach	High throughput; Global coverage; Strong enterprise relationships	Strong enterprise footprint; Backed by Eutelsat Group (EU)	MEO advantage (low latency); Enterprise-grade global network	Designed for telcos; High capacity global coverage	EU sovereign constellation; Secure & resilient infrastructure

amazon — Building the Most Complete Space Connectivity Stack

THE AMAZON ADVANTAGE (POST-ACQUISITION)

- **LEO Constellation** (~3,200 satellites)
- **Spectrum Assets** (Globalstar Band 53 MSS)
- **Cloud & Edge** (AWS Global Infrastructure)
- **Device Ecosystem** (Apple Partnership)
- **Carrier Partnerships** (Verizon, AT&T & more)
- **Enterprise & Government** (Global Reach)

3 MAIN MODELS IN THE MARKET

1 DIRECT-TO-DEVICE (D2D)
- Starlink + T-Mobile
- Amazon Leo + Globalstar + Apple
- AST SpaceMobile
- Iridium

Enables messaging, voice & broadband directly to smartphones / IoT devices

2 TELCO BACKHAUL & HYBRID
- Amazon Leo (backhaul partnerships)
- OneWeb + Orange / Airtel
- SES + Vodafone / Orange
- Telesat Lightspeed

Strengthens mobile networks, enterprise connectivity & extends coverage

3 SOVEREIGN / GOVERNMENT CONSTELLATIONS
- IRIS² (EU)
- National security constellations
- Defence & critical infrastructure

Focus on security, resilience & digital sovereignty

LEGEND

LEO – Low Earth Orbit
MEO – Medium Earth Orbit
GEO – Geostationary Earth Orbit
MSS – Mobile Satellite Service
IoT – Internet of Things
D2D – Direct-to-Device

KEY TAKEAWAY: Amazon's acquisition of Globalstar gives it the critical spectrum and D2D capability to complement its LEO constellation, while its partnership with Apple provides direct access to billions of devices. This positions Amazon as the strongest full-stack challenger to Starlink in the satellite connectivity race.

Sources: Company announcements, press releases, investor reports (2024-2026)

Deutsche Telekom combines satellite IoT, NB-IoT for GEO, LEO constellations, + Terrestrial services

- Deutsche Telekom offers Internet of Things (IoT) services via satellites in different orbits & terrestrial mobile networks for more reliable connectivity in hard-to-reach places.
- Multi-orbit narrowband IoT (NB-IoT) roaming operates across geostationary Earth orbit (GEO), low Earth orbit (LEO), and terrestrial mobile networks, combining services from satellite newcomers Skylo, Sateliot, and OQ Technology with those of old-timer Iridium.
- The goal is to blend continuous coverage of GEO with the lower latency and higher data rates of LEO

multi-orbit IoT roaming

SATELLITE CONNECT EUROPE

There is government demand for sovereign, secure connectivity with Europe & China.

skylo **GEO coverage**

SATELIOT **Connectivity to LEO satellites for Sateliot & OQ Technology.**

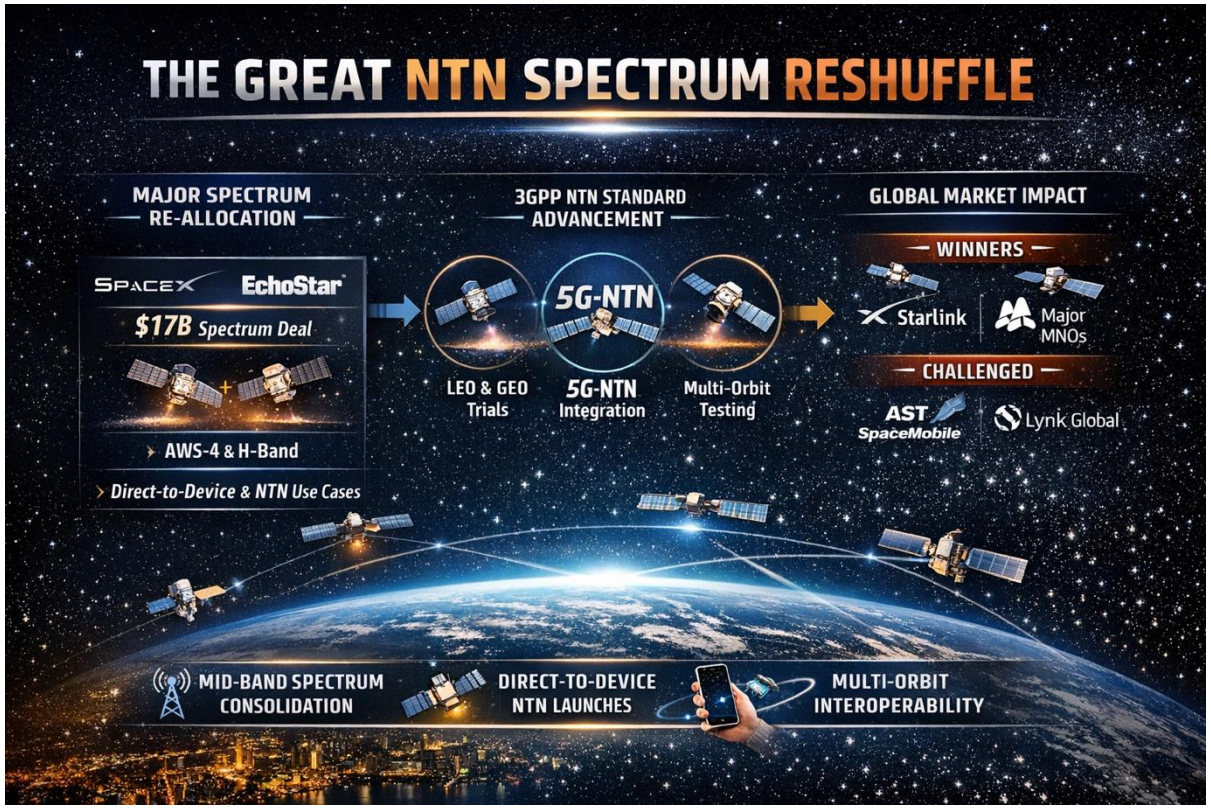
OQ TECHNOLOGY

iridium connected **LEO-based NTN Direct for IoT applications**

Viasat +Inmarsat **IoT apps that transmit more data**

”Great 2026 satellite spectrum reshuffle"

- The **Starlink & Echostar** spectrum reshuffling is driven by the need for more spectrum to support advanced wireless and satellite services: Direct-to-Device (D2D) or Direct-to-Cell (D2C) Partnership between **Starlink & T-Mobile** ("T-Satellite”/Direct-to-Cell) is a partial multi-orbit strategy; it technically represents a **hybrid terrestrial-satellite strategy**
- **AST SpaceMobile's (LEO) Constellations & Vodafone** team up to connect directly to standard, existing consumer devices, offering an "MNO-first" approach that integrates seamlessly with existing terrestrial networks.
- **SES and Lynk** Bridge Satellite & Cellular: Team Up to Deliver Multi-Orbit D2D Connectivity for Commercial and Government Markets
- **Deutsche Telekom** combines satellite IoT, NB-IoT for GEO, LEO constellations, + Terrestrial services, many partners
- **Eutelsat Group's** multi-orbit strategy is **World’s first fully integrated satellite operator** by combining its fleet of **33 (GEO) satellites** with **OneWeb low Earth orbit (LEO) constellation** of over 600 satellites.
- **Amazon LEO/GlobalStar & Vodafone** partnered LEO services to connect 4G/5G mobile base stations in remote or rural areas across Europe & Africa (Through Vodacom).



There is government demand for sovereign, secure connectivity with Europe & China.

Multi-Orbit: NTN Satellite + Terrestrial Mobile Spectrum

D2D (Direct-To-Device) uses ***3GPP NTN standards (5G NR-NTN, NB-IoT NTN, LTE-M NTN), which involve both MSS (Mobile Satellite Service) spectrum (L-Band & S-Band) for two-way communications and reuse terrestrial mobile spectrum; it works*** with unmodified Smartphones and specialized IoT devices, sensors, and wearables.

D2C (Direct-To-Cell) Satellites connect directly to Smartphones for voice/data, using terrestrial (licensed)spectrum authorized for space usage (Starlink/T-Mobile, EchoStar Spectrum).

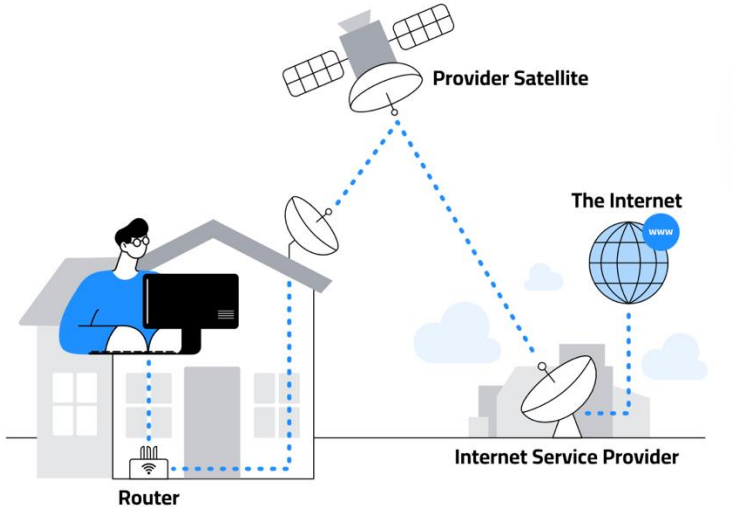
MSS spectrum

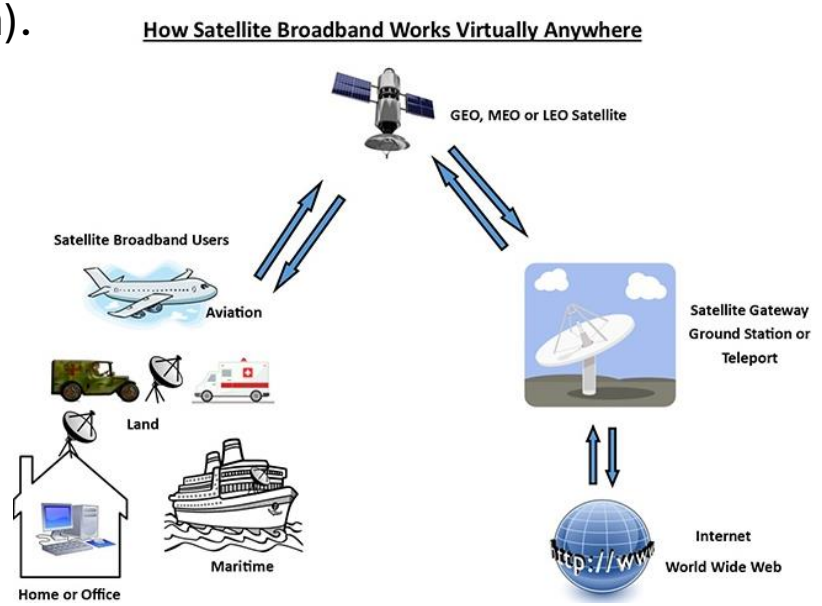
- Satellite player uses dedicated MSS spectrum (allocated to MSS use regionally/globally) to provide D2D services
- Players using MSS spectrum include Globalstar, Viasat, EchoStar, Space42, Omnispace, Iridium

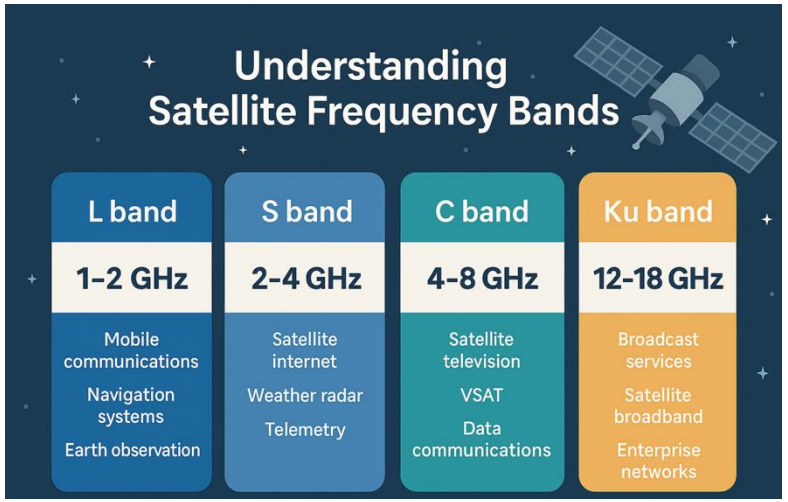
Terrestrial mobile spectrum

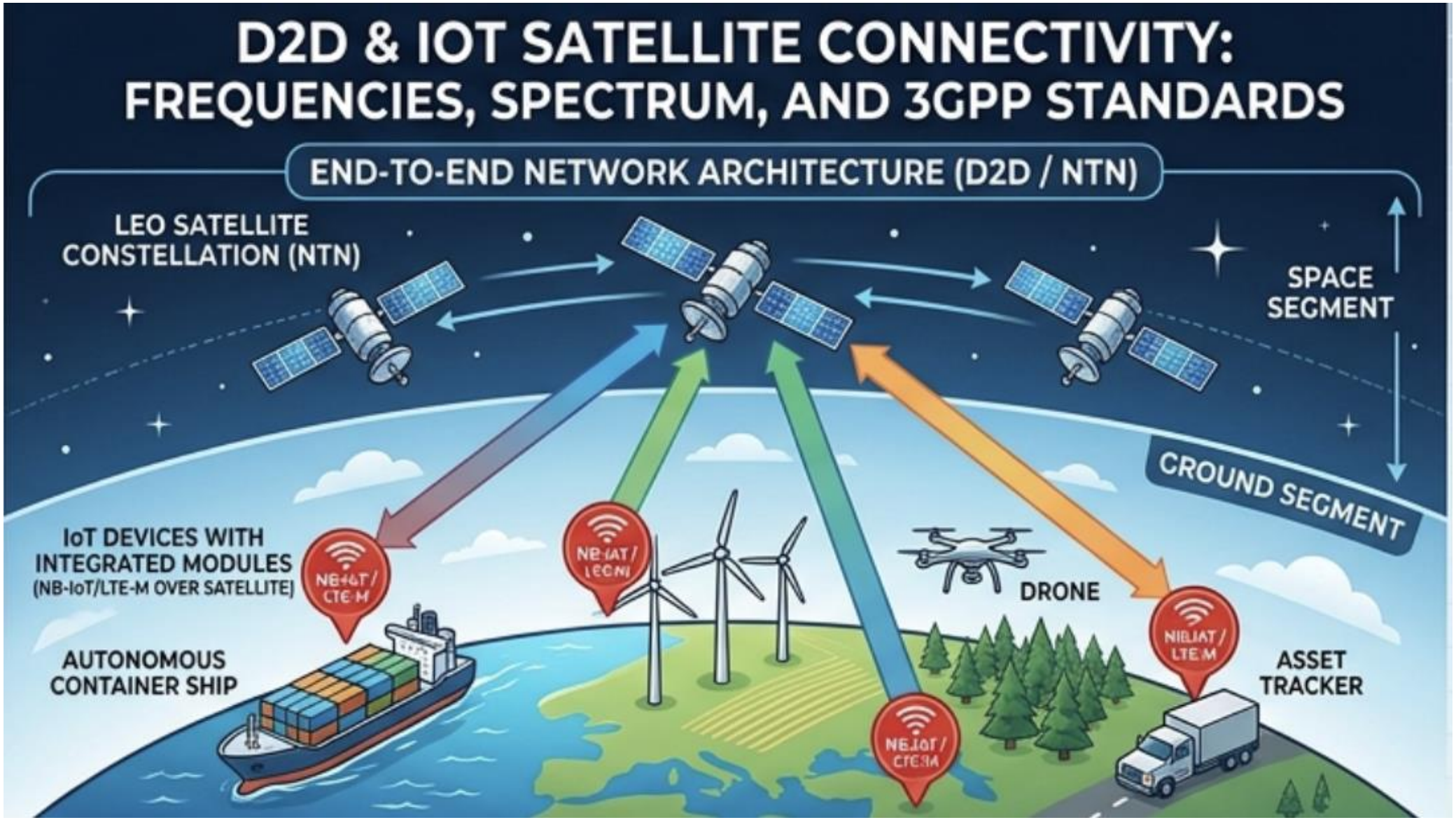
- Satellite player collaborates with MNOs within a market to use the mobile spectrum assigned to the MNO in the satellite payload
- Players using terrestrial spectrum include AST SpaceMobile, Lynk and Starlink D2C

Source: Analysys Mason








D2D & IOT SATELLITE CONNECTIVITY:
FREQUENCIES, SPECTRUM, AND 3GPP STANDARDS
END-TO-END NETWORK ARCHITECTURE (D2D / NTN)
LEO SATELLITE CONSTELLATION (NTN)
SPACE SEGMENT
GROUND SEGMENT
IoT DEVICES WITH INTEGRATED MODULES (NB-IoT/LTE-M OVER SATELLITE)
AUTONOMOUS CONTAINER SHIP
DRONE
ASSET TRACKER

3GPP STANDARDS & PROTOCOLS (NTN SUPPORT)

3GPP RELEASE 17 & BEYOND
(NB-IoT / LTE-M ENHANCEMENTS)

KEY NTN FEATURES

- GNSS ASSISTANCE (DEVICE LOCATION FOR PRE-COMPENSATION)
- TIMING ADVANCE & DOPPLER PRE-COMPENSATION
- MODIFIED HARQ (HYBRID ARQ) FOR HIGH LATENCY
- EPHEMERIS & SIB BROADCASTS (SIB21, SIB32)

PROTOCOL STACK

- APP (e.g., MQTT, CoAP, NIDD)
- TCP/UDP (Optional for NIDD)
- PDCP / RLC / MAC / PHY (NTN OPTIMIZED)

CORE NETWORK

NTN CORE (AMF, UPF), IWF (INTERWORKING FUNCTION), To Terrestrial Networks

NTN CONNECTIVITY MODELS

Transparent (via Gateway)

Regenerative (Satellite with Processing)

TERRESTRAL NETWORKS

D2D & IOT FREQUENCIES & SPECTRUM BANDS (MSS)

1.6 GHz - 1.7 GHz
GLOBAL, LOW POWER, PENETRATION
(e.g., 3GPP Band n255, n256)

1.9 GHz - 2.2 GHz
HIGHER DATA CAPACITY, TRACKING
(e.g., 3GPP Band n256, n254)

SAMPLE 3GPP BANDS FOR IoT-NTN

Band	Frequency	Region	Sample Usage
n255	(L-Band)	n255	Sample Low Tracker
n255	(L-Band)	n222	Asset Tracker
n222	(S-Band)	n254	Asset Tracker
n252	(S-Band)	n224	Sample Low Tracker

IPHONE DIRECT TO CELL (D2C) SPECTRUM & FREQUENCIES

APPLE NATIVE SATELLITE SERVICE
(GLOBALSTAR)

EMERGENCY SOS TEAM

GLOBALSTAR SATELLITE

UPLINK (PHONE TO SAT)
(1.6 GHz) Band n53
L-BAND (1.6 GH26.5 MHz

S-BAND (2.4 GHz) Band n53
DOWNLINK (SAT TO PHONE)

iPhone 15 Pro

n53
(PRIMARY D2C BAND)

PURPOSE:
EMERGENCY SOS & MESSAGING

CARRIER-PARTNERED D2C SERVICE
(STARLINK/T-MOBILE)

STARLINK V2 SATELLITE

BIDIRECTIONAL COMMUNICATION

LTE BAND 25 (1.9 GHz / 1900 MHz)
U-BAND (18.0 GHz) Band n53
1850-1915 MHz (Uplink), 1930-1995 MHz (Downlink)
PCS SPECTRUM

S-BAND 25

Lte

CELLULAR DATA

TERRESTRIAL SPECTRUM USED FROM SPACE

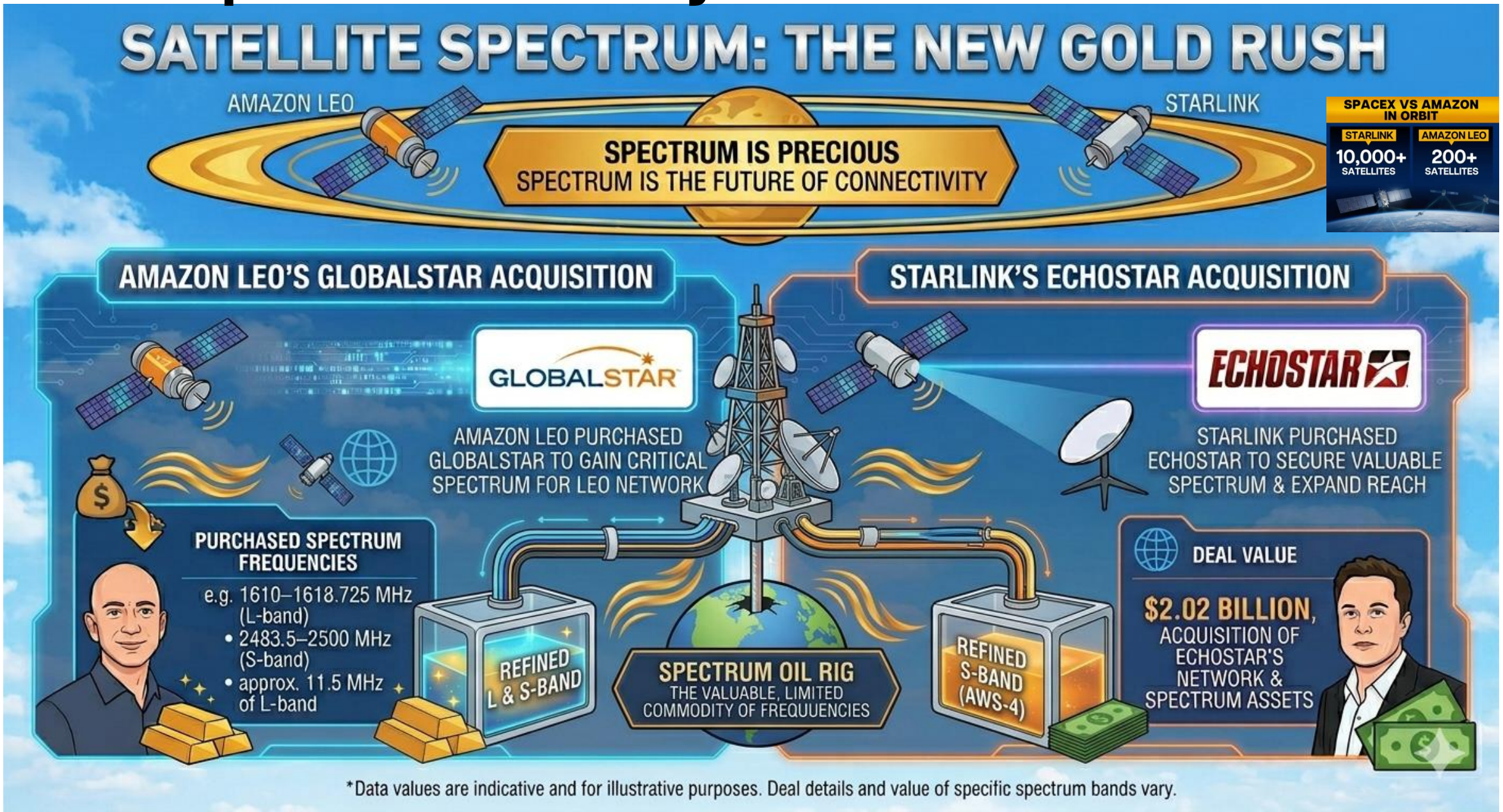
iPhone 14

PURPOSE:
VOICE, SMS, MMS (FUTURE DATA)

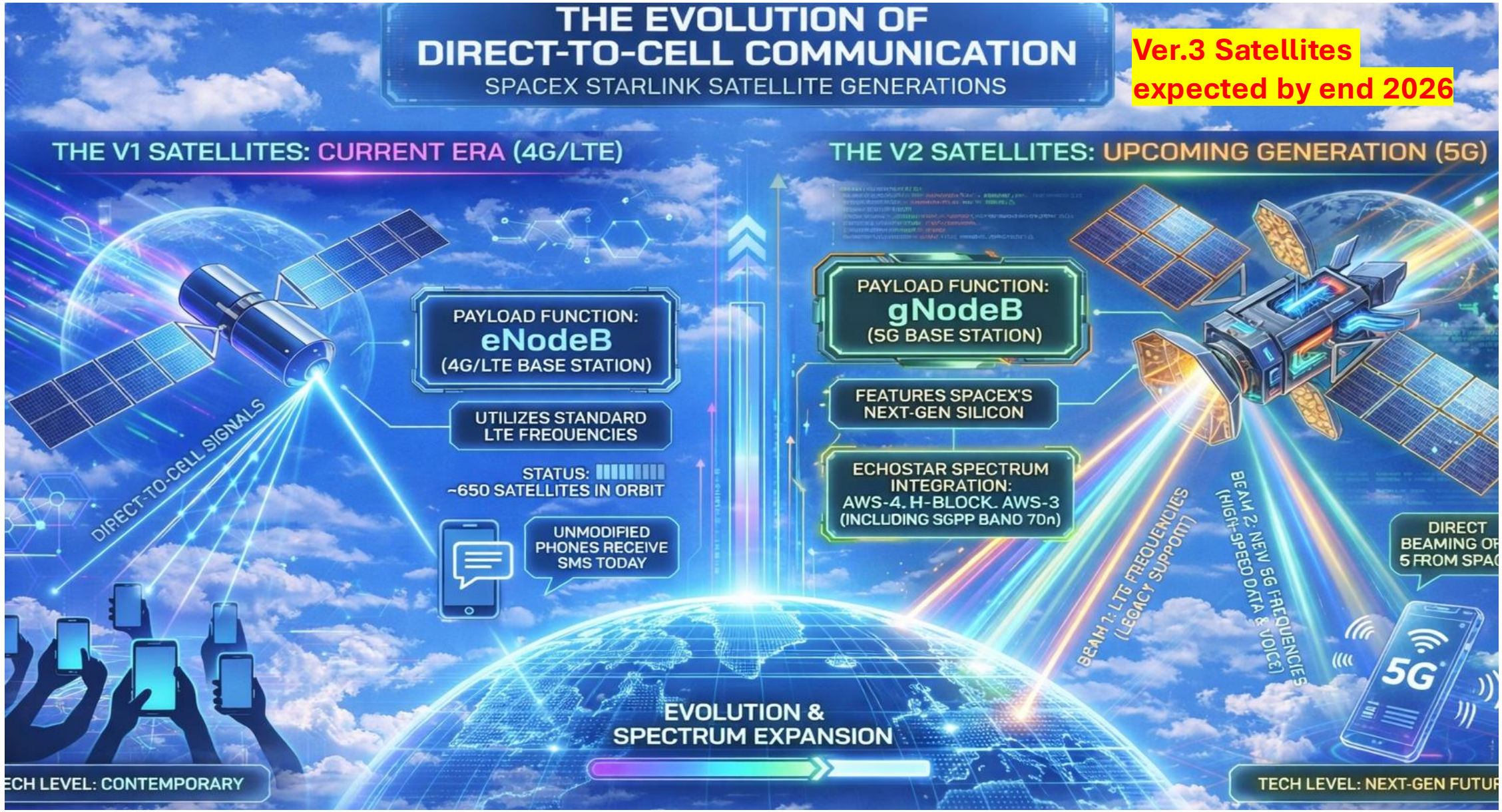
THE "GOLDILOCKS" FREQUENCY RANGE

- **PHYSICALLY SMALL ANTENNAS** (IPHONE COMPATIBLE)
- **GOOD ATMOSPHERIC PENETRATION** (LIGHT CLOUD/FOLIAGE)
- **CARRIES MESSAGING DATA**

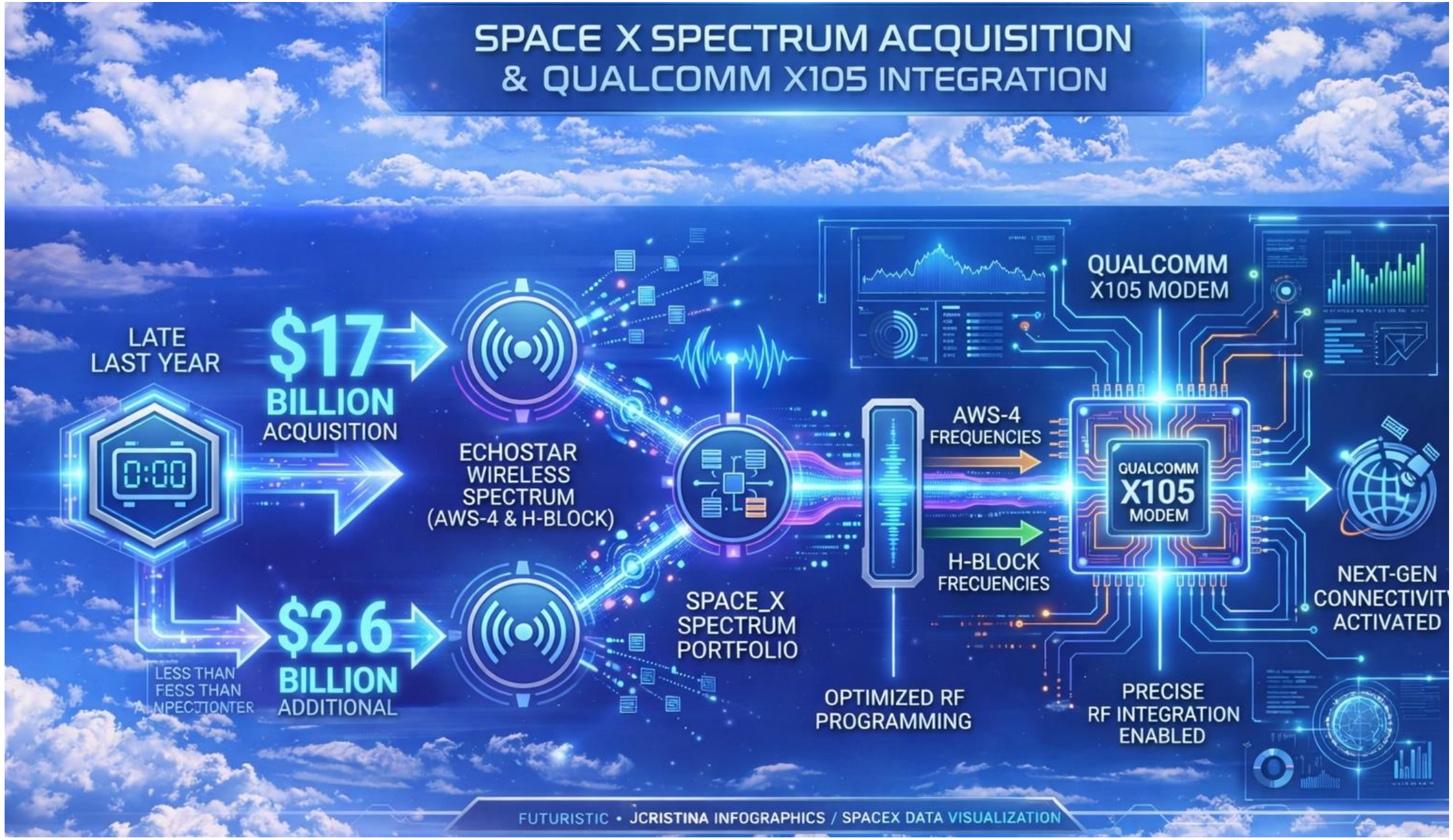
Spectrum is truly the New Oil + Gold



The Evolution of D2C Direct-To-Cell



SpaceX Spectrum Acquisition & Qualcomm's X105 G-Node–B modem



Starlink"V2-Mini (Gen3) D2C satellite - Cell Tower in the Sky"

1) Smartphone transmits a Terrestrial LTE signal (1.9–2.0 GHz PCS band) up to the Satellite
2) Satellite contains a giant phased-array antenna that “hears” the Smartphone’s signal on Earth
3) Satellite locks onto Smartphone signal (340–550 km above Earth), a full LTE base station (eNodeB)
4) Satellite connects to the internet using laser backhaul, receives traffic from Smartphone, forwards the data using laser links (ISLs) to other satellites, and for download to a ground station, then to your MNO.
5)your carrier (MNO) treats it like a normal LTE roaming call

A satellite is treated as a tower registered to your carrier’s spectrum license; it's all seamless to the Smartphone user

.

Key Chipsets Supporting Multi-Orbit Satellite Connectivity

1. Sony Semiconductor Altair ALT1250

Certified for dual-mode cellular + satellite IoT connectivity via Skylo's platform, supporting NB-IoT and IoT-NTN standards. **Role in Multi-Orbit**: Supports multi-orbit cellular and satellite (GEO/NTN) connectivity, essential for devices that need global redundancy.

3. Qualcomm Satellite-Capable Modems (212S & 9205S)

Qualcomm has introduced 2 IoT-NTN modems compliant with 3GPP Release-17 for satellite IoT connectivity, seamless switching between terrestrial and satellite, and a **Role in Multi-Orbit:** Standard-based IoT satellite support that can integrate both GEO and LEO NTN links, reducing coverage gaps.

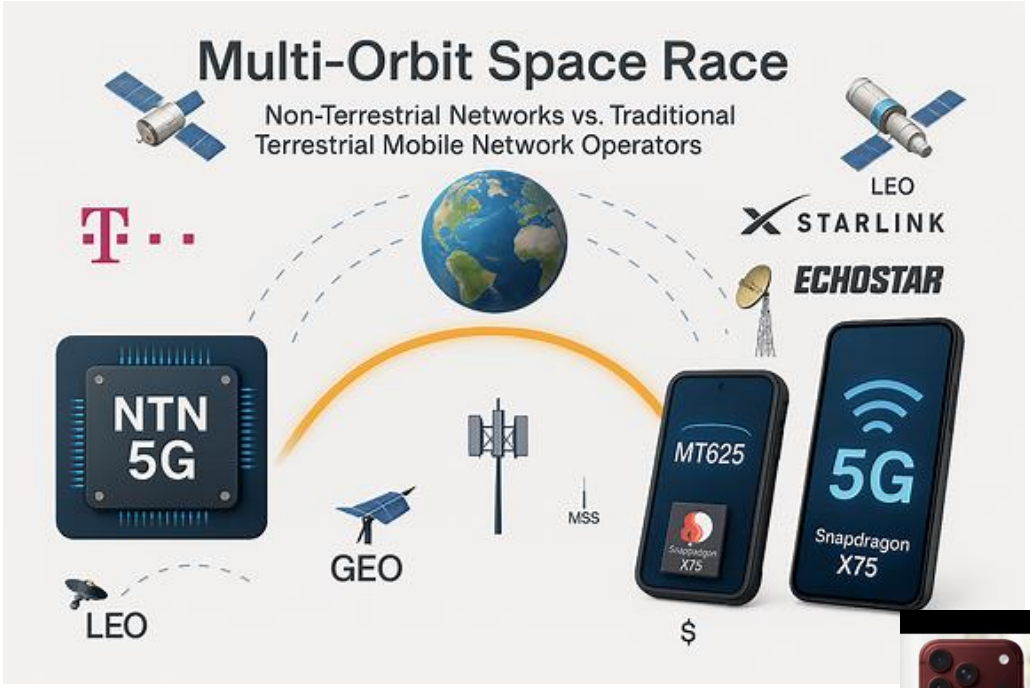
2. MediaTek MT6825 IoT-NTN Chipset

A 3GPP Release-17 IoT-NTN compliant chipset designed for two-way satellite messaging and IoT, supporting standard cellular and satellite networks. Works on L-band can connect to GEO/standard NTN satellites. **Role in Multi-Orbit:** A platform that enables devices to natively use NTN satellite links in addition to ground cellular, removing the need for external modems.

4. Nordic Semiconductor nRF9151

Certified by satellite operators like OQ Technology for NB-IoT/NTN connectivity, operates as a 3GPP NTN-compliant low-power IoT chipset suitable. Expected to also integrate upcoming services like Iridium NTN Direct. **Role in Multi-Orbit:** A low-power industry-standard chipset that lets IoT devices connect across cellular and satellite networks, with no complex hardware redesign.

NTN 5G chips/Smartphones bridge Multi-Orbit cellular/Satellite connectivity



- **MediaTek & 5G NTN Integration** - Beyond, MediaTek's MT6825 chip for the IoT-NTN roadmap includes integration with mainstream 5G modems for both NB-IoT & (future) NR-NTN services.
- **Qualcomm & Snapdragon Satellite Integration - Snapdragon Satellite-ready modems like X75 and mission-tactical radios** embed satellite waveform support alongside 5G connectivity, offering integrated multi-mode connectivity in next-gen platforms.

Cellular + Satellite IoT Chipsets

- **Sony Altair ALT1250** — Dual cellular + satellite IoT
- **Qualcomm 212S / 9205S** — Satellite IoT standard modems
- **Nordic nRF9151** — Low-power standard IoT NTN chipset

Integrated NTN & Smartphone Platforms

MediaTek MT6825 — IoT-NTN 3GPP R17 chipset

Qualcomm Snapdragon (X75/MTR) — Future integrated satellite + cellular platform

Hybrid & Satellite-IoT Modules

LoRa satellite modules (EchoStar) — Satellite backhaul via LoRa tech

Technology	Role
3GPP Non-Terrestrial Networks (NTN)	Standardized framework enabling satellite connectivity (GEO + LEO) with mobile cellular protocols.
NB-IoT (Release-17/18)	Narrowband low-power satellite IoT connectivity.
5G NR-NTN	Higher-data-rate satellite communication with 5G performance. **This is the future of Smartphones**
LoRa/Satellite hybrids	Indirect satellite connectivity via relays (EchoStar Mobile modules).

CAN YOUR 5G PHONE CONNECT TO SATELLITES TODAY?

NOT QUITE.

While **3GPP Release 17** has made 5G Non-Terrestrial Networks (NTN) technically ready, the device ecosystem is **still catching up.**

DEVICES BEFORE 2025

Most smartphones lack the NTN-capable modem needed to connect to satellites.

This is a **hardware limitation,** not something solvable by a software update.

The chip inside your phone was **not designed to talk to satellites.**

2025 FLAGSHIP DEVICES

Pixel 9 · Galaxy S25

Early exceptions like Google Pixel 9 and Samsung Galaxy S25 feature 3GPP Release 17–compliant chipsets.

Current capability:

Emergency messaging only

ANDROID ECOSYSTEM: MOVING FORWARD

Leaders are adopting 3GPP NTN to deliver more than just texting.

- **Snapdragon Satellite** (2023) with Iridium network support
- **NR-NTN** demos with commercial chipsets (2023–2024)
- **Exynos Modem 5410** (rumored in Galaxy S26) with Release 17 support

5B+ NTN-capable devices expected by 2030*

*Source: ABI Research, GSMA Intelligence

APPLE'S DIFFERENT PATH

Apple's Emergency SOS via satellite (iPhone 14 and later) uses a proprietary system via Globalstar.

Not part of the 3GPP NTN ecosystem. Not interoperable with 5G NTN.

A NOTE FOR EARLY ADOPTERS

Standalone 3GPP NTN chips exist and could add satellite connectivity to devices.

But this requires hardware modification – not something a regular consumer can do.

BOTTOM LINE: D2D is real. The standards are ready. But the device ecosystem is **still catching up.**

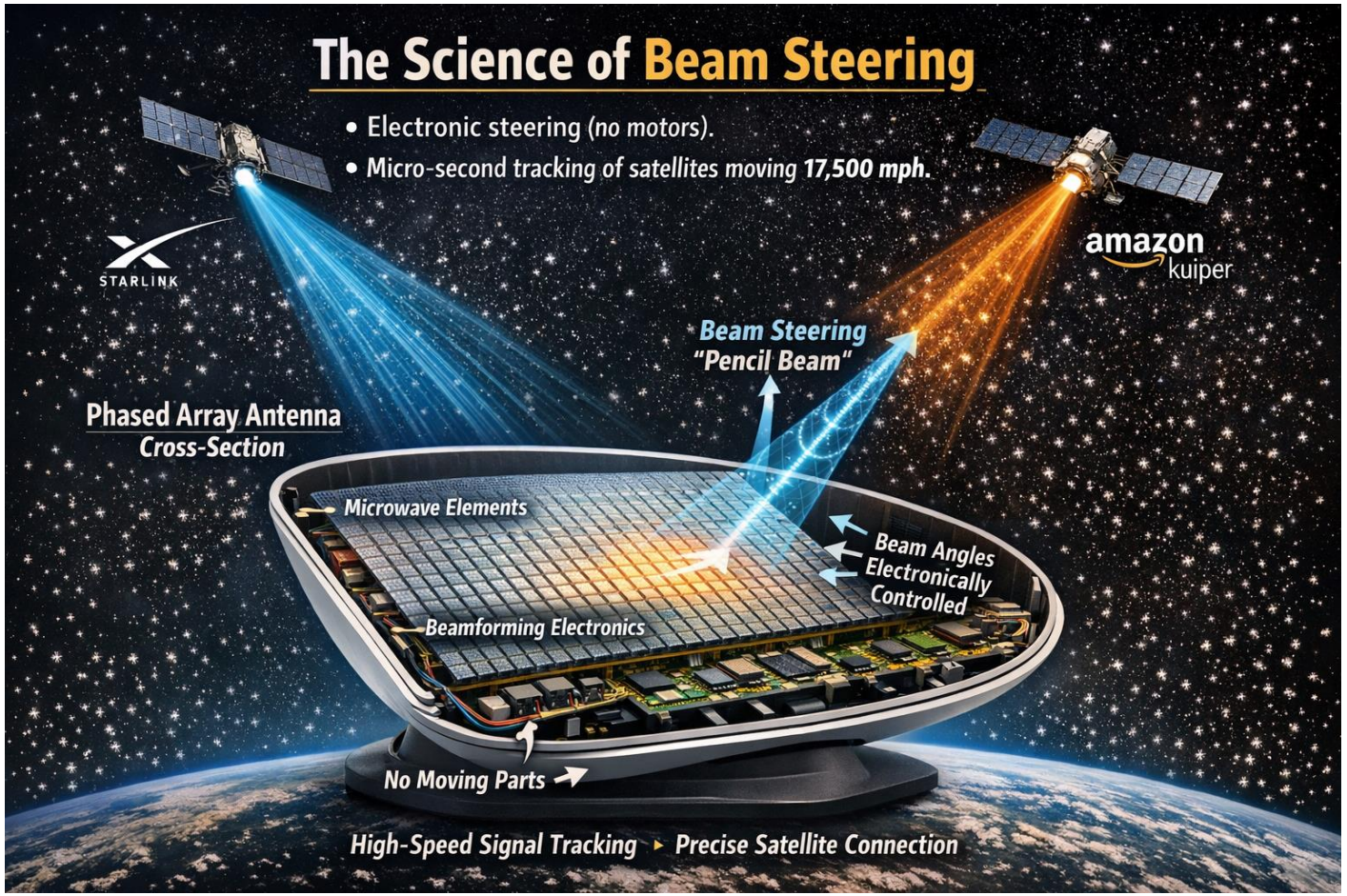
The next wave of smartphones won't just connect to towers—they'll **connect to space.**

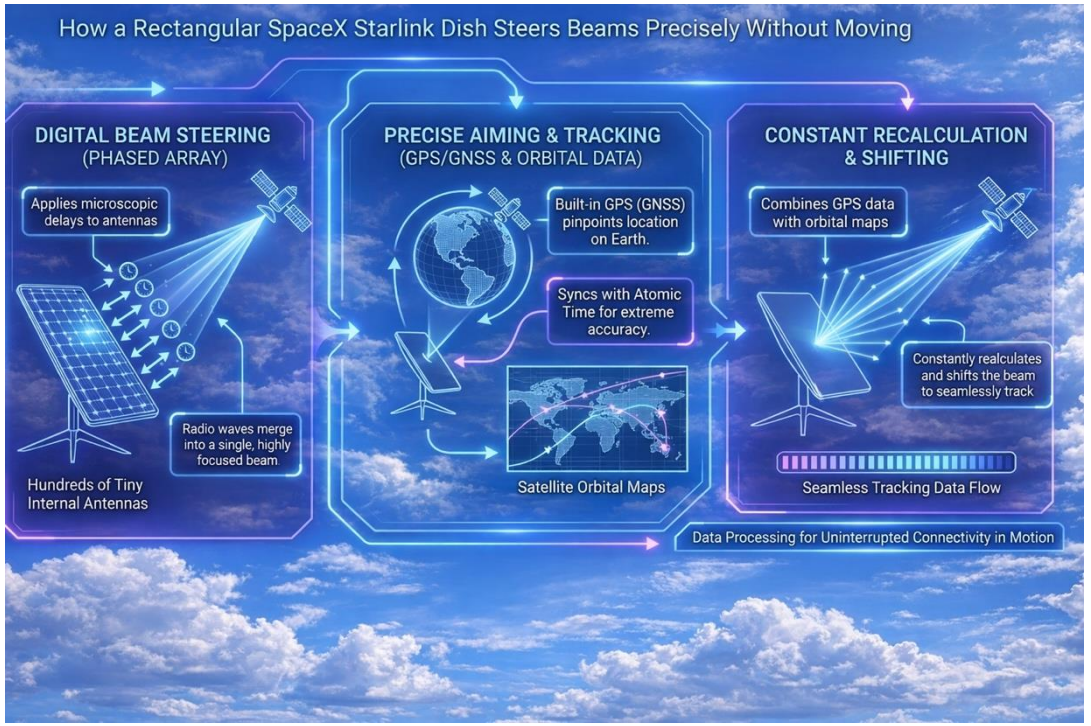
REFERENCES

- 3GPP Release 17 NTN Specifications (Rel-17, finalized 2022)
- Qualcomm Snapdragon Satellite Announcement (CES 2023)
- Apple Emergency SOS via Satellite (iPhone 14 Launch, 2022)
- GSMA & ABI Research NTN Device Forecasts (2023–2030)
- MediaTek NR-NTN Demos with Satellite Partners 2023-2024


BRITISH AIRWAYS
AIR FRANCE
oute will be operated by Airbus A350-900
36 AIRLINES HAVE NOW COMMITTED TO STARLINK IN-FLIGHT WI-FI
brussels
AIRLINES
Alaska
AIR NEW ZEALAND

Phased Array & MIMO, beam steering antennae Tech



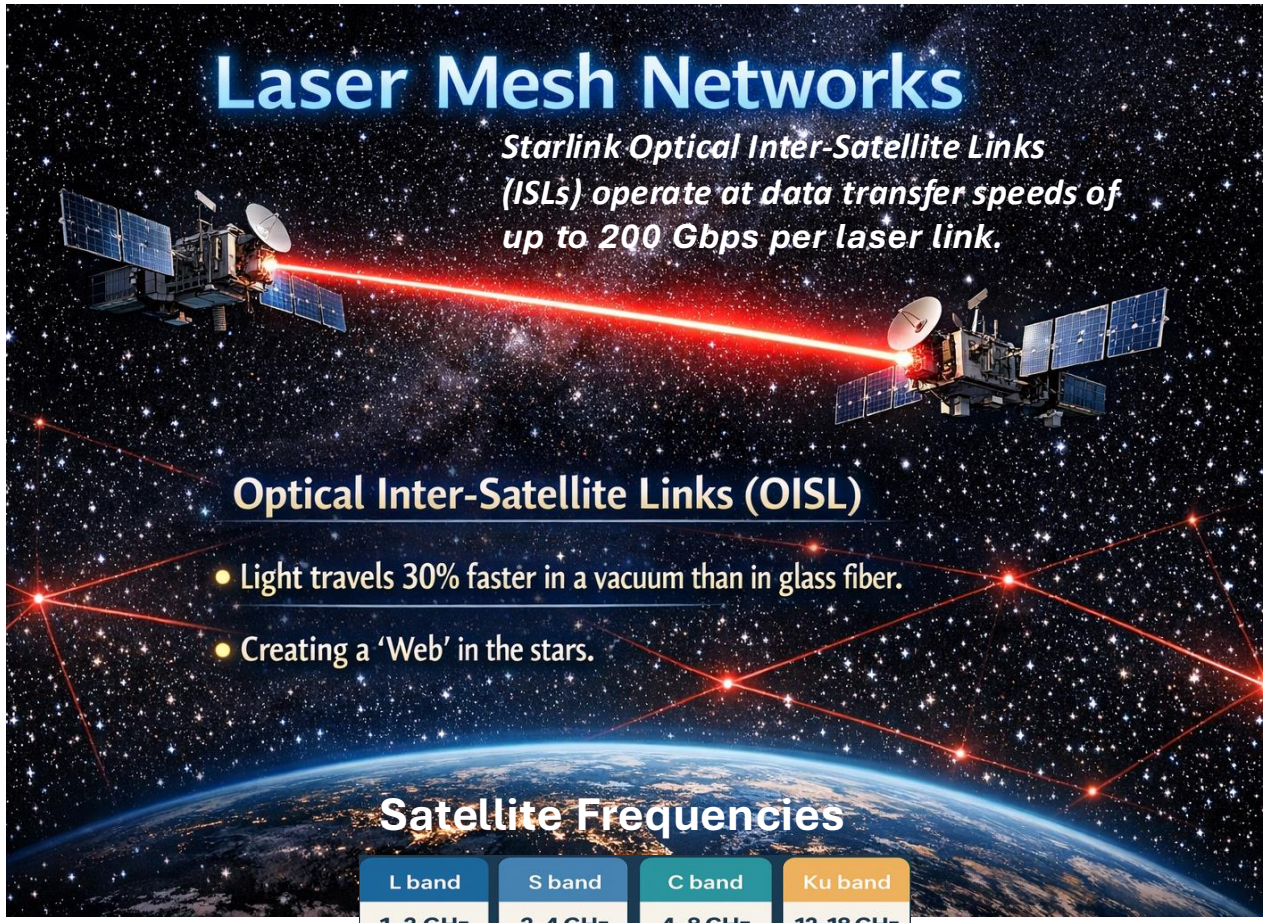


The beam can shift direction in m/s, it has no moving parts to wear down, and it focuses energy exactly where needed, but does require high-speed digital processing, is a complex hardware design, and needs to manage heat in high-power arrays

Apple iPhone 17 Pro/Max utilizes a modern, high-speed beam steering **5G mmWave antenna module** to manage connections (USA Model)

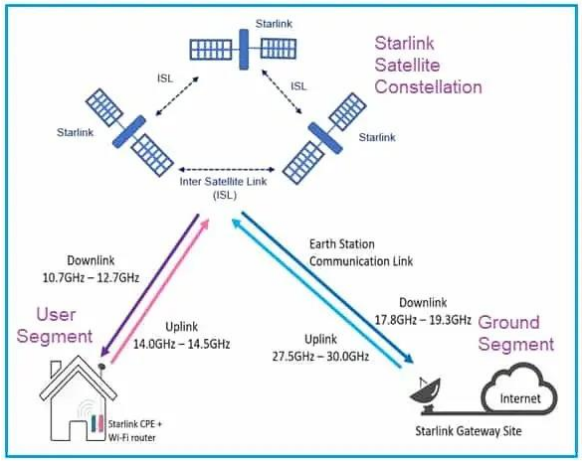
Laser Mesh Networks for Satellite Constellations

Satellites use lasers or radio frequencies to communicate directly with adjacent satellites, forming a mesh network in space.



Optical Inter-Satellite Link Communications Terminals

Honeywell Aerospace



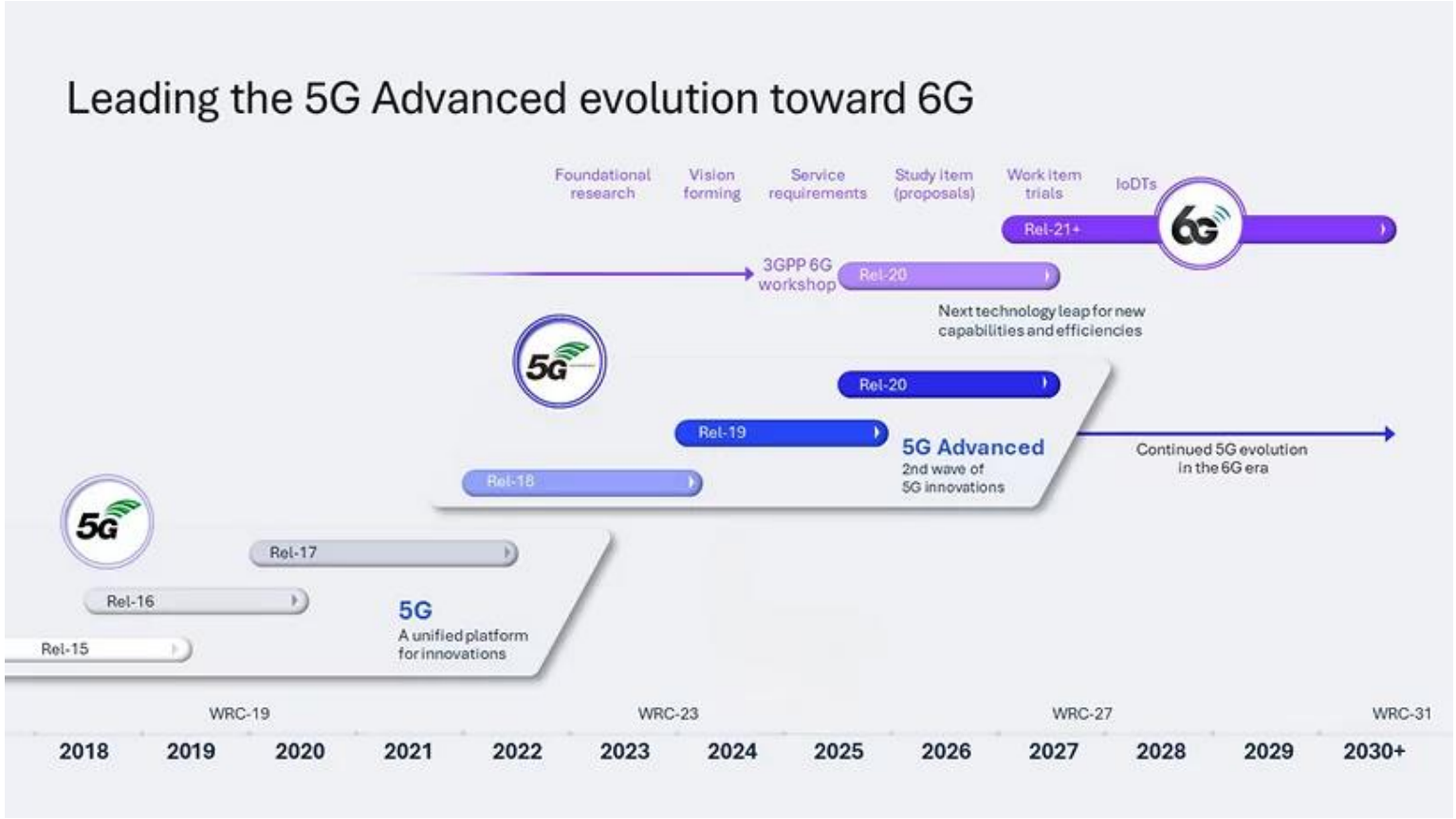
- **Optical Inter-Satellite Links (OISLs)**: In space applications, OISLs enable satellites to send data directly to one another, forming a high-speed orbital network that avoids the need to link to ground stations constantly.
- **Interconnected nodes of LEO satellites** with ***laser inter-satellite links***—to route data directly between satellites, bypassing the need for constant, intermediate ground station contact. Nodes in the network jointly communicate in a meshing fashion.

Satellite And Cellular Begin To Merge = 6G

The 3GPP is organized in three different streams: RAN – Radio Access Networks, Services & Systems Aspects & Core Network & Terminals.

•Global cellular standards (Release 17/18/19) integrate satellite links with the cellular stack — enabling seamless roaming, messaging, and IoT over space

- **Release 17 (5G Phase Two Part one)** - Support for low-power and low-cost "RedCap" devices. Support for "non-terrestrial networks," enabling 5G integration with different types of satellite-connected links.
- **Release 18 (5G Advanced)** - Many performance improvements, including expanded carrier aggregation and advanced MIMO techniques, and integration of AI technologies.
- **Release 19 (5G Advanced Phase Two)** - Continued enhancements and improvements from Rel. 18, including enhanced massive MIMO, AI, more robust satellite integration, more use cases, and better power efficiency.

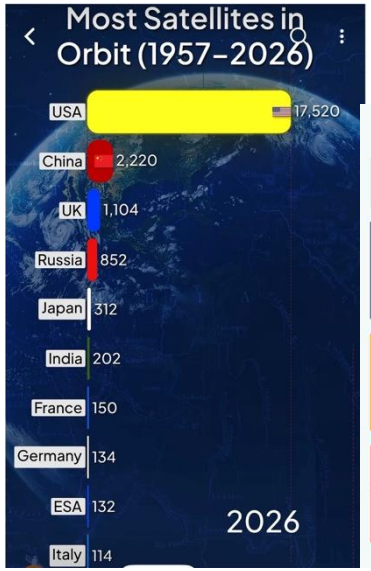


Satellite Communications Market Growth Rate- Astro-Political Bifurcation

*The **USA and China** are projected to be the largest and most influential markets for satellite Direct-to-Cell (D2C) and Direct-to-Device (D2D) services. While the U.S. currently leads in revenue and infrastructure, China is rapidly scaling through state-backed initiatives and a massive mobile subscriber base*

United States: The dominant market, accounting for a significant portion of the **34.2% North American market share**. Growth is driven by partnerships between major carriers (e.g., T-Mobile, AT&T, Verizon) and satellite operators like **SpaceX** and **AST SpaceMobile**.

China: Leading the Asia-Pacific region, China is leveraging its **900+ satellites** and national programs like the "Digital Silk Road" to integrate satellite connectivity with its 5G networks.



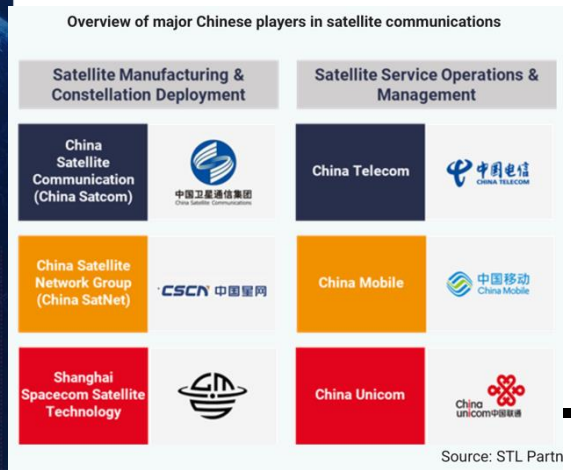


Table 1: Number of LEO Satellites in Orbit as of January 30, 2026

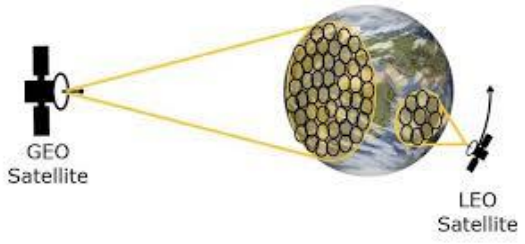
Category	United States	China
Satellites in Orbit	**11,006**	**1,168**
Private Sector	10,364	524
Public Sector (civil, military, intelligence)	600	609
Planned Satellites	**~59,000+**	**~40,000+**
Private Sector	12,000	240
Public Sector	~500+	14,000

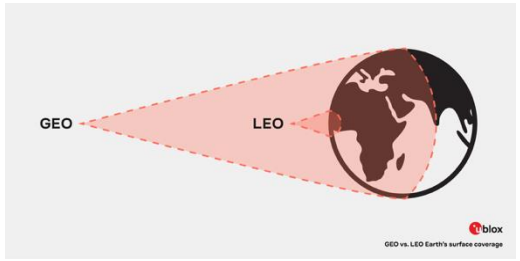
Note: Excludes academic/nonprofit satellites. Numbers for planned satellites include government filings.

Source: Aggregated from public and private sources.

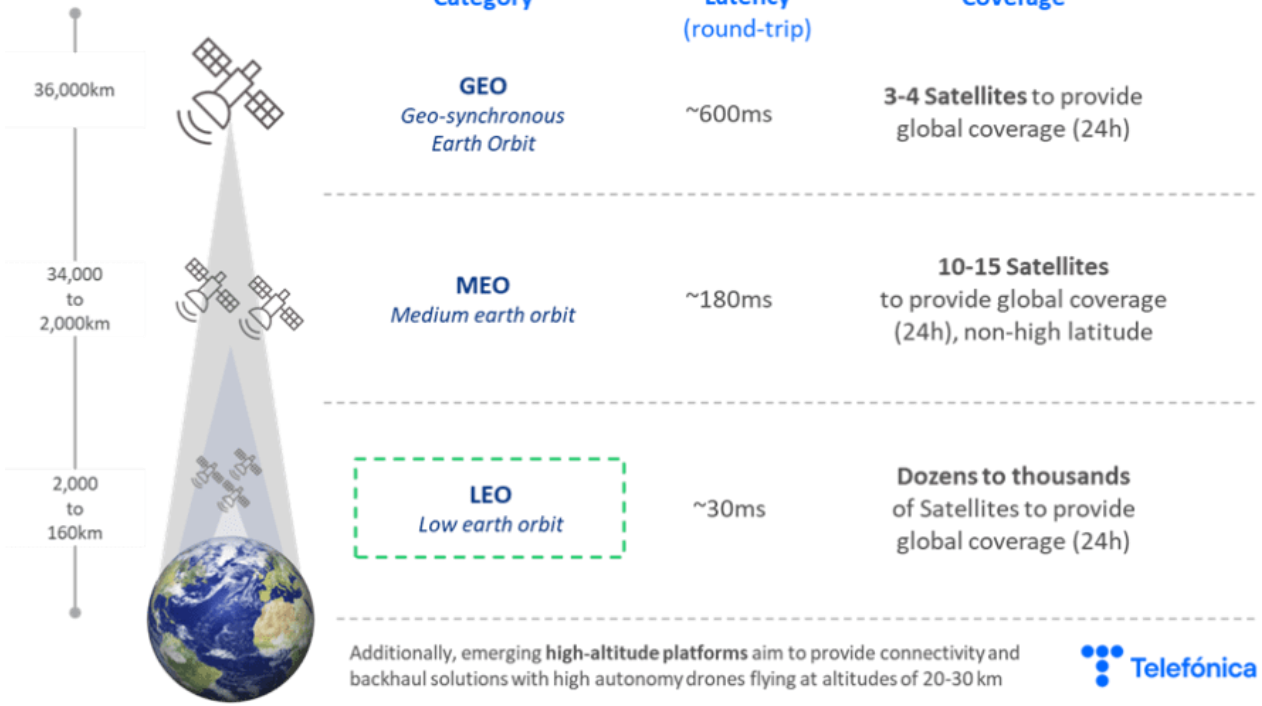
CSIS

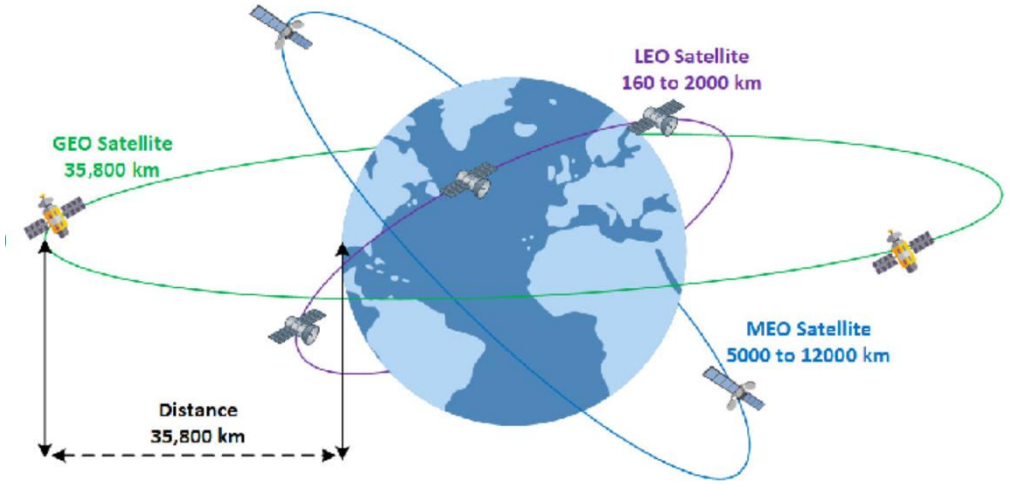
Satellite Constellations: Latency vs. Coverage





LEO constellations to provide new connectivity in remote areas



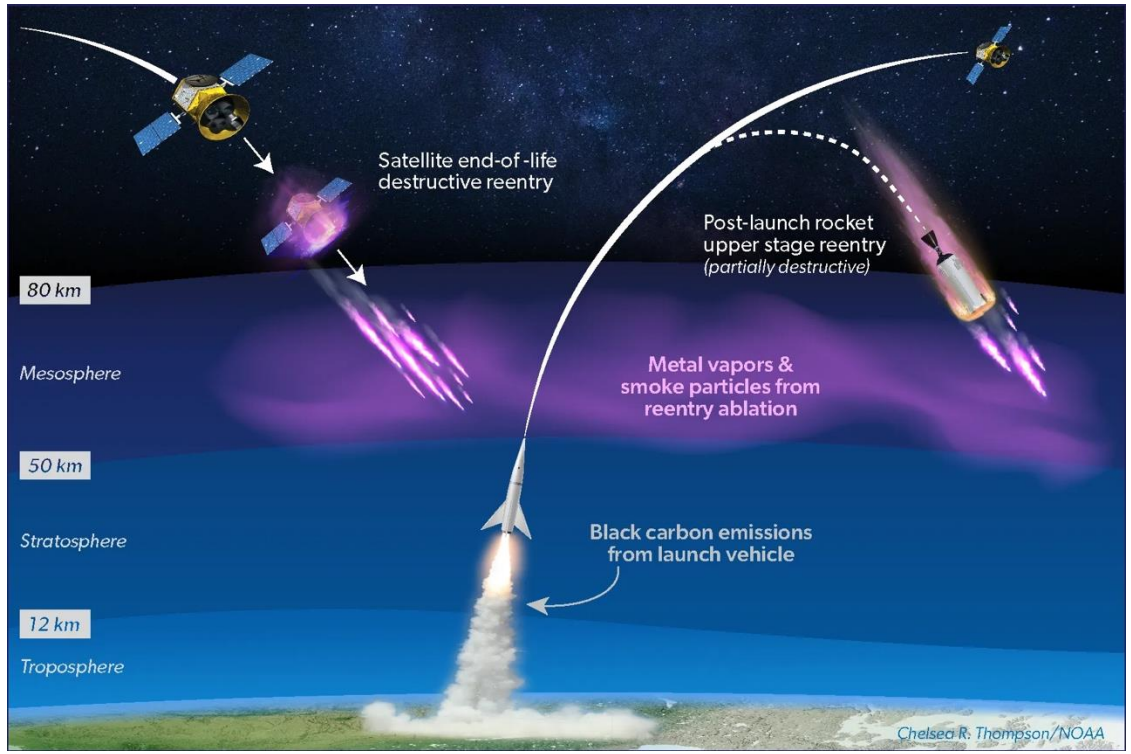


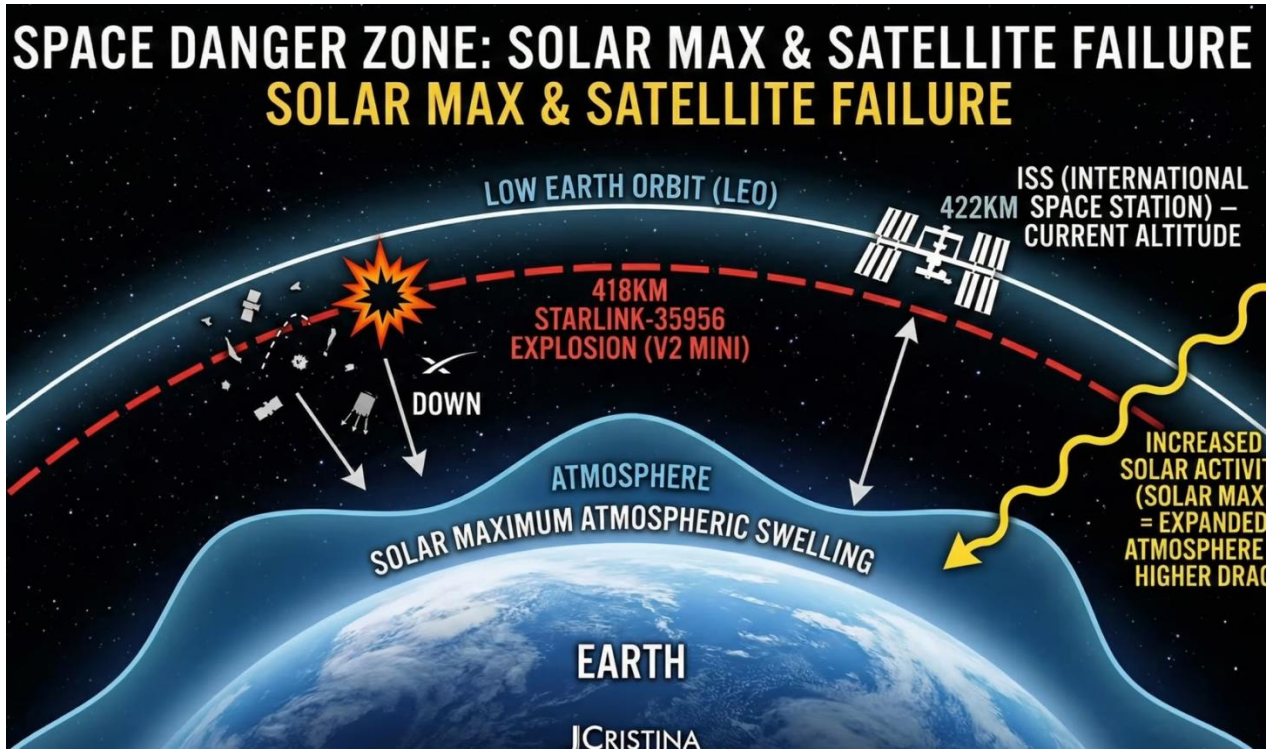
Different orbital Satellites (GEO, MEO and LEO)

- **GEO** satellites orbit & rotate west-to-east above the equator, stationary life's Earth's 24-hour rotation
- **MEO** satellites (GPS) rotate at various inclinations in the same direction for 2–12 hours per orbit.
- **LEO** satellites orbit rapidly (90-120 mins), often in polar/inclined paths, and move independently of Earth's rotation.

Satellite Asmospheric Drag

Satellite Asmospheric Drag: the aerodynamic friction exerted by the thin upper atmosphere on satellites in low Earth orbit (LEO), typically below 2,000 km, acting opposite to their motion. This force causes kinetic energy loss, resulting in orbital decay, lower altitude, and eventual re-entry and burn up entering the asmosphere.





AI is becoming the brain behind modern satellite systems.

Artificial Intelligence is transforming satellite systems by automating management, optimizing connectivity, and enabling autonomous operations across space-ground infrastructure. AI improves resource efficiency, reduces latency, enables predictive maintenance & facilitates dynamic beam steering for LEO constellations, IoT & user devices (Smartphones)

1. AI Algorithms for Satellite Constellations(LEO) & Ground Stations: AI manages large-scale networks (LEO/MEO) by optimizing routing, ensuring data synchronization, performing autonomous collision avoidance, and managing power/fuel efficiency. For Ground stations, AI automates scheduling, optimizes antenna pointing, detects anomalies in telemetry data, and enhances cybersecurity.

2. AI for Beam Steering Antennas (Phased Arrays): AI enables real-time adjustments to signal direction and strength, adapting to user movement and traffic load (beam-hopping).

3. AI for User Terminals/Smartphones/IoT devices (D2D/D2C): AI optimizes signal acquisition, manages mobility across different satellites & enhances data compression for low-latency broadband on Smartphones, manages connectivity for IoT devices in remote areas, filtering data at the edge to optimize bandwidth and power usage.

4. AI for Self-Healing Networks: If one satellite or laser link fails, AI automatically reroutes data through adjacent satellites, ensuring zero downtime for Laser Mesh networks; goal is to assure zero point of failure!

LEO Satellites support Orbital Edge Computing of Data Centers

- SpaceX is proposing massive, solar-powered constellations to process data directly in space due to AI demand.
- Reduces reliance on ground-to-space transmissions, reduces latency
- Use high-speed laser communications for data processing.
- Offers unlimited solar energy, natural passive cooling in a vacuum
- Other actors, including Starcloud, Kepler Communications, and Chinese firms, plan to develop substantial orbital compute infrastructure.

THANK YOU!

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