National Aeronautics and Space Administration

SCaN Overview of Commercial Space Relay Transition and the Communications Services Project

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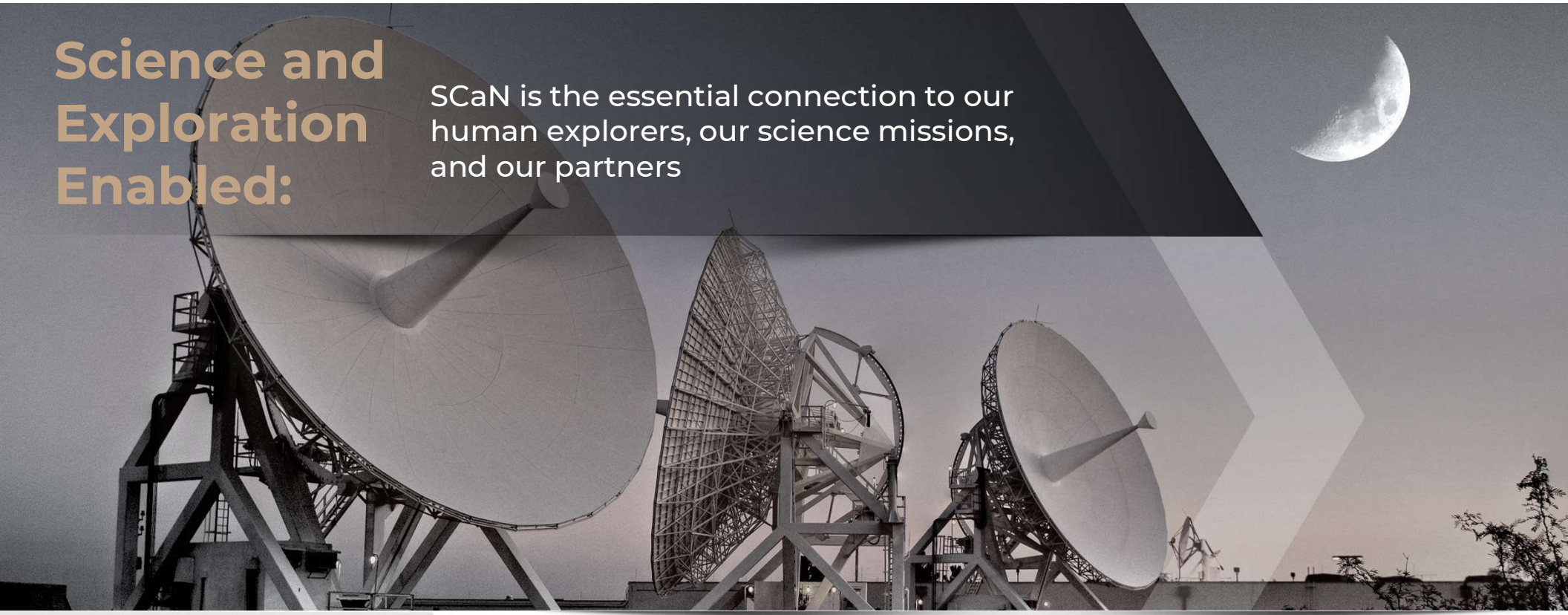
SCaN Space Communications and Navigation

Science & Exploration, enabled.

Science and Exploration Enabled:

SCaN is the essential connection to our human explorers, our science missions, and our partners



Space Communications and Navigation (SCaN) Serves as the enterprise responsible for all of NASA's space communications activities.

24/7 Global Near Earth and Deep Space Communications and Navigation Services

100+ Missions currently enabled by SCaN

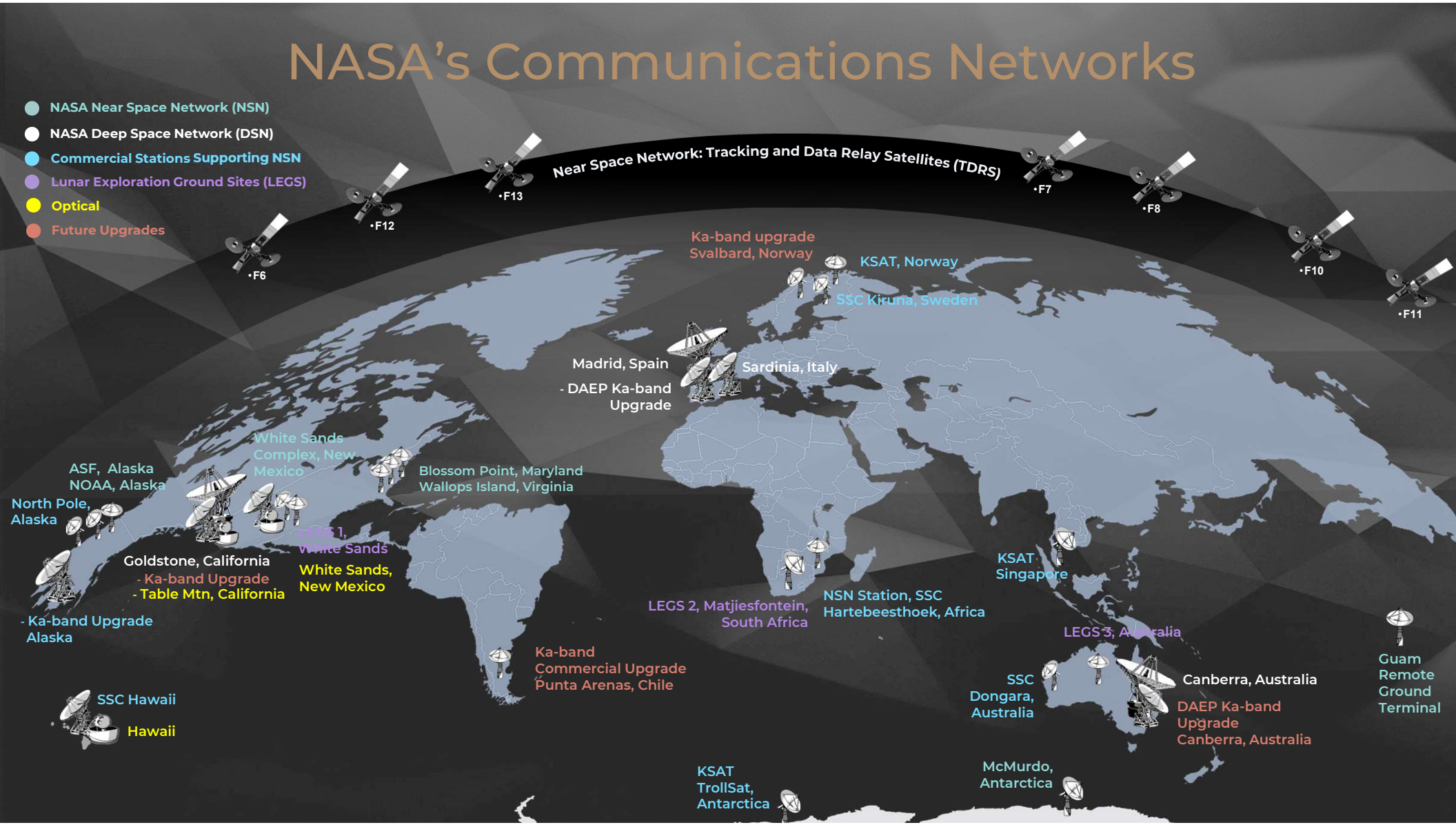
Focal Points for Change: Strategic Evolution

Engage
as One Team, One Mission, One Network

Execute
with Sound Technical and Programmatic Fundamentals

Evolve
the Network to Satisfy Mission Customer Needs of the Future

Empower
Our Science and Exploration Partners


NASA's Communications Networks
NASA Near Space Network (NSN)
NASA Deep Space Network (DSN)
Commercial Stations Supporting NSN
Lunar Exploration Ground Sites (LEGS)
Optical
Future Upgrades
Near Space Network: Tracking and Data Relay Satellites (TDRS)
•F6
•F12
•F13
•F7
•F8
•F10
•F11
Ka-band upgrade
Svalbard, Norway
KSAT, Norway
SSC Kiruna, Sweden
Madrid, Spain
- DAEP Ka-band Upgrade
Sardinia, Italy
White Sands Complex, New Mexico
ASF, Alaska
NOAA, Alaska
North Pole, Alaska
Blossom Point, Maryland
Wallops Island, Virginia
LEGS 1, White Sands
White Sands, New Mexico
Goldstone, California
- Ka-band Upgrade
- Table Mtn, California
- Ka-band Upgrade
Alaska
LEGS 2, Matjiesfontein, South Africa
NSN Station, SSC Hartebeesthoek, Africa
KSAT Singapore
LEGS 3, Australia
Canberra, Australia
DAEP Ka-band Upgrade
Canberra, Australia
SSC Dongara, Australia
Guam Remote Ground Terminal
Ka-band Commercial Upgrade
Punta Arenas, Chile
SSC Hawaii
Hawaii
KSAT TrollSat, Antarctica
McMurdo, Antarctica

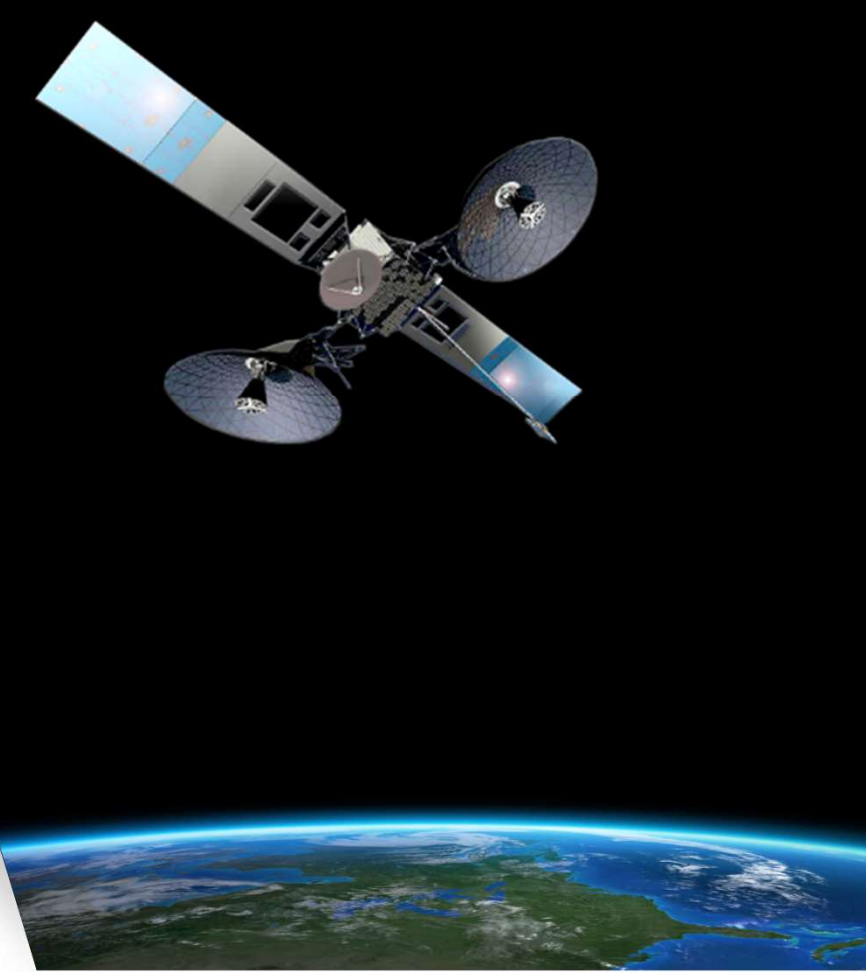
Near Earth Relay: Historical Context

Origins of Tracking and Data Relay Satellite (TDRS) System were with the Shuttle and International Space Station and the driving need for 24x7 coverage

- TDRS system was built up over decades in deployments of three generations of satellites – the first launched in 1983 and the last satellite in 2017
- Capabilities incrementally improved over the generations, but fundamental architecture remained consistent over 40+ years

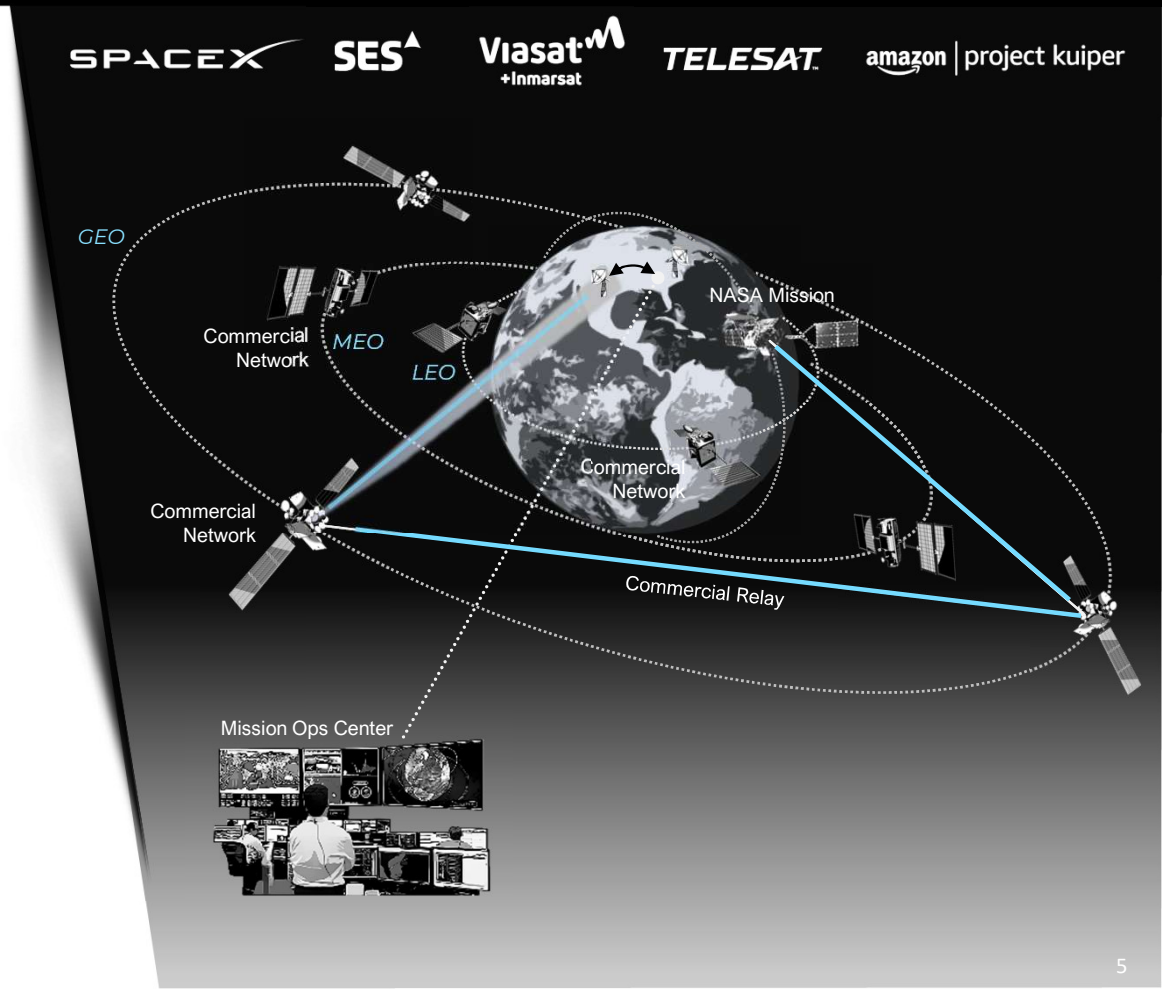
NASA will not be launching additional TDRS

- Options for a subsequent 3rd generation spacecraft (TDRS-N) was rejected by the Office of Management and Budget (OMB) and unsupported in congressional justifications
- OMB consistently communicated for over a decade that NASA should transition away from TDRSS, aligning with National Space Policy



NASA is Pivoting to Commercial Space Relay

- In 2020, SCaN defined a strategy to transition NASA's Low Earth Orbit missions to commercial SR services
  - SCaN will maintain critical space relay capabilities including global coverage for TT&C
  - Commercial SR will provide transformative new capabilities to science missions
  - Communications Services Project (CSP) is targeting operational commercial SR service by 2031



Opportunity

Fly out of TDRS is an opportunity not a set-back; there will be real opportunities for break-through

Legacy Architecture and Services (Switchboard in the Sky)

- NASA owned and contractor operated with high O&M costs
- Substantially limited capacity
- Even “demand access” relies on scheduling and coordination
- Esoteric, bespoke, closed ecosystem
- Complex and costly mission integration

- This legacy paradigm has held back mission network performance, forcing users to use 1980’s vintage networks with significant constraints

Technology and Service Evolution

- Diverse commercial SATCOM-as-a-service offerings with lower costs
- Ability to support 10’s of thousands of users simultaneously
- On-demand capabilities akin to cellular
- Supported by a large industrial base and market
- Capability offerings that increase user autonomy and reduce network reliance

- High-throughput, demand-responsive networks have the potential to unleash new modes of science, and remove long-standing network constraints

Market Context – Supply and Demand Outlook is Positive

SCaN remains focused capitalizing on larger market trends on supply side

- Commercial SATCOM capacity is anticipated to increase ~20x in the next decade
- Global SATCOM market worth USD 77.08 billion in 2022 - expected to grow at a compound annual growth rate (CAGR) of 9.7% from 2023 to 2030
- Entry of first-gen LEO mega-constellations has opened greater business-to-business/ gov./ mobility and consumer markets
- Satellite direct to cellular is accelerating the integration of satellite and terrestrial networks → Non-Terrestrial Networking (NTN)
- NTN = opportunity for NASA to capitalize on a market with a massive number of mobile users with similar interests

Becoming one of many users is achievable; emerging user ecosystem is significant

- Growing remote sensing market will benefit from space relay to capitalize on low latency, high availability, high data rates, and the ability to bring data down to any location
- NOAA Commercial Data Program engaging on satellite data-as-a-service to improve weather forecasts as well as near-real-time insight of space weather
- Government commercial services buys anticipated to drive toward space-based relay solutions exemplified by NRO commercial imagery contracts
- NASA already communicating strategy to international space agencies developing their own human spaceflight programs, such as ISRO

Emerging User ECOSYSTEM

**Representative not all inclusive*

Unlocking next generation technology & services through CSP

- **Commercial Geosynchronous Orbit (GEO) L-band relay network** — inmarsat
- **Optical Low Earth Orbit (LEO) network** — amazon | project kuiper
- **GEO C-band and Medium Earth Orbit (MEO) Ka-band networks** — SES GOVERNMENT SOLUTIONS
- **Optical LEO network** — SPACEX
- **RF relay networks offering C-band and Ka-band services** — TELESAT
- **GEO Ka-band relay network** — Viasat

Communications Services Project (CSP)

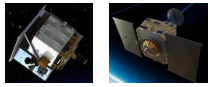
NASA announced on April 20, 2022 that the CSP awarded contracts totaling **$278.5 million** to demonstrate how commercial satellites can support NASA missions.

Six providers are matching / exceeding the awards with own funds. Estimated total investment of **$1.5 billion** over five years.

Vendors are progressing successfully through their agreed to milestones. Demonstrations will continue through mid-2027

CSP's Funded Space Act Agreement Partners: Projected Services

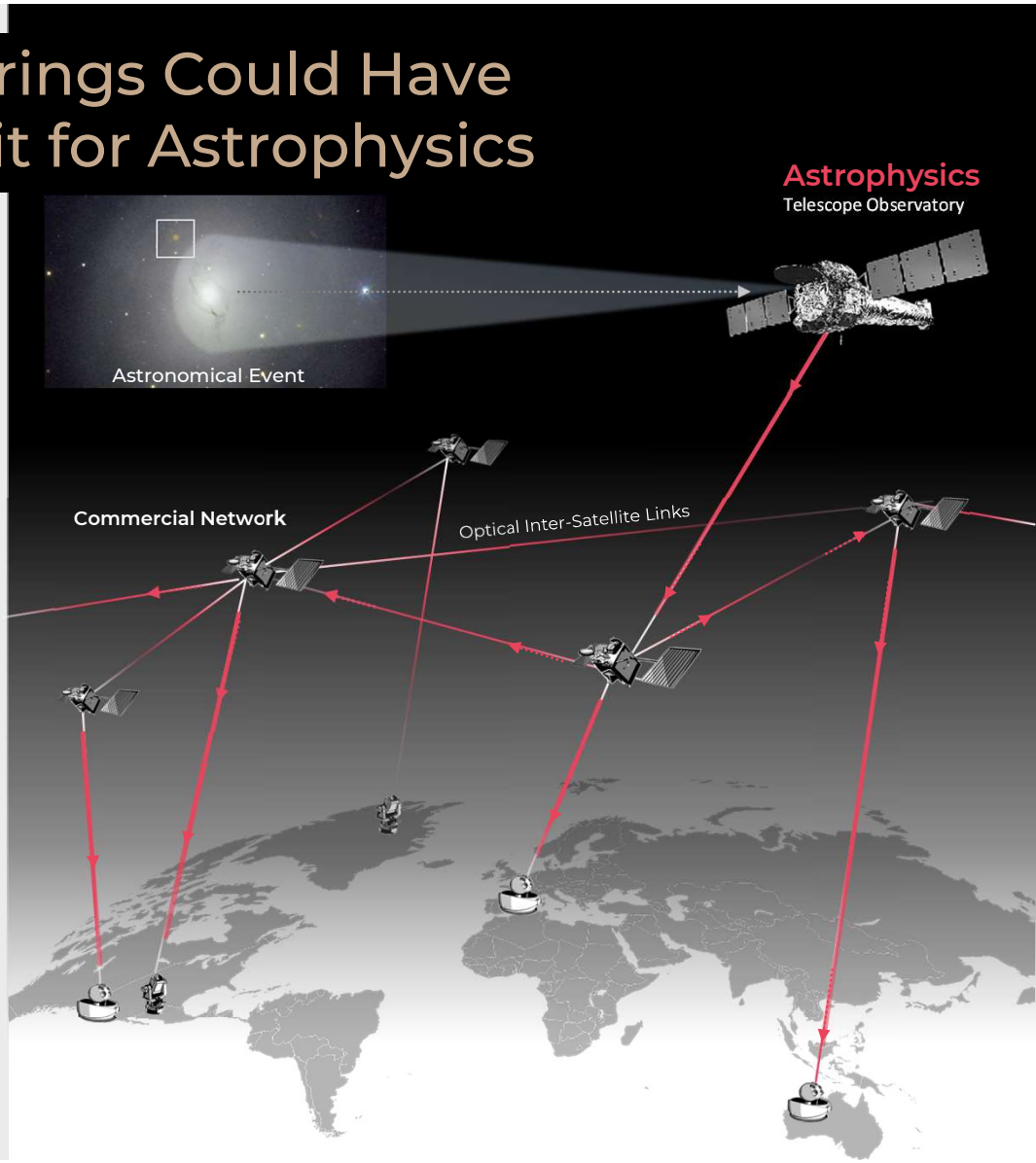
CSP's FSAA partners will demonstrate end-to-end services to meet multiple NASA mission use cases ranging from routine operations to TT&C, launch, and LEOP support. FSAAs are unique based on partner services and proposed milestones

FSAA Partners	Demonstration Architecture	Data Rate [1]	Round Trip Latency (ms) [1]	Mission Partners	Demo target dates
amazon | project kuiper	Optical LEO Network	**100 Gbps**	45	Amazon mission & Blue Canyon 	Q3 FY25 Q1 FY26
SPACEX	Optical LEO Network	**100 Gbps**	30	Commercial Crew* 	Q1 FY26
Viasat +Inmarsat	GEO Ka-band	100 Mbps	550	Maxwell** & Loft Orbital 	Q1 FY26 Q2 FY26
	GEO L-band	200 kbps	2000	Blue Origin & Maxwell** 	Q4 FY25 Q2 FY26
SES	GEO C-band and Ka-band	100 Mbps	150	Planet 	Q4 FY25
TELESAT	Optically linked LEO providing Ka-band relay. GEO C-band.	240 Mbps	50	Planet 	Q1 FY27

1) Estimates based on demonstration architecture. Values are not representative of future service offering performance.

Commercial Offerings Could Have Significant Benefit for Astrophysics

- Science demand for low latency data has grown and is expected to continue
- Always-on, low-latency data return is a significant enabler for individual mission science and coordinated science
- TDRS Demand Access Service was a step toward providing space-users this capability, but was only a partial success – return link only rather than two-way
- Commercial offerings could unlock coordinated science in a whole new way – massive interconnected networks bringing data in near-real-time to multitudes of locations
- For example, this could ensure instant global alerts about a short-lived astronomical event detected by an on-orbit spacecraft, enabling rapid-response tasking of assets worldwide



CSP will Deliver Services by 2031

1 Demonstrations Continue

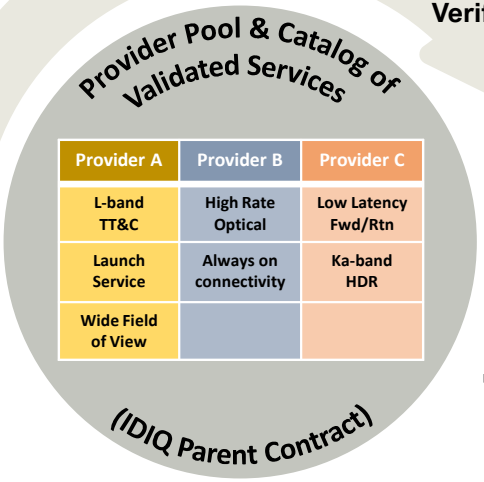
- Flight demos between 2024 - 2027
- Current partners expected to have operational services as early as 2025

2 Requirements Development

- Continue to collaborate with the mission community to finalize Service Requirements
- Identify need for backward compatible services and cost to deliver

3

- Pursue acquisition and prepare for transition



All services are verified & validated before being added to the Catalog and made available to Missions

4 Verification & Validation

- Validate capabilities before transitioning to operations

5 Target: Portfolio of Services

- Managed by the Near Space Network
- Portfolio approach provides diversity
- NASA as one of many users / buyers

Interoperability and Risk Mitigation Through Wideband Terminal Efforts

- Long-term concern for missions about the potential for vendor lock-in and the related risks
  - SCaN is pursuing a two-part solution – promotion of common standards through existing commercial frameworks and interoperable user terminals
  - User terminal solution is targeted at providing a comm payload that is compatible with multiple commercial offerings as well as TDRS
- The Polylingual Experimental Terminal (PExT) is a SCaN-funded, Applied Physics Laboratory-led flight demonstration
  - PExT completed spacecraft integration and environmental testing at York Space Systems
  - Launch planned on Transporter 13 (Feb '25)
  - 6-month flight demonstration will support communication with TDRS, O3b mPower, Inmarsat GX
- The PExT terminal is currently a TRL 7 / flight demonstration effort -- future work required to push the terminal to a real "catalog" available item

Illustration of PExT Terminal installed on York Space Systems bus

Inmarsat Global Xpress
- GEO Constellation
- 28 Steerable Antennas in orbit
- 7 new satellites

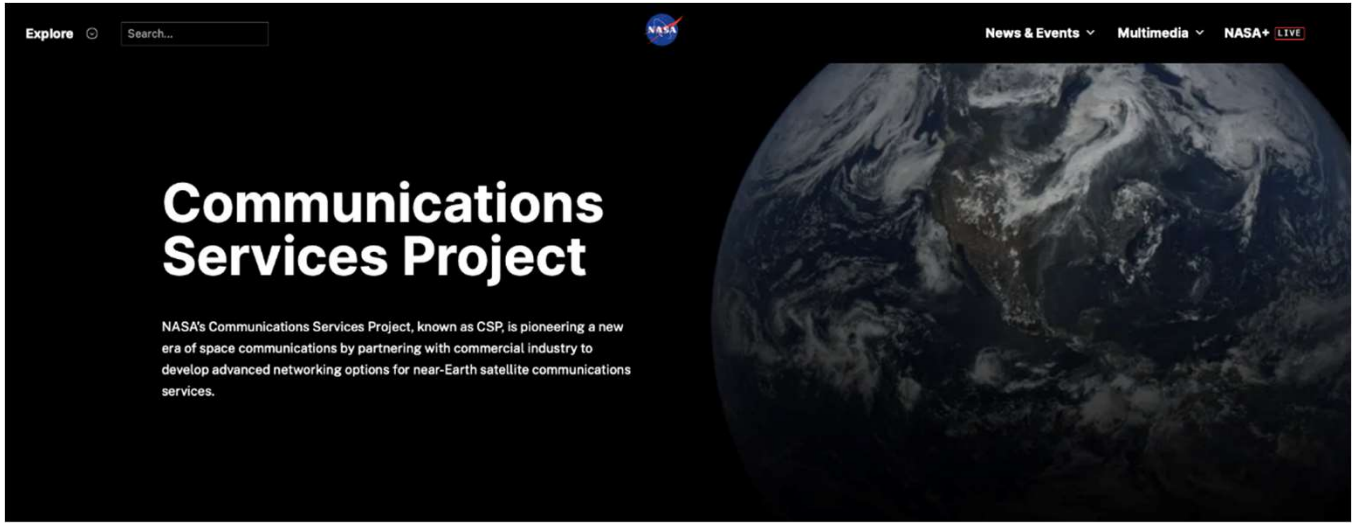
O3b mPOWER
- MEO Constellation
- Thousands of beams per satellite
- 11 satellites

Telesat Blackjack
- LEO Constellation
- 2 steerable antennas per satellite
- 2 satellites in DARPA mission

Summary

- NASA will transition to commercial space relay services and will not be launching additional TDRS.
- Commercial space relay offerings could have significant benefits for astrophysics.
- The Communications Services Project (CSP) is leading the Agency's transition to commercial services.
- CSP's FSAA partners will demonstrate end-to-end services to meet multiple NASA mission use cases over the next few years.
- CSP will deliver operational services by 2031.

Visit the CSP home page on NASA.gov to learn more.



https://www.nasa.gov/communications-services-project/

Want to understand how commercial services can meet your mission needs? Contact the CSP Mission Support Sub-Project.

Want to talk to a CSP FSAA partner? Contact the CSP Capability Development and Demonstration Sub-Project.

Interested in support service requirements development? Contact the CSP Service Infusion Sub-Project team

SCaN

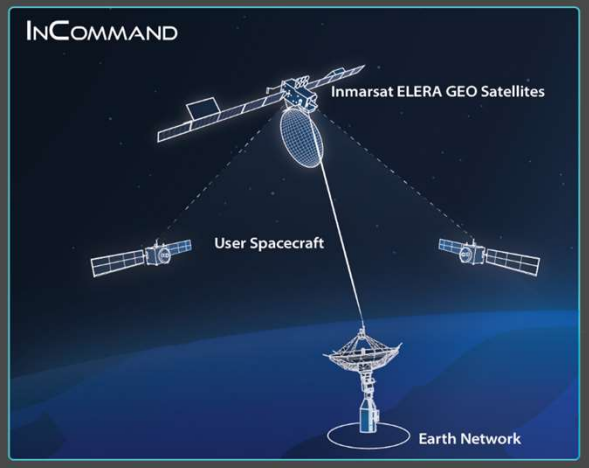
Space Communications and Navigation

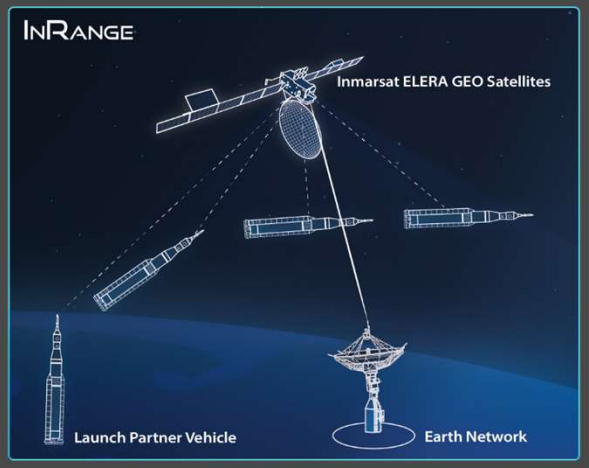
National Aeronautics and Space Administration

Science & Exploration, Enabled.

Legacy Inmarsat

NETWORK ARCHITECTURE





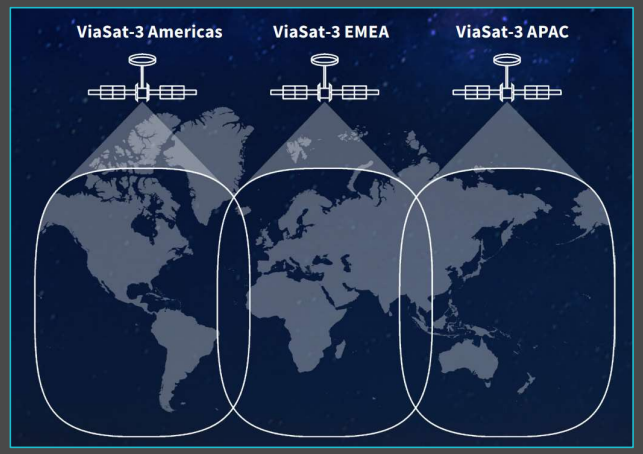
Inmarsat Government will leverage their established ELERA L-band network and satellite constellations to support user satellite communication needs. The revolutionary InRange and InCommand capabilities powered by ELERA is expected to provide critical support for launch and space relay services.

KEY FEATURES

- World-wide L-band network with 99.9% network reliability
- Eliminates dependency on ground infrastructure
- Continuous near real-time telemetry
- Rapidly deployable using existing space and ground infrastructure
- Decreased “black-out” communications phases post launch

Viasat

NETWORK ARCHITECTURE



The ViaSat-3 constellation is Viasat's next generation of ultra-high-capacity, Ka-band satellites in GEO. Viasat-3 will offer enhanced global coverage, network capacity. The first satellite of the global ViaSat-3 constellation was successfully launched from NASA's Kennedy Space Center in Florida in 2023.

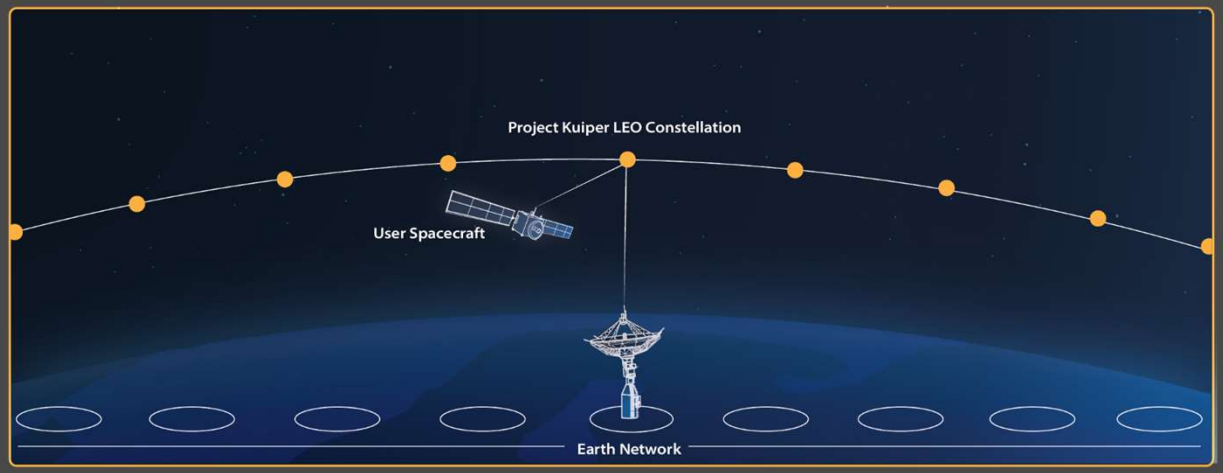
For space-users, the constellation is designed to significantly reduce the time it takes to transmit data from satellites by extending the real-time Earth network into space. This will enable space relays between satellites in different orbits and allow Earth-observation satellites and others to download their data more quickly.

KEY FEATURES

- Ka-band operations
- Each ViaSat-3 satellite is planned to have the ability to deliver download speeds of up to 100+ Mbps and 1 Terabit of throughput data per second
- Near-global coverage
- Dynamic bandwidth allocation to move capacity where and when needed

Project Kuiper

NETWORK ARCHITECTURE



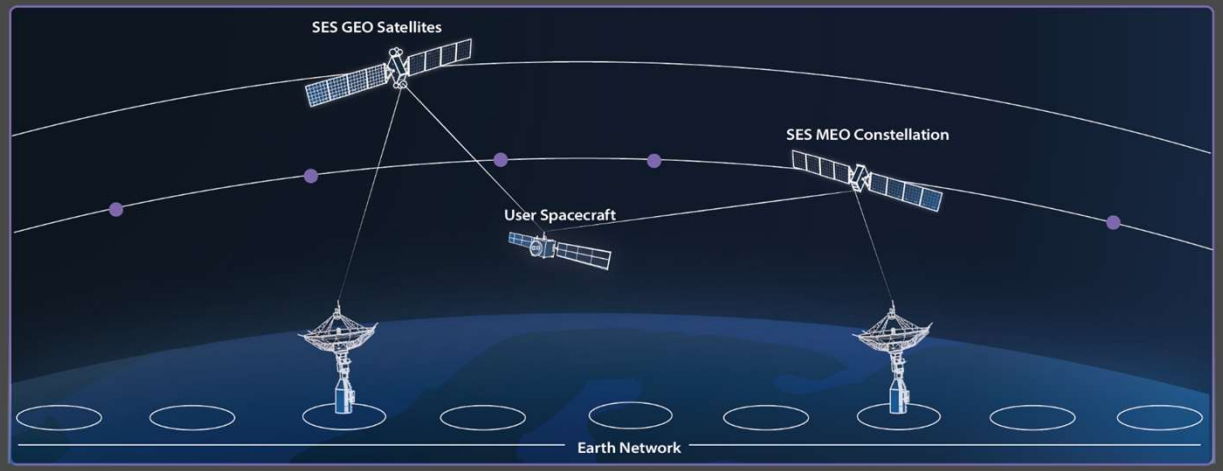
A constellation of more than 3,000 satellites deployed in LEO and equipped with optical terminals and advanced antennas will link to a secure, ground-based communications network to deliver resilient, low-latency communications to users on Earth and in space.

KEY FEATURES

- High-speed, low-latency optical services
- Resilient on-orbit optical mesh networking
- End-to-end encryption for customers
- Secure, global ground network
- Improved performance over traditional C- and Ku-bands

SES

NETWORK ARCHITECTURE



SES' multi-orbit, multi-band offering will support routine missions, contingency operations, launch and ascent, and early operations phase communications across multiple bandwidths for spacecraft in low-Earth orbit.

KEY FEATURES

- Multi-band, multi-orbit satellite services
- Proven non-geostationary orbit (NGSO) innovative technology
- 5000 customer beams per O3b mPOWER satellite
- Designed to meet stringent cybersecurity requirements
- High throughput – up to 100 Mbps per LEO spacecraft

SpaceX

NETWORK ARCHITECTURE

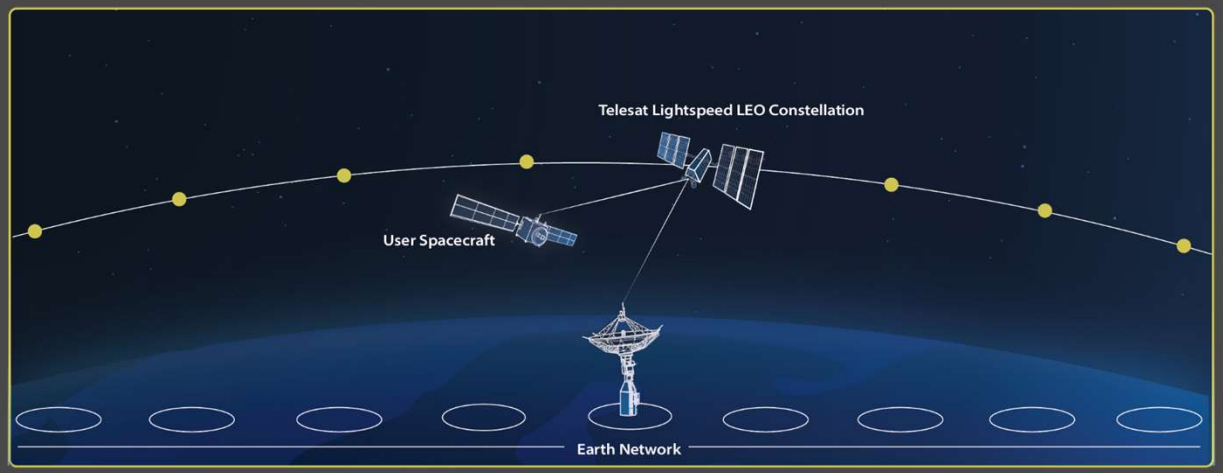
SpaceX will leverage the powerful mesh network of their established Starlink satellite constellation and leading-edge laser communications technology to provide data relay services for a variety of missions.

KEY FEATURES

- Reputable Starlink LEO constellation with proven reliability
- Enabled through leading-edge laser communication technology
- Mesh communications network constructed of optic intersatellite links
- Always-on capability with no prioritization or de-confliction required enabled by autonomous scheduling and data routing
- Bidirectional communication from and to anywhere in less than 100ms

Telesat

NETWORK ARCHITECTURE



Telesat will harness the power of their advanced Telesat Lightspeed network to demonstrate connectivity, tasking and command, telemetry, and mission data flow services to users in LEO.

KEY FEATURES

- Optically linked LEO satellites
- RF space-to space relay capabilities
- Inter-satellite latency on par with fiber networking
- High throughput providing enterprise-class connectivity
- Advanced digital beam-forming technology for dynamic capacity allocation