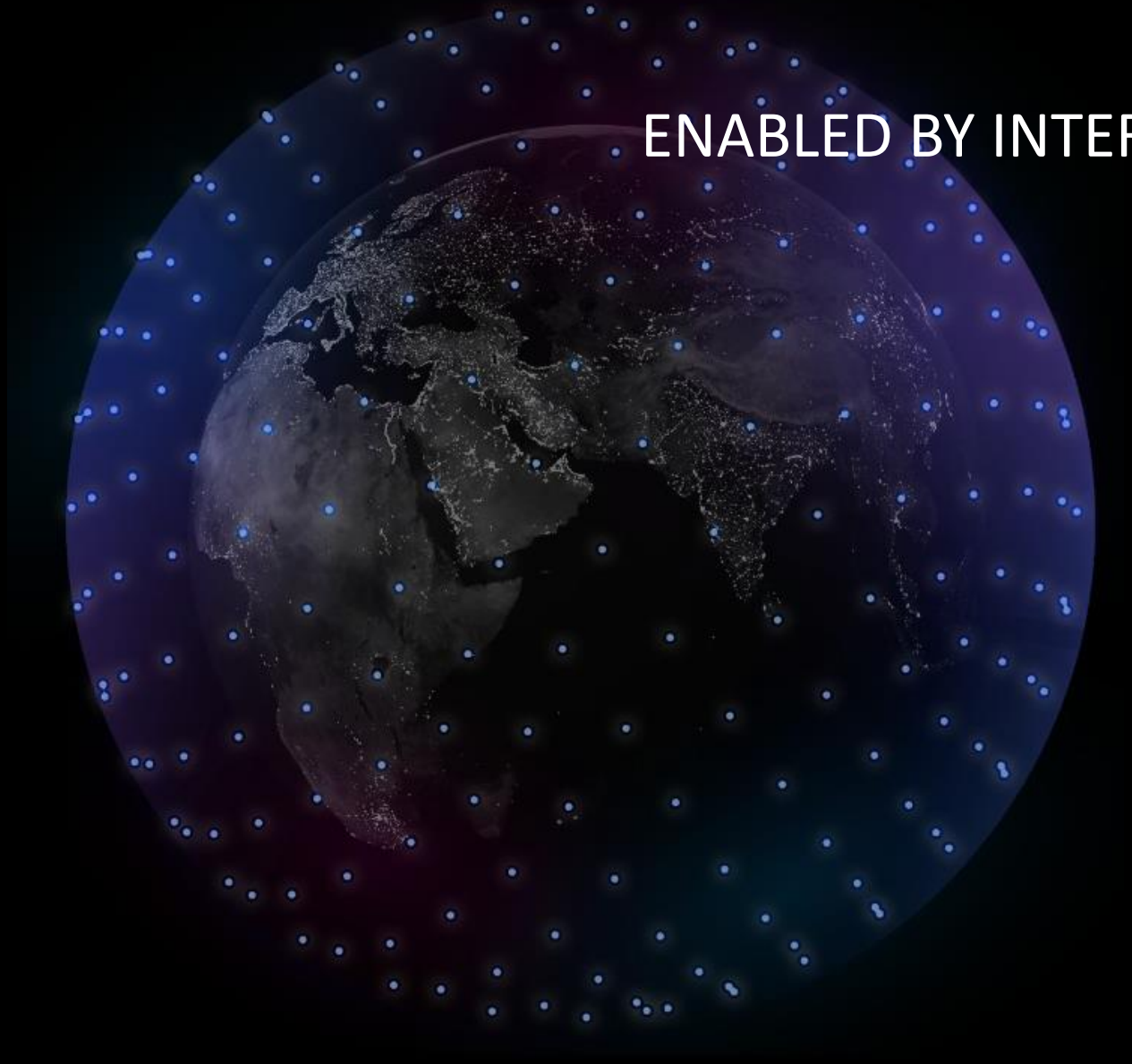
NEXT GENERATION SATELLITE CONSTELLATIONS IN PROLIFERATED LOW EARTH ORBIT (pLEO) – ENABLED BY INTERSATELLITE LASER COMMUNICATION



Thomas Laurent

RIVADA

EPIC Technology Meeting on Photonics for New Space – Optical Communication during ESA Industry Days

INTERSATELLITE LASERCOMMS IN THE NEWS

- *“Polaris Dawn Mission to Test Starlink Laser Communications”* - Via Satellite
- *“SpaceX To Sell Starlink-Derived Laser Comms To Other Sat Providers”* - Aviation Week
- *“Mynaric’s CEO, CFO Out After Production Issues With Laser Comms”* - Aviation Week
- *“Tesat Opens New Production Facility in Germany for Laser Terminals”* - Via Satellite

ABOUT US

THE OUTERNET

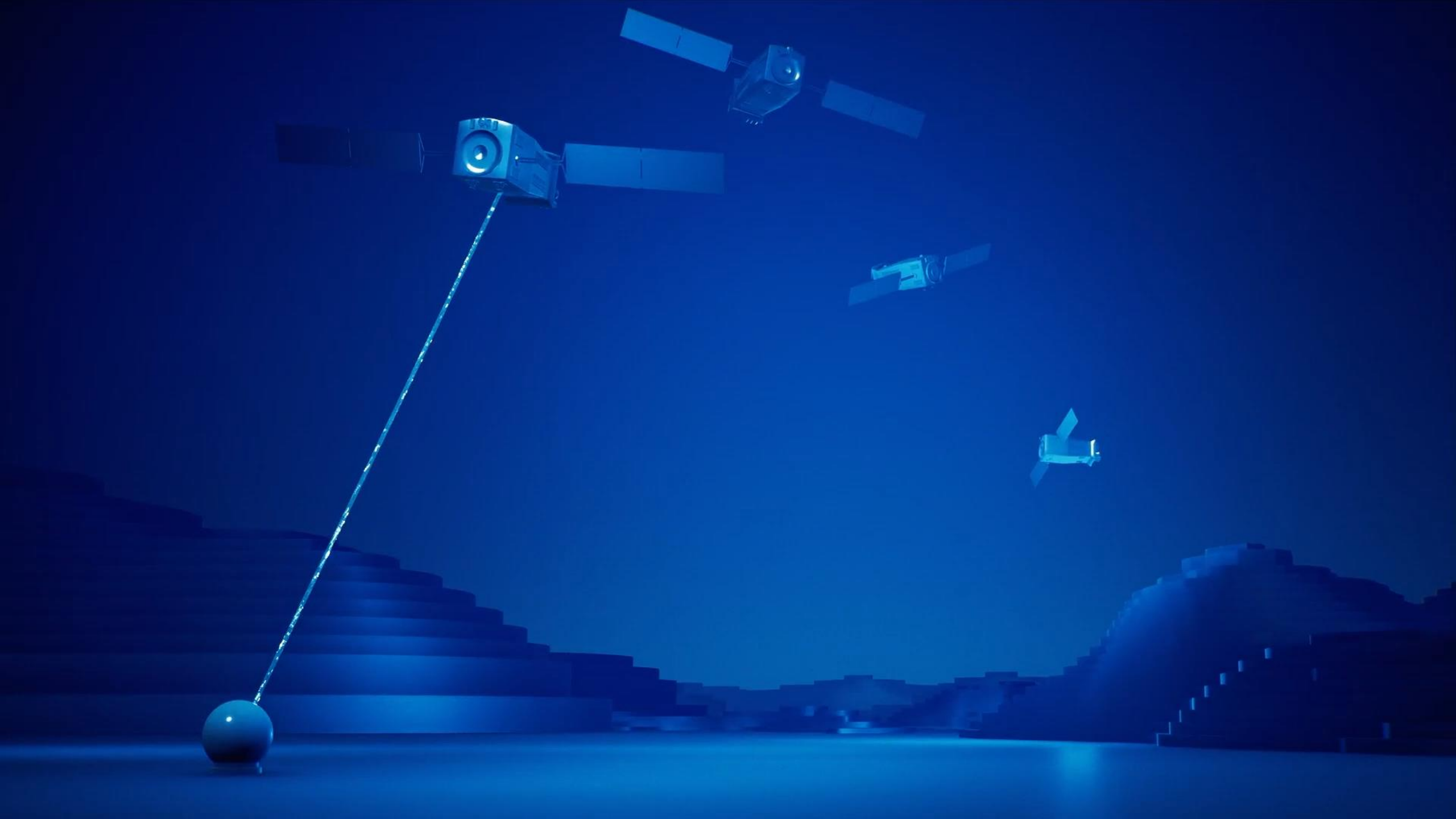
Fast, Secure, Everywhere

RIVADA SPACE NETWORKS

- Founded in March 2022
- Headquartered in Munich, Germany
- Growing, international team 140+
- Building the Rivada Outernet
- Defence, Security, Enterprise, Maritime, Aviation

RIVADA'S OUTERNET

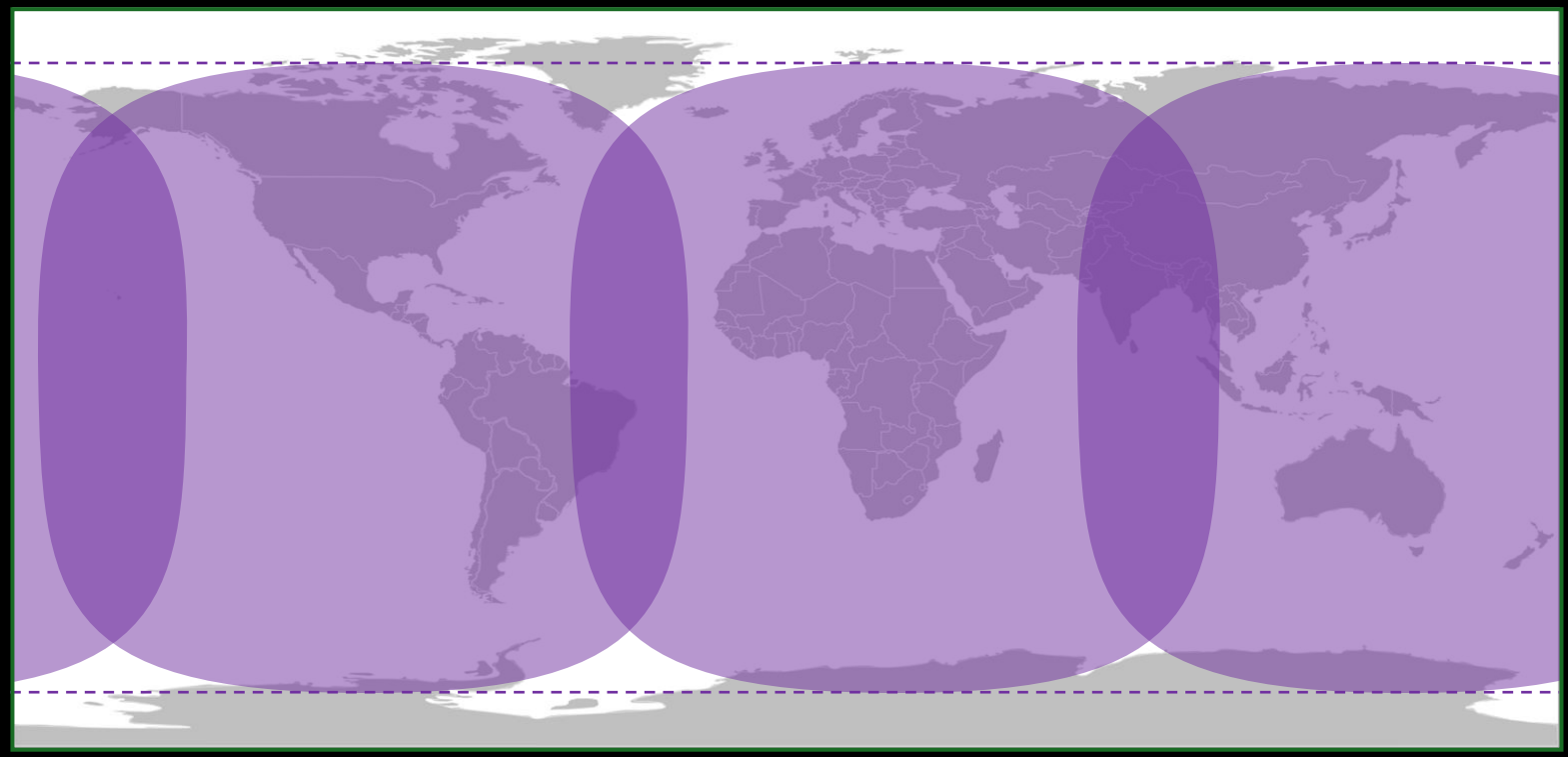
- Proliferated Low Earth Orbit
- 1050km altitude
- Ka Band
- Gateway-less architecture
- Symmetrical high throughput
- Ultra low latency
- MPLS in the sky – fully optically meshed
- High security
- Data sovereignty
- Pole to pole coverage



ON COVERAGE

GEO (1-3 sats)

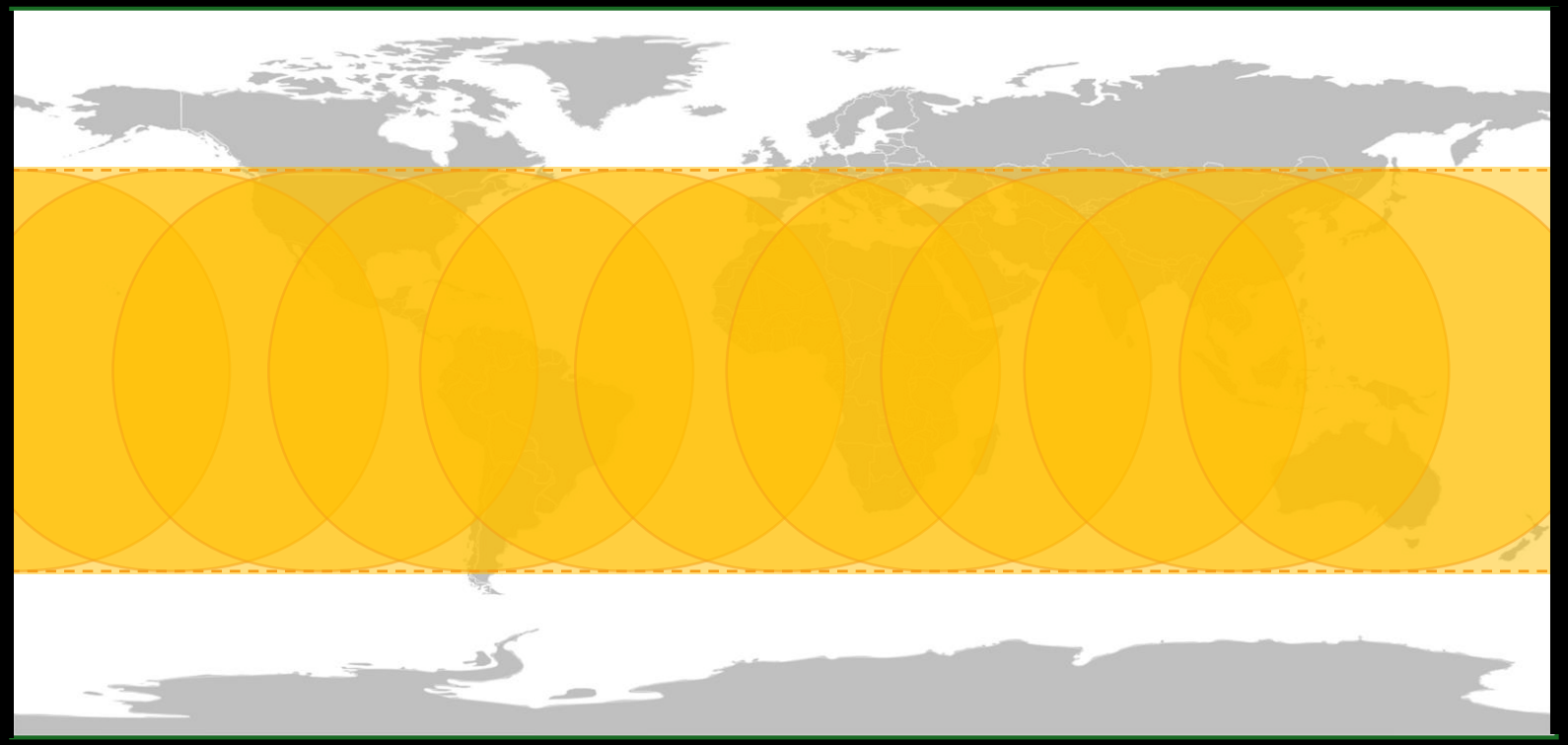
- Only up to 60-70° latitude
- Low elevation angles in high latitudes
- Obstruction issues



ON COVERAGE

MEO (a dozen sats)

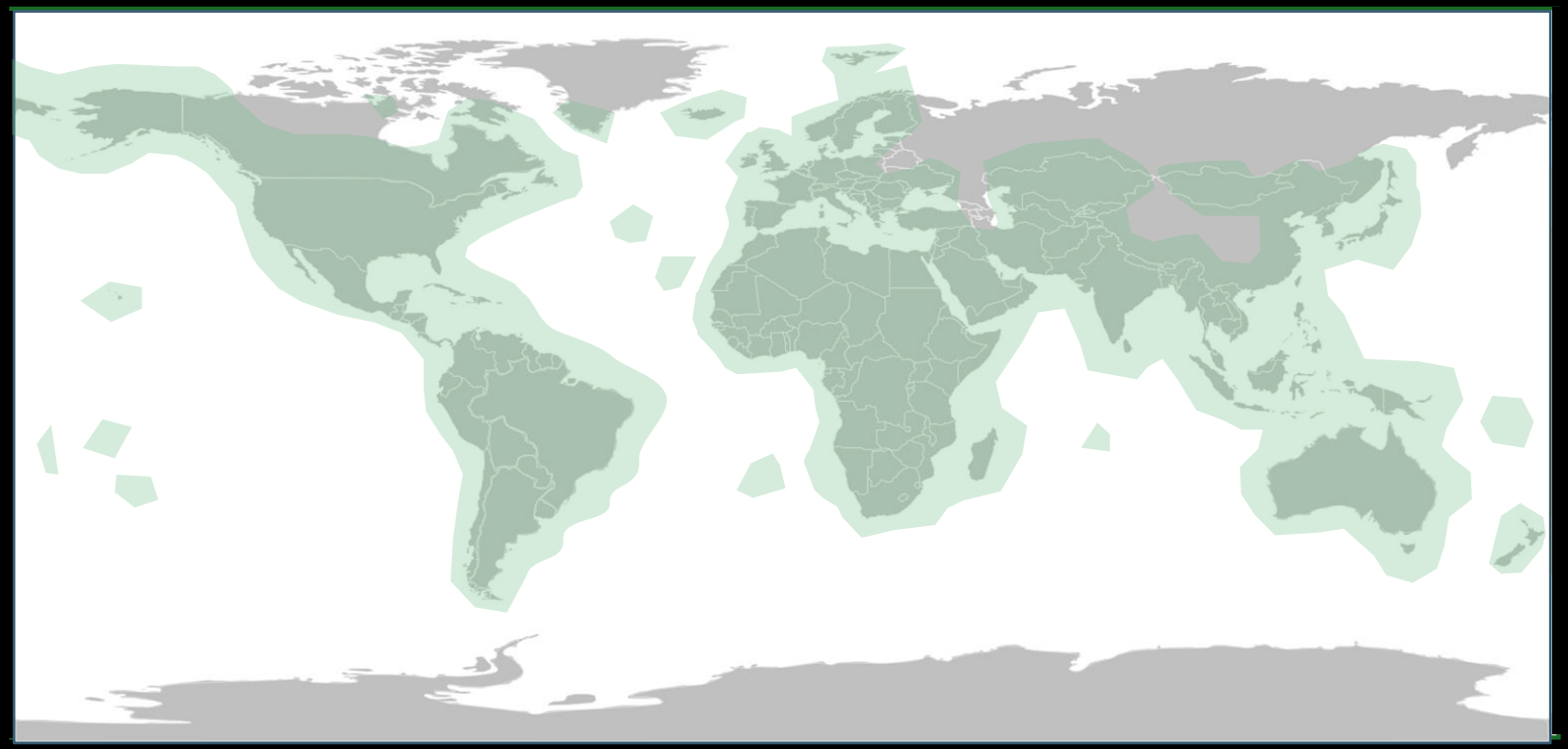
- Only up to 50° latitude
- Low elevation angles in mid to high latitudes
- Obstruction issues



ON COVERAGE

LEO with Gateway (hundred's)

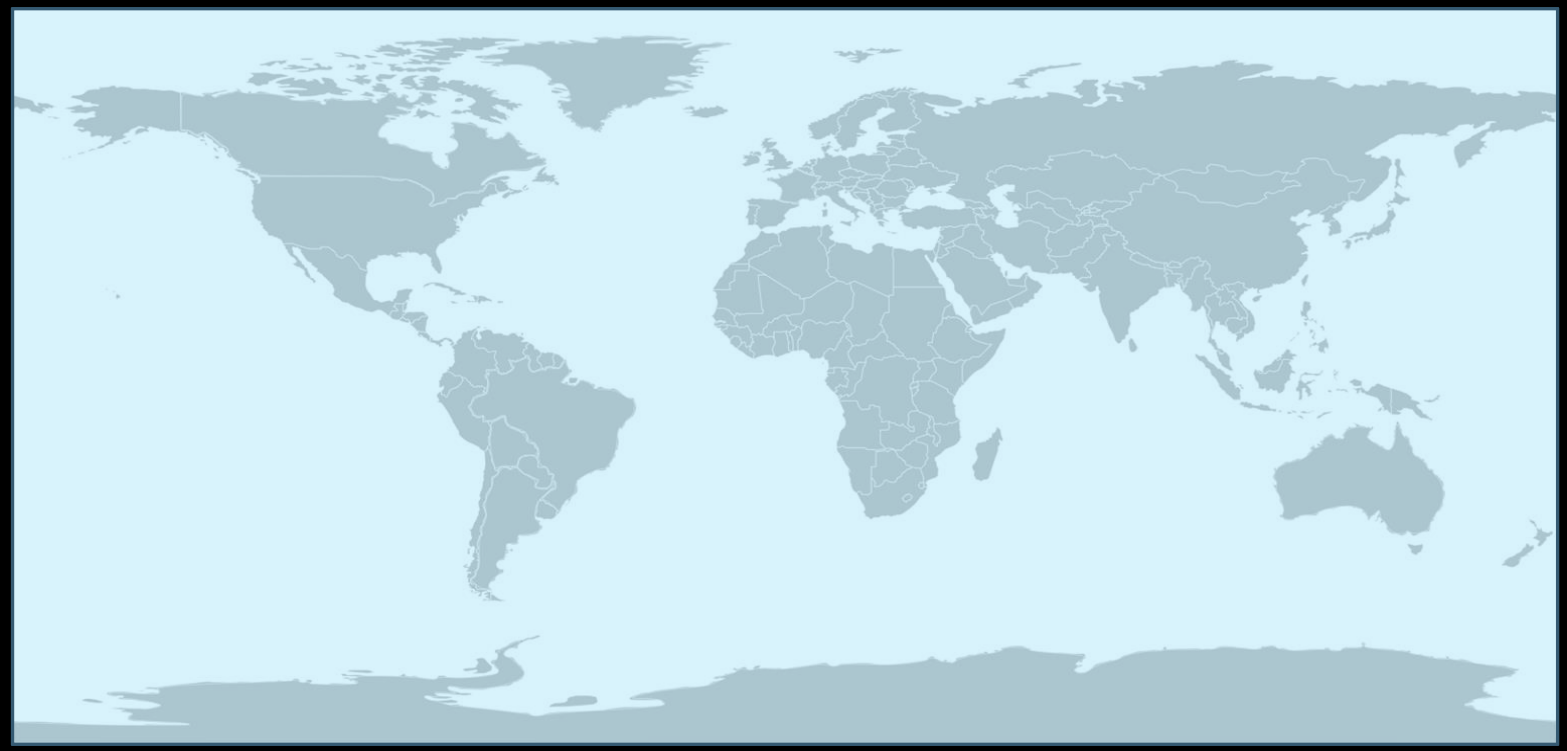
- Coverage only with a gateway in sight
- Most of oceans unreachable
- Reliance on land-based infrastructure (gateways and optical fiber)



ON COVERAGE

LEO w/o Gateway (hundred's)

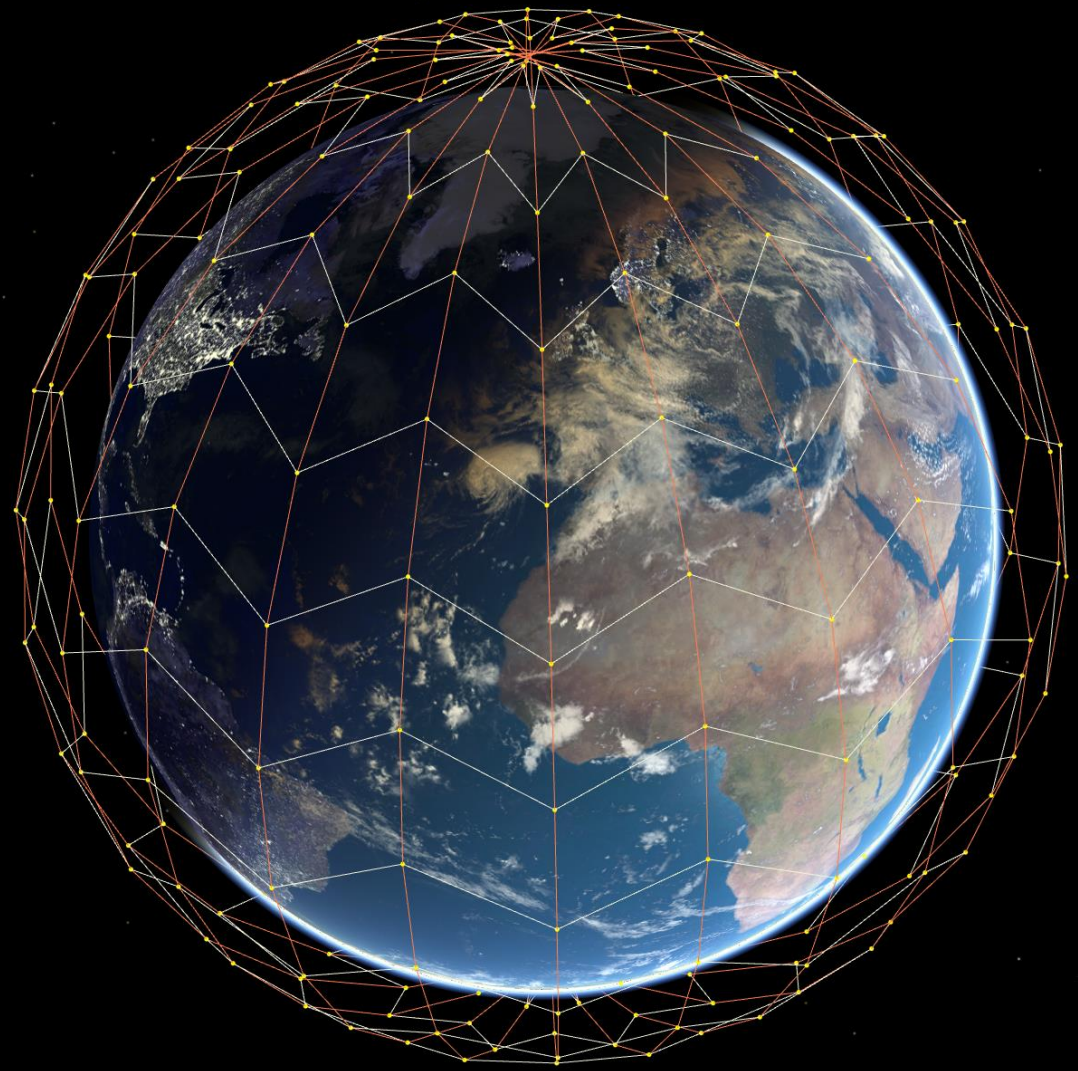
- Truly global coverage
- Pole-to-pole
- Open oceans
- Independent of terrestrial infrastructure



PROLIFERATED LEO (pLEO)

Key characteristics of pLEO*

- **Large number of satellites**: Having hundreds or thousands of satellites provides redundancy and resilience.
- **Low altitude**: pLEO satellites orbit from 160 km to 1200 km, which reduces latency compared to higher orbits
- **Global coverage**: A large pLEO constellation can provide connectivity across the entire planet, including remote areas.Typical roundtrip time <150 ms
- **Short satellite lifespan**: pLEO satellites typically last 5-10 years before orbital decay, so constellations must be frequently replenished.
- **Lower costs**: Small satellites and mass production reduces pLEO costs compared to traditional satellites.

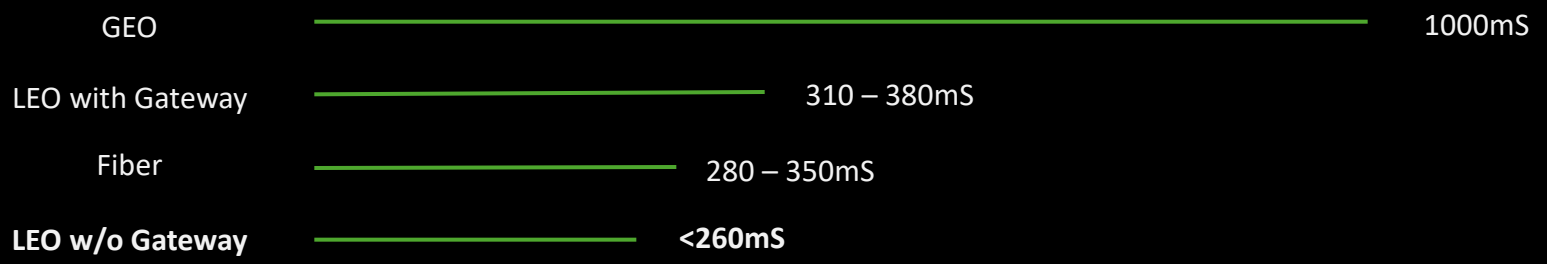


*) https://newspaceeconomy.ca/2023/10/23/what-is-proliferated-low-earth-orbit-pleo/

ON LATENCIES

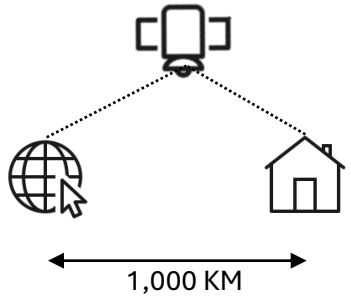
Ultra Low Latency only in LEO

- 35x times closer than GEO
- 30% faster in vacuum than in fiber optic cable
- Efficient shortest path with optical intersatellite links
- Typical roundtrip time <150 ms
- RTT < 25 ms up to 1000 km distance



NOT ALL LEO CONSTELLATIONS ARE CREATED EQUAL

Type 1
Last Mile to Gateway



Last mile connectivity

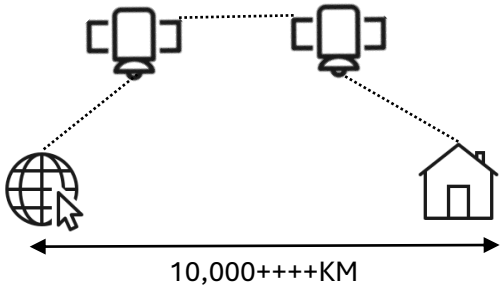
Routes to nearest Internet gateway

Optimized for consumers and SME

STARLINK OneWeb

Gen 1

Type 2
Last-mile to Gateway
With Laser Extension



Last mile connectivity

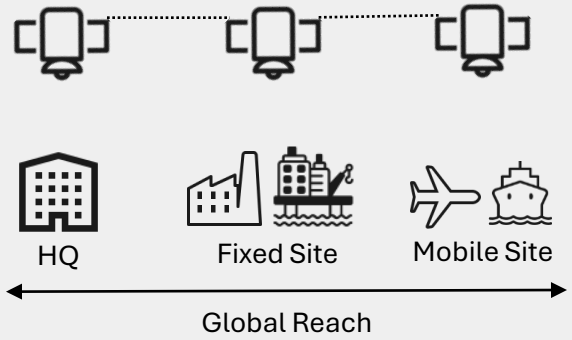
Routes to nearest Internet gateway

Optimized for consumer and SME

STARLINK OneWeb amazon | project kuiper

Gen 2

Type 3
Meshed Network in Space
The Outernet



Global Carrier Ethernet Network

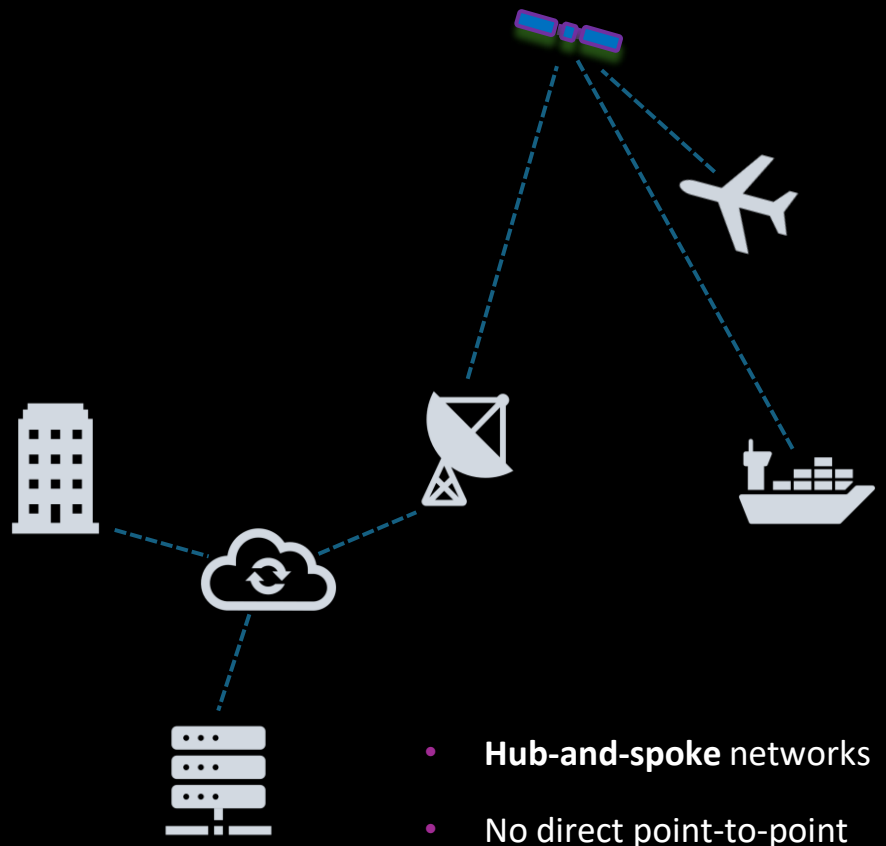
No Gateway required

Optimized for **Corporate Networks**

RIVADA

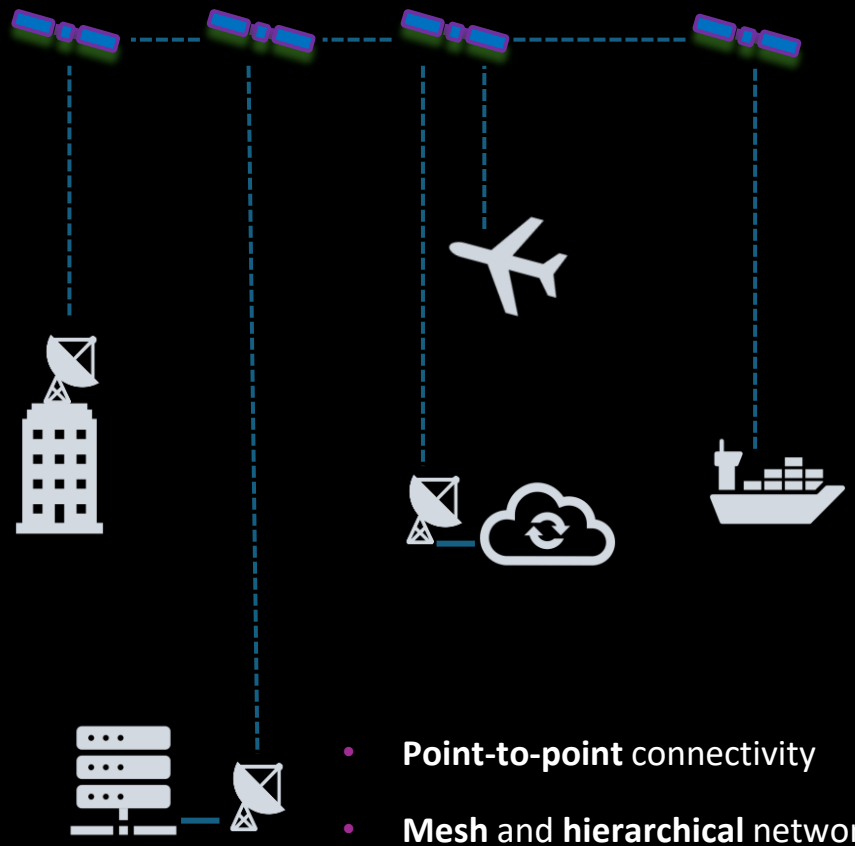
ON NETWORK TOPOLOGIES

Gateway-based Architecture (5G era)



- **Hub-and-spoke** networks
- No direct point-to-point
- Multi domain

Gateway-less Architecture (5G, 6G era)



- **Point-to-point** connectivity
- **Mesh** and **hierarchical** networks
- Single domain

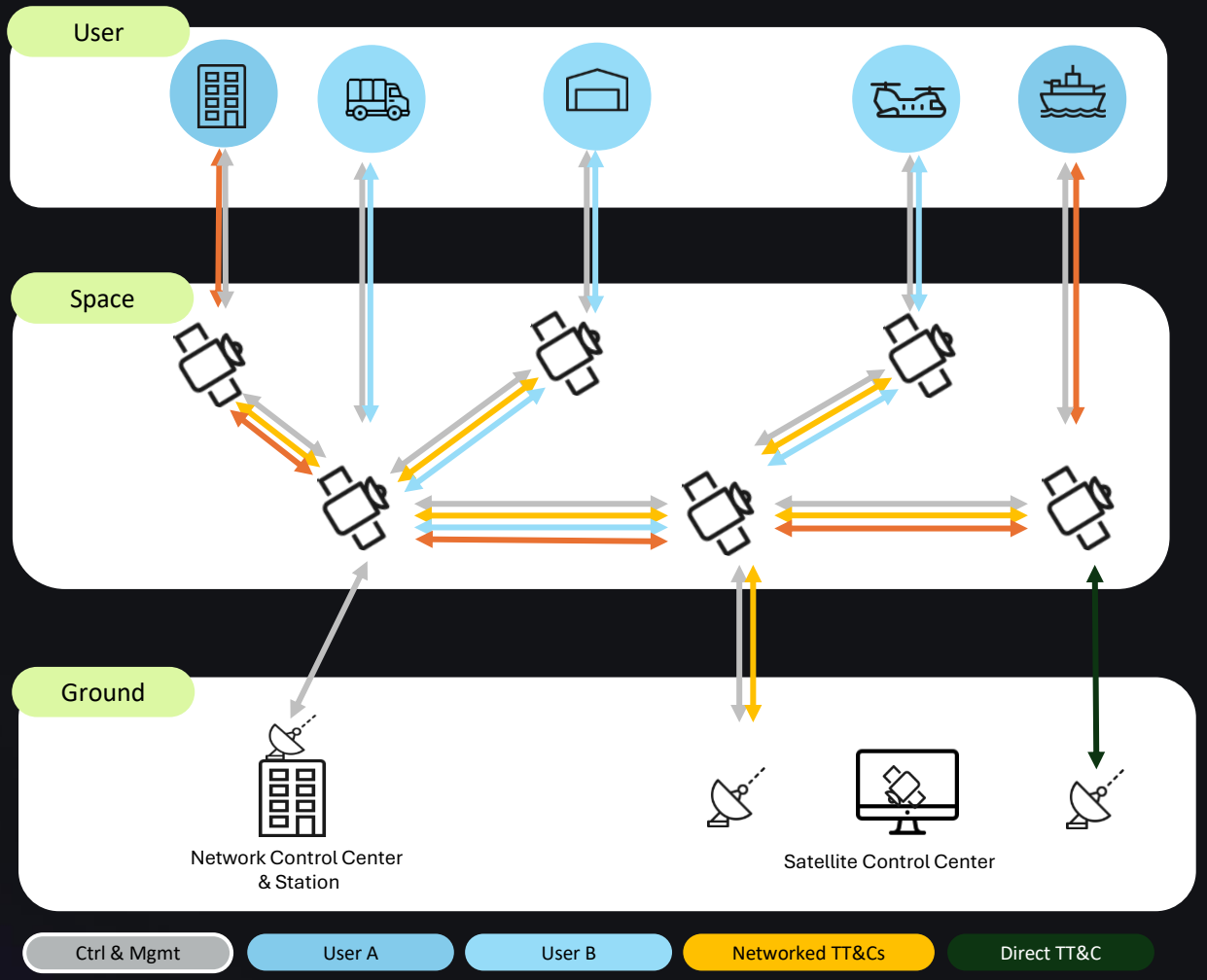
RIVADA'S NETWORK TOPOLOGY IN MORE DETAIL

Ultimate Data Sovereignty

- Ground Segment and User Segment separation
- User data flows only via the orbital private network
- No intermediate landings on the ground
- No 3rd party networks

Network Resilience

- System and network control independent of the Internet
- Proliferated LEO architecture with inherent resilience
- High redundancy of network nodes and links
- Centralized control via redundant NCC and SCC

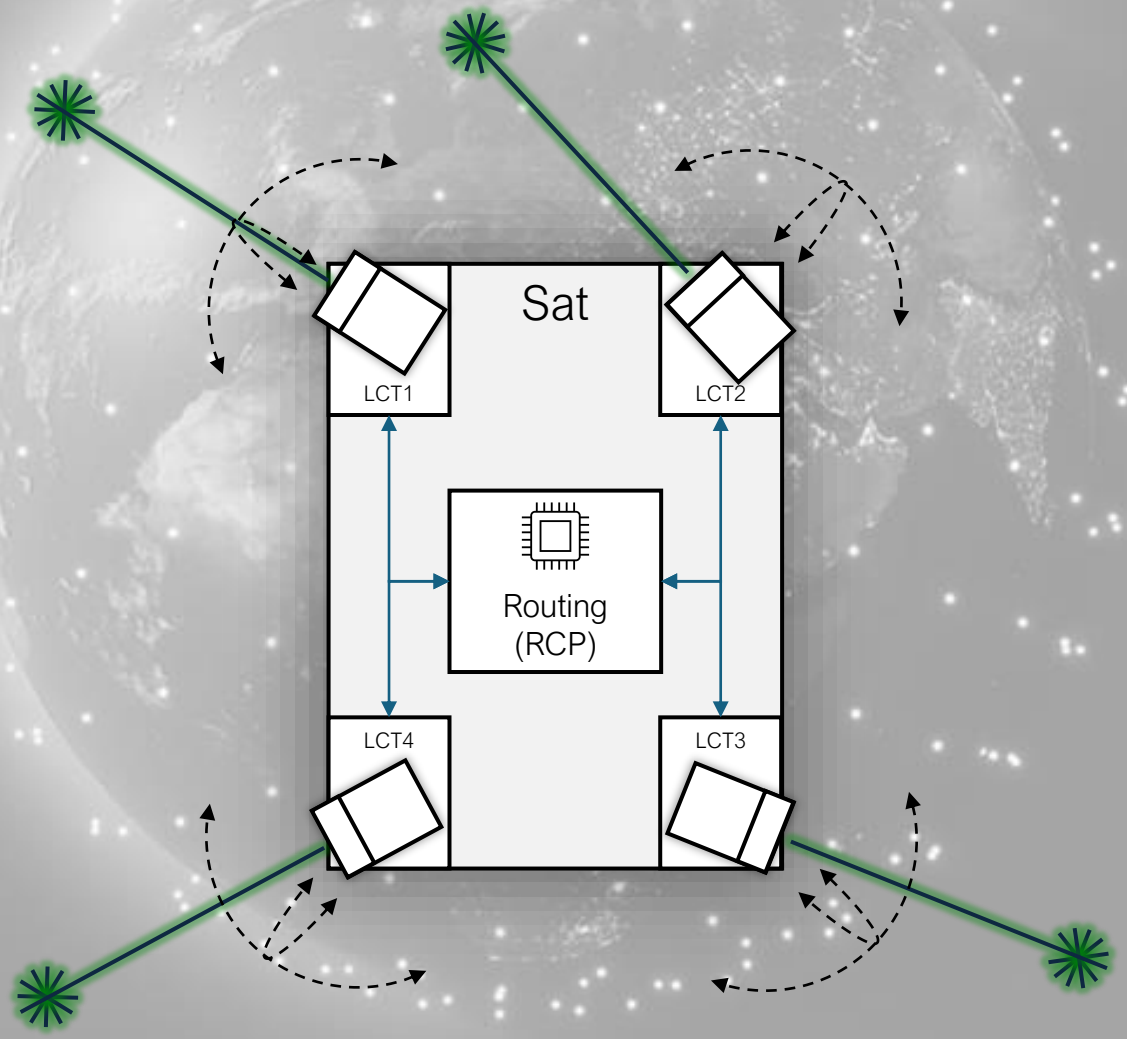


OPTICAL INTERSATELLITE LINKS BASELINE CONFIGURATION

- Each satellite equipped with four independent Laser Comm Terminals (LCT)
- Up to 1176 steady point-to-point links

- Automated tracking of the relative movement of connected satellites
- Full-duplex optical links with 10 Gbps and more connected to the on-board Router (RCP)
- Upcoming generations aim for >>10 Gbps

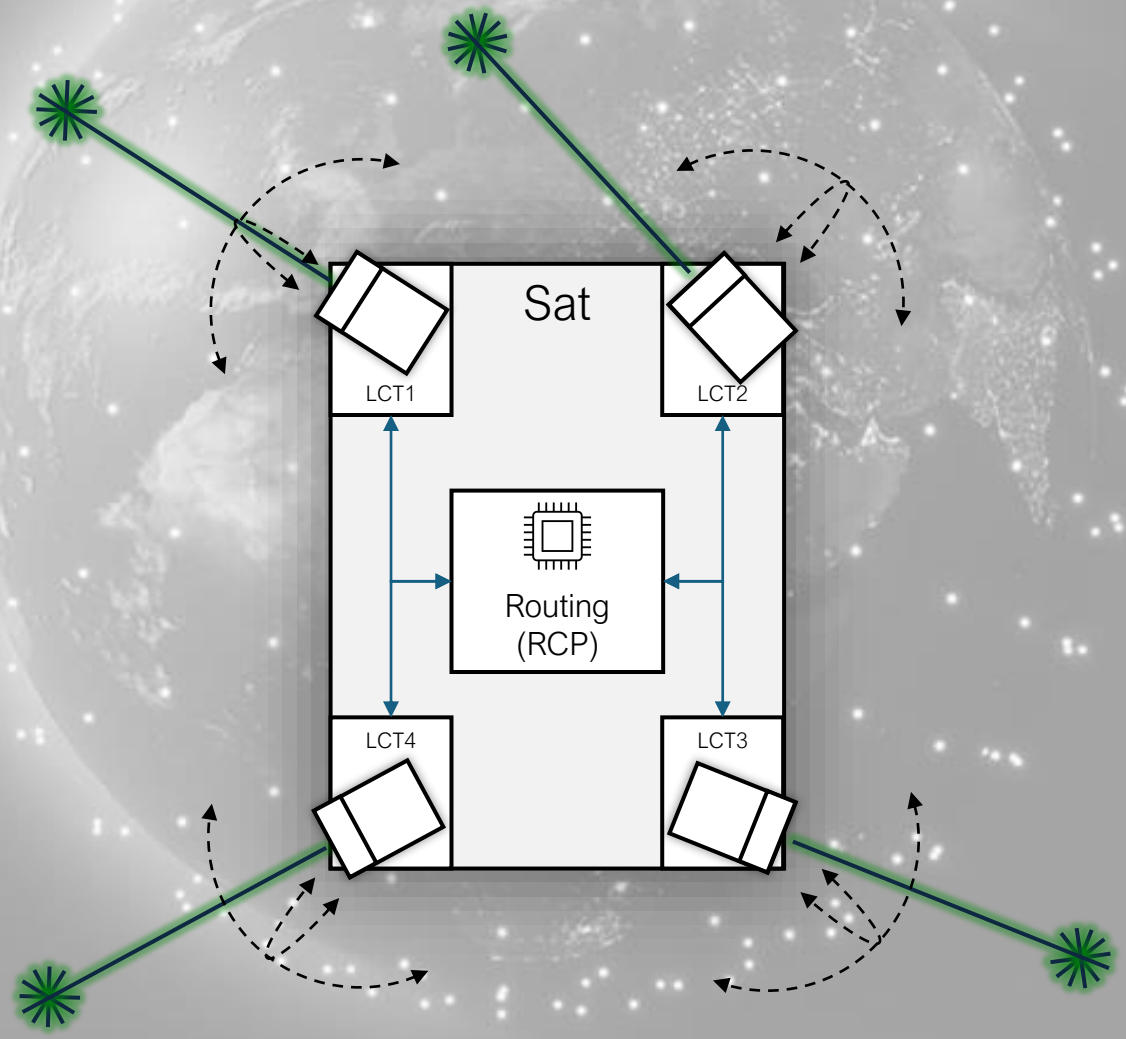
- Laser links bridge distances from ~450 up to ~7000 km



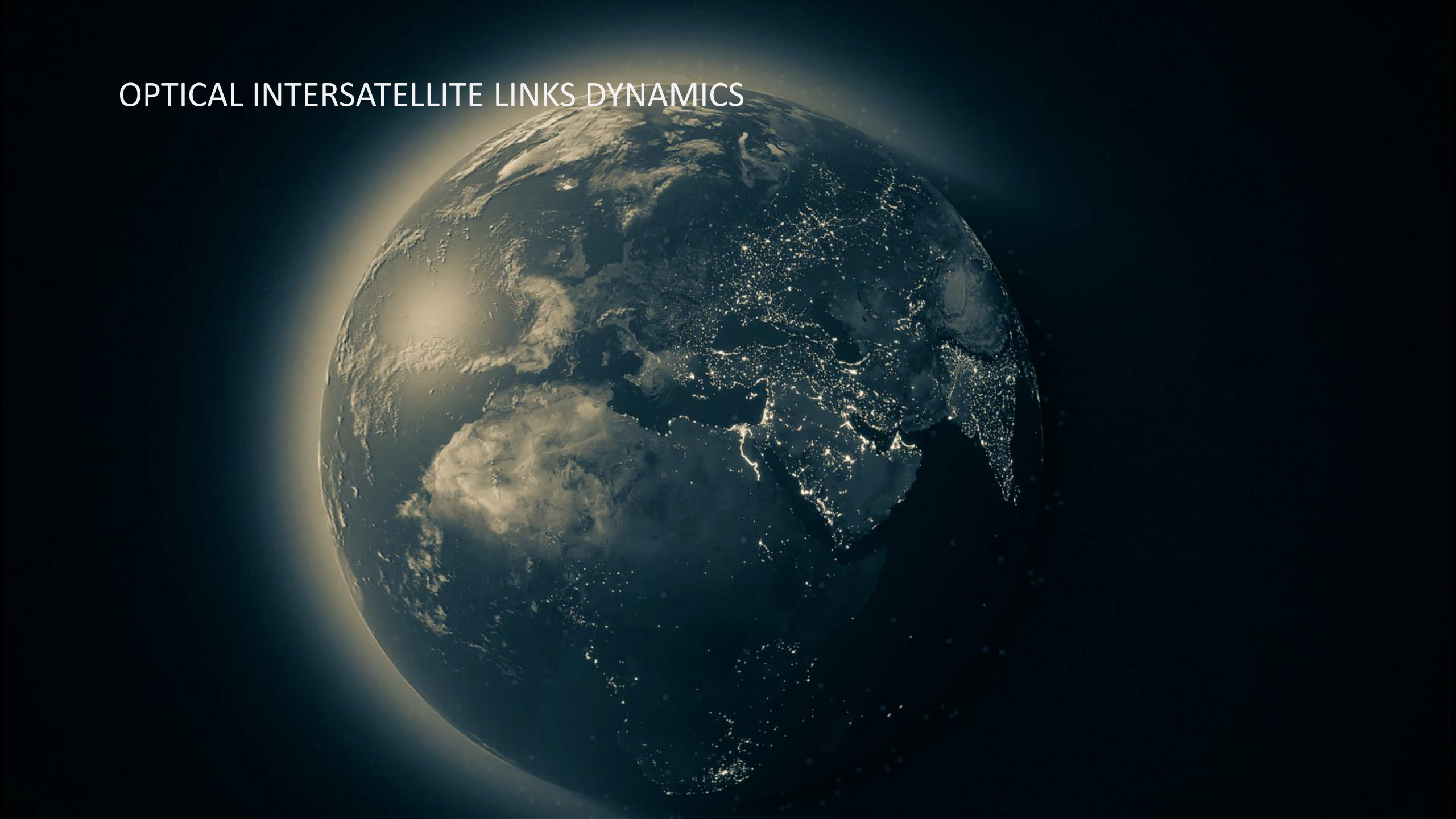
OPTICAL INTERSATELLITE LINKS BENEFITS

- Narrow beam –
  physically secure end-to-end user links
- Substitutes a ground station based bent-pipe approach

- Lowest impact on propagation delay compared to bent-pipe and/or fiber backbone (in space: n = 1)
- High link redundancy



OPTICAL INTERSATELLITE LINKS DYNAMICS



OPTICAL INTERSATELLITE LINKS DYNAMICS

- “Polar Satellite Ballet”

Thank You