

NASA'S EFFORTS TO PURSUE COMMERCIAL COMMUNICATIONS SERVICES FOR MISSIONS IN NEAR SPACE

Gregory W. Heckler

National Aeronautics and Space Administration, 300 E Street NW, Washington D.C. 20546,
(202) 358-1626, gregory.w.heckler@nasa.gov

Marie T. Piasecki

National Aeronautics and Space Administration - Glenn Research Center, 21000 Brookpark Rd,
Cleveland, OH 44135, (216) 433-6427, marie.t.piasecki@nasa.gov

Neal F. Barthelme

National Aeronautics and Space Administration - Goddard Space Flight Center, 8800 Greenbelt
Rd, Greenbelt, MD 20771, (301) 286-5973, neal.f.barthelme@nasa.gov

Peter J. Schemmel

National Aeronautics and Space Administration - Glenn Research Center, 21000 Brookpark Rd,
Cleveland, OH 44135, (216) 433-6677, peter.j.schemmel@nasa.gov

Erica L. Weir

Teltrium, 6406 Ivy Lane, Suite 210, Greenbelt, MD 20770, (720) 318-7296, eweir@teltrium.com

Allison C. McCarthy

Teltrium, 6406 Ivy Lane, Suite 210, Greenbelt, MD 20770, (301) 232-6903,
amccarthy@teltrium.com

Jeffrey C. Dobereiner

Teltrium, 6406 Ivy Lane, Suite 210, Greenbelt, MD 20770, (202) 630-4443,
jdobereiner@teltrium.com

Abstract

The National Aeronautics and Space Administration (NASA) Space Communications and Navigation (SCaN) Program enables high speed, robust, secure, and cost-effective space communications and navigation services to current and future science and exploration missions. Consistent with National Space Policy, NASA is seeking commercial services for all its future near-Earth requirements by incorporating additional direct to Earth (DTE) providers and introducing commercial satellite relay communications (SATCOM) vendors as NASA's Tracking and Data Relay Satellites (TDRS) begin to decline. Through the progression of these efforts, SCaN is also integrating commercial services in the cislunar domain. The overarching objective is to satisfy the demands from the mission community – both in terms of capacity and capability – in a robust, reliable, and cost-effective way, leveraging the strong and growing commercial space sector.

For near earth space relay, six SATCOM vendors were awarded Funded Space Act Agreements in June of 2022 to demonstrate the ability to serve near-Earth missions with space-based communication relay services. All six vendors are working through their committed milestones with end-to-end service demonstrations taking place throughout the mid-2020's. The failure of TDRS Flight-9 (F9) in late 2022 prompted an increased tempo of mission engagement to identify driving user needs that commercial SATCOM can meet in the near-term. NASA has set a course to accelerate a decision to terminate offering TDRS services to new missions and is developing a plan to execute validation and risk reduction efforts with early adopter "pathfinder" missions, paving the way to operational services.

As the Artemis Program matures and builds on the successful Artemis I flight in November-December of 2022, the definition of the supporting communications and navigation architecture has further been refined. Although NASA government assets will continue to play a key role in provision of services, such as through the Deep Space Network, SCaN is pursuing commercial services offerings to expand ground network capability and implement lunar relay services. In February of 2023, SCaN released solicitation for services that include DTE services to missions near-Earth and in cislunar space, as well as lunar relay services. Further, SCaN is seeking opportunities to integrate commercial capability into lunar surface communications infrastructure. NASA is also advocating for standards that promote interoperability and strategic technology investments in the commercial sector.

This paper addresses the recent progress and future plans in the near-Earth space and lunar regimes, discusses the unified approach for industry engagement, and highlights both the common and unique challenges of commercialization efforts in the two regimes.

1. Introduction

NASA's Space Communications and Navigation Program provides essential communication and tracking services to the entire NASA mission family, from CubeSats to Curiosity. Until 1997, these services were delivered exclusively through government assets. Since that time, and enabled in part by a rapidly growing space economy, SCA_N has increasingly sought robust, reliable, and cost-effective commercial solutions for service provisioning in near Earth space. Now, outside vendors and partners provide ~60% of NASA's near-Earth DTE services, and commercial SATCOM is poised to supplant the use of the Tracking and Data Relay Satellite System (TDRSS) for future in-space relay needs, igniting key conversations about the role of interoperability standards in the near Earth domain.

As with pre-1997 near Earth space, all cislunar communication services are currently provided by government assets like Deep Space Network (DSN) and international partner facilities. These services already face excess demand, and the high throughput requirements for the Artemis Program are increasing this capacity deficit. There is an urgent need for updated communications and navigation capabilities for the moon. The Moon to Mars (M2M) campaign, and U.S. National Space Policy, urge the creation of an interoperable communications and navigation network and the integration of commercial service providers and partners.

This paper explores how SCA_N is applying decades of lessons learned from work with commercial providers in the near-Earth domain to better fulfil user demands in cislunar space. Lunar infrastructure requirements for DTE, in space-relay, and interoperability echo SCA_N's ongoing work to address these needs with private vendors in near Earth space. Furthermore, broader practices of contracting, industry engagement, and risk management employed in near Earth space by NASA's Near Space Network (NSN), Communication Services Project (CSP) and Commercialization, Innovation, and Synergies (CIS) Office, and first pioneered by Commercial Orbital Transportation Services (COTS), offer key frameworks for work with commercial partners at the moon. It is in this context that SCA_N is expanding commercial communication services to cislunar space and beyond.

2. Objectives for Commercial Communications Services and Current Status

In the near-Earth domain, SCA_N has two primary goals: (1) to shift the proportion of commercial direct-to-Earth (e.g., ground station) services from current levels to near 100% in the near term; (2) to transition all new missions requiring the high availability of space-based data relay to commercial SATCOM as soon as is viable.

2.1 Near Earth DTE Services

NASA has a long history of using commercial DTE services, beginning in 1997, when NASA invested in the SG1 antenna in Svalbard, which was then commercially operated. As of 2012, all services from the two current partners, Kongsberg Satellite Services (KSAT) and Swedish Space Corporation (SSC), were provisioned with commercially owned and operated assets. In 2022, services provided by KSAT, SSC, and university partners, represented approximately 60% of the minutes provisioned to NASA missions. In an effort to further increase the proportion of commercial services, the NSN released a Request for Proposal in February of 2023 [1]. Proposals have been received and are under evaluation. Current missions relying on government ground assets will be transitioned to alternate commercial sites and services, and new missions will be directed to the array of commercial services offered through the new contract.

2.2 Near Earth Space-based Relay Services

For operational flight missions, the ability to transition to use of alternate ground stations may take effort, but it is not insurmountable given that accommodations can be made on the ground-terminal side to ensure compatibility with the mission. This is not the case for space-based relay, which is why current missions using the TDRS will fly out using that system, and instead SCA_N is targeting new missions – currently in their planning phases – to adopt a commercial approach. Although the commercial SATCOM industry is robust, the user base is largely terrestrial, aeronautical, or maritime. Some examples of servicing other space users have occurred, one example being the use of AddValue's Intersatellite Data Relay Service (IDRS) by Capella Space to enable quick tasking of their synthetic aperture radar satellites [2]. However, the use of space-to-space relay is not yet prevalent, and a robust array of service

options is not yet available. For this reason, SCA_N formulated the CSP to pursue Funded Space Act Agreements (FSAA) with a variety of partners to validate commercial SATCOM ability to meet the NASA space data relay use case.

In June of 2022, CSP awarded six FSAA's with Inmarsat Government Inc., Kuiper Government Solutions (KGS) LLC, SES Government Solutions, Space Exploration Technologies, Telesat U.S. Services LLC, and Viasat Incorporated. These six vendors, summarized in Figure 1, will receive a combined \$278.5 million with a total combined (NASA-commercial) investment amount of more than \$1.5B to complete technology development and in-space demonstrations over the next several years [3]. All six vendors are working through their committed milestones with end-to-end service demonstrations tacking place throughout the mid-2020's.

The failure of the TDRS-9 spacecraft in late 2022 and subsequent retirement in early 2023 (10 years earlier than anticipated) has only increased the pressure to ensure the CSP demonstrations and subsequent validation with NASA missions is successful. SCA_N is actively evaluating the health of the constellation, the ability to meet mission needs, and the projected timeframe in which the commercial solutions will be operational, in order to define at the Agency-level, when new missions in formulation will no longer be allowed to plan for TDRS services.

2.3 Cislunar Services

Recently the Agency unveiled a set of 63 objectives in the M2M campaign [4]. Several of those objectives highlight the critical need for both communications and navigation infrastructure at the moon, to enable cislunar science and exploration on a sustained level. Recurring tenets for M2M include the importance of interoperability, international partnerships, and commercial partnerships. Based on this guidance, as well as the desire and ability to apply lessons from the LEO domain to the Moon, SCA_N is pursuing commercial services and capabilities for multiple aspects of the lunar infrastructure, as highlighted in Figure 2.

The first is for additional Earth ground station services. Artemis represents a significant demand on the networks, particularly the DSN, which is already challenged to meet deep space user demand Figure 3. Although some of the Artemis elements, such as the Orion crew vehicle, will continue to rely on the DSN, other elements like the Gateway orbital outpost may be offloaded on to new / supplementary ground stations. Although NASA is developing a subset of these stations, dubbed LEGS—Lunar Exploration Ground Sites—commercial services are being pursued to extend the capacity and geographic diversity of the initial government-led stations. Lunar capable ground segment services were included in the previously mentioned NSN Services RFP and are anticipated to be awarded in October 2023. Building on lessons learned in near Earth space, in particular emergent challenges of S-band spectrum congestion, the RFP requires commercial service providers to use a multi-band approach. Offering S, X and Ka bands services from the start will provide mission flexibility, accelerate the use of relatively less constrained Ka band frequencies, support alignment with lunar spectrum management guidance, and help reduce future spectrum conflicts and constraints.

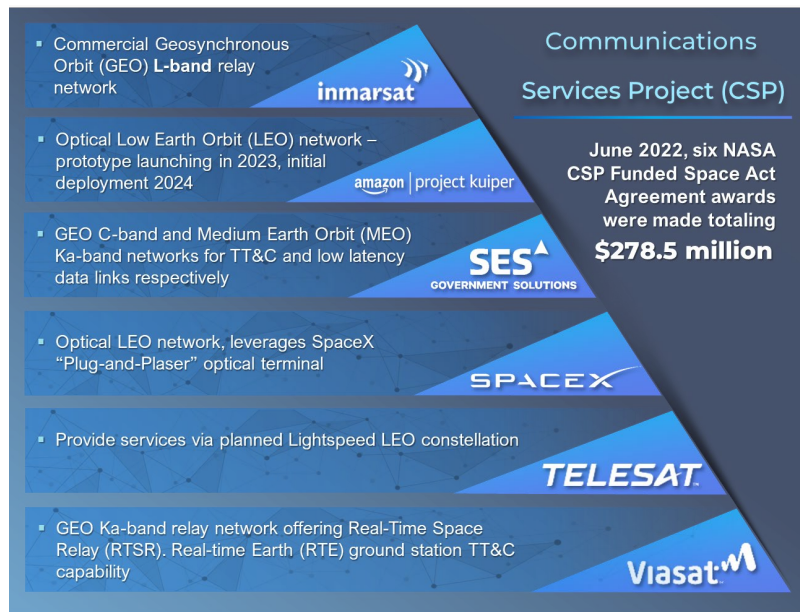


Figure 1. NASA Communications Services Project's Six Funded Space Act Agreement Awardees

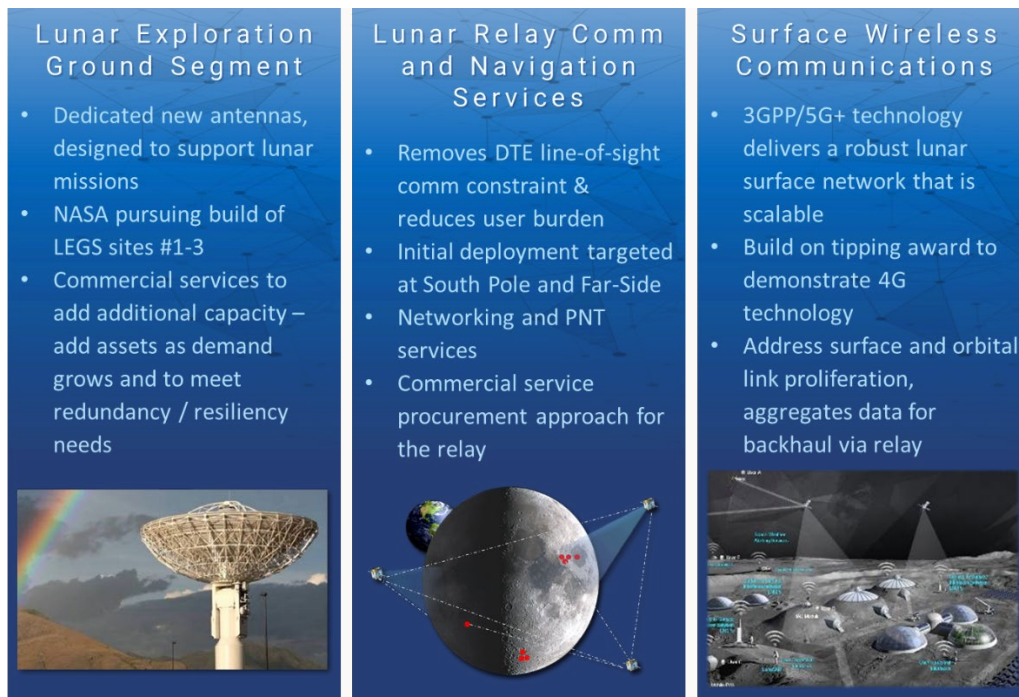


Figure 2. Key communications and navigation capability areas targeted for commercial services in cislunar space: ground networks, lunar relay, and surface communications.

The second, also included in the same RFP, is lunar relay services. The Artemis Program has identified challenging exploration goals, including visits to the Lunar south pole and global exploration capability, which limits or eliminates the option for DTE communications at times, necessitating the use of an orbital relay to maintain critical connectivity with Earth—particularly for crew.

The third is on the lunar surface in support of communications between an increasingly complex array of assets. Surface-to-surface communications are integral for sustained presence; it enables autonomy, reduces latency and practically speaking, routing all communications through Earth is both infeasible and undesirable. A tipping point demonstration was awarded to Nokia in 2020 to demonstrate 4G (4th generation) commercial cellular technology for point-to-point communications that include vital command and control functions, remote control of lunar rovers, real-time navigation and streaming of high-definition video, enabling voice and video communications capabilities, telemetry and biometric data exchange, and deployment and control of robotic and sensor payloads. This effort is the first step towards a more robust architectural solution. SCaN and its partners in the M2M Program are actively studying the alternatives and implementation opportunities for 5G (5th generation) and beyond capabilities at the moon, with the objective of leveraging commercial industry technology and standards to promote an interoperable set of services.

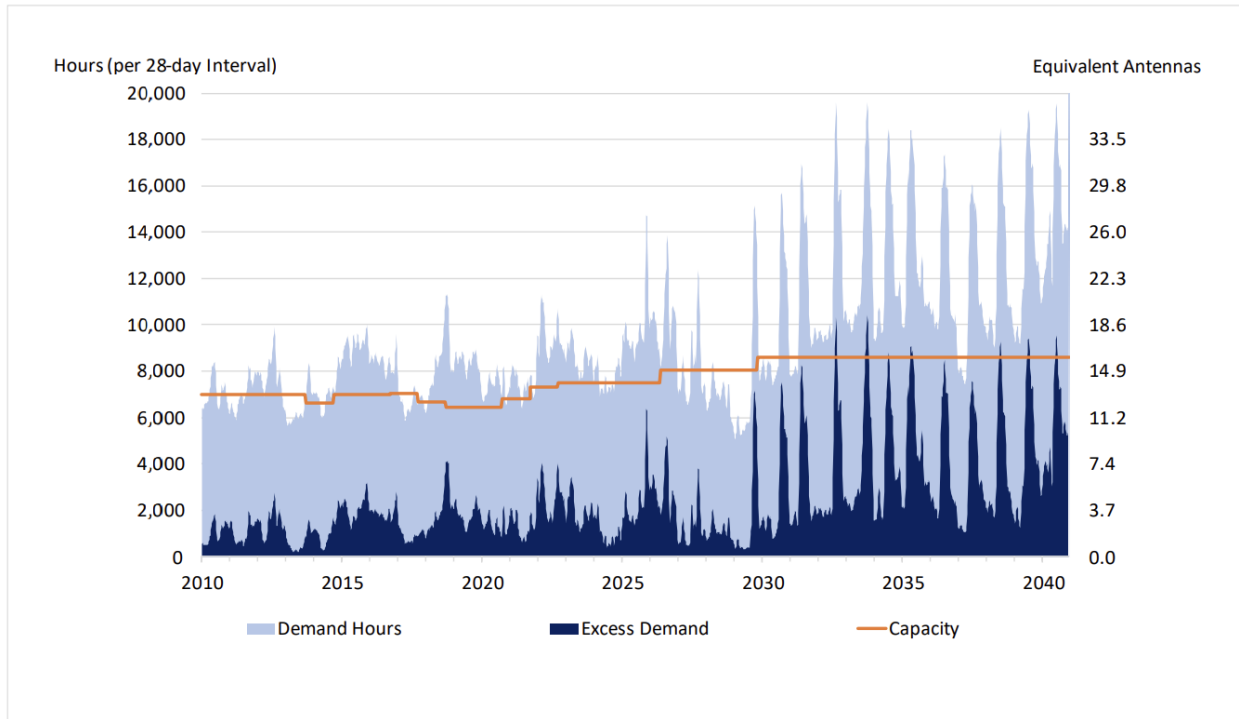


Figure 3. Projected Growth in DSN Demand: Downlink Antenna Hours per 28-day periods from the full array of users projected into the 2030's – including non-lunar science, lunar science, and Artemis program vehicles. Source: NASA Office of the Inspector General, 7/12/23 [5]

3. Mechanisms for Meeting Objectives and Challenges

The objectives described above are ambitious—spanning domains that are “old” and well established like Earth ground services, as well as “newer” —like space relay at the Moon. NASA and SCA/N are managing the efforts to meet these objectives in a holistic way, with a focus on a sustainable long-term partnership with industry and the development of robust architectures that are resilient and effective for NASA’s mission. This manifests in three key dimensions: (1) a deliberate and consistent method of industry engagement, (2) promoting service interoperability, and (3) appropriately managing risk and uncertainty.

3.1 Industry Engagement

At the core of promoting and fostering commercial services in both the near Earth and cislunar domains, is a sustained approach to keeping abreast of industry capability and shifts in technology. This necessitates engaging directly and routinely with all varieties of businesses in a two-way dialogue, to both communicate NASA’s interests and needs, as well as capture, understand, and integrate industry capabilities into government systems. Fundamentally, NASA must keep up with the disruptive innovation that has been and will continue to occur throughout the space community.

To facilitate this engagement, SCA/N formed the Commercial Innovation and Synergies (CIS) Office at Goddard Space Flight Center. The CIS charter underscores the importance of identifying key opportunities, nurturing diverse relationships, and implementing collaborative solutions to enhance capabilities and technologies in support of exploration and space communications. Through a series of engagement initiatives, CIS forms synergistic relationships and accelerates infusion opportunities by leveraging private industry, other government agencies, and international partners.

The CIS team has established multiple avenues for promoting industry interaction and dialogue including:

- Uplink sessions: One-on-one opportunities for interested partners to meet with NASA on a select topic to communicate capability and have a dialogue, often related to other, more formal, requests for information.
- OneLink sessions These open forums with industry are an opportunity for the NASA team to communicate plans, status, and interests to a wide audience. Sessions have been held on a variety of topics, including but

not limited to, lunar interoperability standards, 3GPP/5G Lunar Surface Networking, and Delay Tolerant Networking Capabilities.

- CIS Launch Pad: An innovative series highlighting industry on a weekly basis. Every Friday, CIS hosts a company on a first come-first-serve basis to discuss high-level overviews of their capabilities and mission. Companies present on a number of topics that reflect current SCA-N priorities.

CIS has also facilitated use of Broad Agency Announcements to fund industry to study key areas of interest. The CIS team released Next Space Technologies for Exploration Partnerships-2 (NextSTEP-2) Omnibus Broad Agency Announcement (BAA) Appendix O in March 2022. This initial industry led capability study solicited industry input in the areas of: (1) RF compatibility testing that will lead to efficiencies of NSN RF architectures; (2) integration of optical communications ground terminals into the NSN architecture; and (3) implementation of software defined radios and cloud computing assets into the NSN architecture. A second round of study topics was released in July 2023 covering exciting new topics focused on (1) wideband communications, (2) phased array, and (3) constellation crosslink topology with awards anticipated in September 2023. The BAA structure is designed to support the flexible addition of future study areas as SCA-N and the NSN identify future needs.

Early Requests for Information (RFIs) are another avenue CIS executes for understanding the capabilities and interests of industry. RFIs in combination with BAA study awards made by Glenn Research Center helped form the basis of the decision to pursue SATCOM demonstrations via the CSP Project for example. Similarly, multiple RFIs were leveraged to determine the market viability for DTE and relay communications services for cislunar missions and shape the NSN Services RFP. CIS released RFIs to solicit industry feedback and interest in collaborative opportunities such as tracking Artemis-I and working with NASA on Goddard's Low-Cost Optical Terminal (LCOT). The RFI on Artemis-I One-Way Doppler Tracking received responses from twenty (20) participants (10 US entities and 10 Non-US Entities) of which 10 provided tracking data. The responses received provided evidence that SCA-N can effectively leverage the emerging commercial DTE market for human spaceflight needs and objectives, and will serve as the basis for a revised RFI for doppler tracking of Artemis II. In response to the LCOT RFI, the CIS Office received eight (8) complete responses from industry.

All these methods, bolstered by the dedicated team that facilitate and execute them, are essential to keeping NASA in lockstep with industry and the future of our national space enterprise. SCA-N will continue to build on these established processes moving forward and further explore NASA's ever-changing relationship with the commercial community.

3.2 Promoting Interoperability

Interoperability is, in part, the ability to exchange and understand information between entities [6]. In our day to day lives, interoperability manifests in ways we don't often consider because of its very nature – seamless and transparent – such as cellular roaming. In the civil space community, NASA and its partners have promoted interoperability between space services primarily to allow for cross-support of missions between networks and the associated safety, robustness, and resiliency it affords all parties. This interest continues to be maintained and promoted, evidenced in NASA's M2M objective to “enable interoperability and commonality (technical, operations and process standards) among systems, elements, and crews throughout the campaign.” The drive to create space infrastructure with the flexibility to incorporate multiple providers is not unique to NASA—the DoD is planning a hybrid space architecture which is designed to address some of the same challenges.

In the near-Earth domain, NASA is operating in an environment in which we want to capitalize on existing and evolving infrastructure driven by commercial industry and the standards and processes established by the private sector. Historically, interoperability within the civil community has been achieved by leveraging Consultative Committee for Space Data Systems (CCSDS) standards. To fully make the leap to a commercial services paradigm however, NASA understands it needs to work within the commercial construct. There is an opportunity to lead and advocate for a common set of commercial standards that promote interoperability over the long term, leveraging existing frameworks such as the 3rd Generation Partnership Project (3GPP)—an umbrella organization known for the development and maintenance of mobile telecommunications standards. NASA joined 3GPP as a provisional (observer) participant in 2020 but transitioned to being an official member organization in 2021.

3GPP's July 2023 release of an integration plan for 5G Non-Terrestrial Networking (NTN) is an important first step in addressing the needs of the space user community. The broader process of building consensus around uniform interoperability standards, including for space-based relay, will take time. Until a uniform standard emerges, the varied spectrum assignments and waveforms used by different providers will impede NASA's planned transition to commercial relay. To bridge this gap, SCA-N is developing a capability that enables the use of diverse commercial and government assets by a single user: wideband, multilingual, user terminals. These terminals support operation across

a range of Ka-band spectrum assignments (a wideband capability), and proprietary protocols and waveforms (a multilingual capability). By enabling a user to switch between network service providers once on orbit, wideband multilingual terminals mitigate the risk of vendor lock-in and allow users to take advantage of new service offerings as they become available.

Building on successful ground tests completed in 2021, NASA is working with the Johns Hopkins Applied Physics Lab (APL) to launch a multi-lingual wideband terminal demonstration mission in Q2 2024 called the Polylingual Experimental Terminal (PEXT). PEXT will execute real-time, on-orbit roaming across constellations with different orbits, coverage areas, and latencies: TDRSS' heritage KaSA service and Inmarsat Global Xpress in GEO, O3b mPOWER in MEO, and Telesat Blackjack in LEO, as depicted in Figure 4. These flight tests will provide end-to-end operational data at a range of symbol rates, link performance parameters, and mission scenarios, laying the groundwork for future near Earth science missions to confidently utilize SATCOM services in lieu of relying solely on TDRSS.

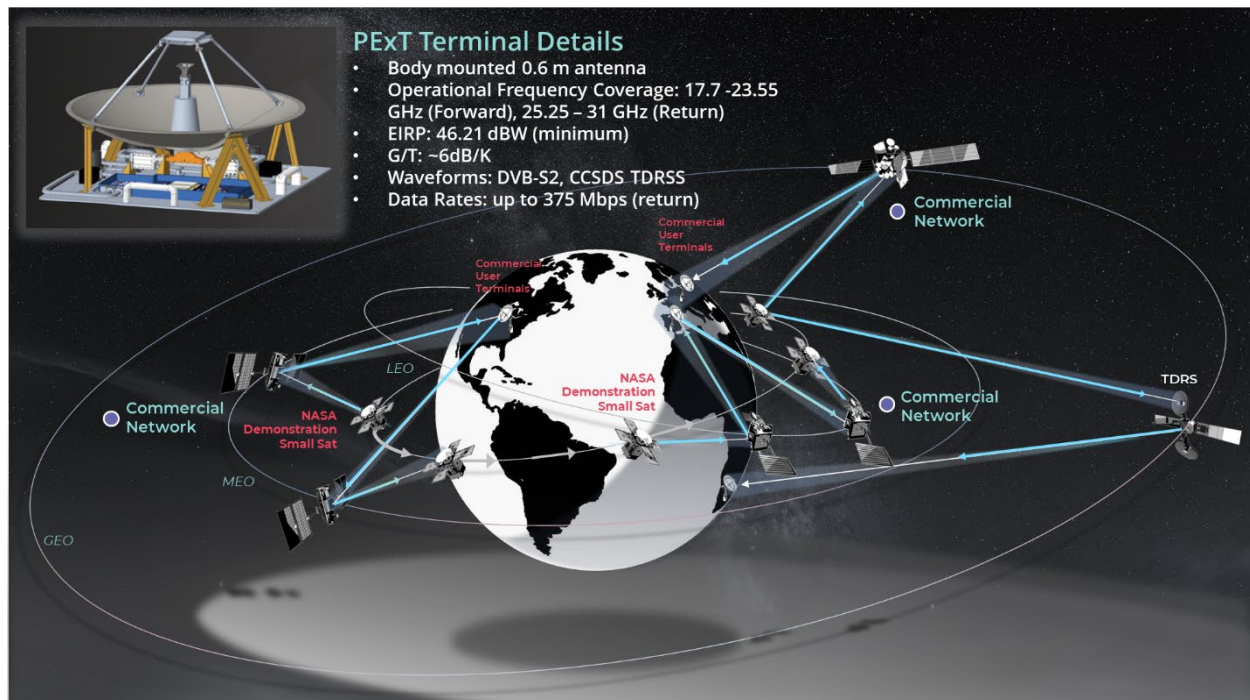


Figure 4. The Polylingual Experimental Terminal is a key element in the strategy to ensure interoperability and robust communication services availability for the mission community.

While proprietary networks and multilingual wideband terminals may have a role in the initial use of commercial SATCOM in cislunar space, the community here has both the advantage and the challenge of a “green field” – there is no existing lunar communications infrastructure. This positions NASA and the space community to build guidelines that require interoperability from the start. NASA is advocating for the concept of LunaNet, a set of cooperating networks providing communications, navigation, and other services for users on and around the moon, based on a framework of mutually agreed-upon standards, protocols, and interface specifications that enable interoperability. This vision for a multi-node interoperable network will integrate all services under a single standard developed in collaboration with the European Space Agency (ESA), and industry—the LunaNet Interoperability Specification (LNIS), which provides the basis for a comprehensive set of specifications of a lunar communications and navigation network capable of interoperating with other networks.

The LNIS defines interface standards for LunaNet services such that users may design their systems with the expectation of available providers. Draft Version 5 is focused primarily on ensuring interoperable services between NASA’s commercial-vendor supported lunar relay capability and ESA’s commercially-procured Moonlight relay services [7]. Future development of the LNIS is anticipated to be more expansive in technical reach, in domains such as node types, and in contributing partners like commercial vendors. Ultimately, the vision is for government stakeholders to reduce their role in LNIS, and for lunar communications interoperability—on the surface, in lunar orbit, and beyond—to be led by commercial providers.

3.3 Managing Risk and Uncertainty

A significant portion of the NASA community—both mission users and network operators—are used to, and have come to expect the status quo, which is fundamentally a very government (or government contractor) heavy presence in communications and tracking service provision. As more commercial services are integrated, there is a sense of uncertainty and a risk. Although NASA/SCaN has facilitated commercial DTE services for LEO missions for decades, the more pervasive use of commercial services that is planned (Earth relay, Lunar relay, Lunar DTE) is new to both the mission community, and in some cases the vendor base. The risk should be managed in both near Earth and the cislunar domain, but the context and approaches differ somewhat.

In the near-Earth domain, NASA is striving to be one of many buyers. For DTE services, this is already the case. For space relay, this goal appears attainable if NASA steers clear of over-specifying requirements and being open to new methods of service delivery and doing business. There is a myriad of other buyers for space relay services, that collectively dwarf NASA in both number of users (spacecraft) needing service, and budget. Although there are legitimate technical details to work through, there is a robust mix of well-established vendors with heritage, new vendors with innovative ideas, and decades of space communications hardware and software development heritage to leverage. The risk to NASA missions is less “is it possible?” but more “will it work for me?” The CSP demonstrations are the first significant contributions to mitigating this risk. Several of the vendors are demonstrating with surrogate spacecraft of their own, or partnering with other companies to provide the user spacecraft side of the demonstration.

For example, SES and Telesat are partnering with Planet (Planet Labs PBC). Telesat will work to build space-based radio frequency (RF) terminals that will be hosted on two Earth observation spacecraft. Once these satellites are in orbit, Telesat will demonstrate Ka-band, high throughput transmission from the terminals to Telesat operated satellites flying at a higher altitude, as well as mesh, space relay connectivity between the optically linked Low-Earth Orbit (LEO) satellites before downlinking data to representative NASA operation centers. On the SES subcontract, Planet will work with SES for a low-latency connectivity solution between SES’s Geostationary Orbit (GEO) satellites and Medium-Earth Orbit (MEO) satellites [8]. However, a subsequent step will be required to validate services with one or more NASA missions to further boost confidence.

For NASA and other U.S. government agencies, a key risk in the transition from government to commercial communication assets is security. To help address this, NASA SCaN built upon a process established by the United States Space Force (USSF) and used by the Space Force Commercial Satellite Communications Office. The process is facilitated by tool to target critical security requirements: a Commercial Security Architecture Questionnaire (CASQ) for vendors. The CASQ is included as an addendum for RFP solicitations and used as part of the overall evaluation criteria. It seeks key data such as cryptographic standards, radio interference resolution capabilities, and personnel security training. Strong CASQ responses from a vendor may be written back into the Statement of Work (SOW) when selections are made, whereas weak responses provide opportunities for feedback. The CASQ enables the evaluation of security challenges without creating prescriptive requirements that increase costs while stifling commercial innovation.

Oftentimes discussion of commercial space data transport services focuses on the technical dimension, or more explicitly the physical and network layers of the service. However, NASA is also challenged with determining how to integrate and manage a much larger portfolio of vendors and services. It is easy to assume familiar ways of operating, with NASA as a central lynchpin in the orchestration of services. Anticipating more disruptive innovation from industry, it is incumbent on NASA to make the appropriate trades and eventual decisions about network operation and associated business process architectures that do not put the Agency in a position to be a barrier in taking advantage of those innovations and benefits to the mission users. The CSP team is leading the critical analyses of alternatives on this very topic. The outcomes will flow into the same Agency-level decision point noted earlier regarding the termination of new commitments to provide TDRS services. The recommendations regarding how NASA should do business in the future, in combination with the technical results of the CSP demonstrations, will also be critical input to shape the future procurement of operationally ready space-based relay services (which are also being purchased by other buyers).

Cislunar space is a bit different. NASA, other U.S. Government agencies, and international space agencies, will be the anchor tenants for these services for the near future, as the commercial lunar economy is in its infancy. The only vendor assets that can currently provide cislunar communication services are a small number of large, Earth-based antennas. With that said, McKinsey & Company estimates that more than one tenth of private space economy investment is now targeting “lunar and beyond”—including communication services [9]. For example, in March 2023, Lockheed Martin stood up their Crescent Space subsidiary to provide communications and PNT “infrastructure-as-a-service for lunar missions.” [10] After going public in late 2022, Intuitive Machines announced new investments in developing “lunar data services” based on their own, private, satellite and ground station networks [11]. These are just

two among several firms that have highlighted lunar relay, DTE, and communication services as potential areas for growth. Teams receiving awards under the Commercial Lunar Payload Services (CLPS) Program have also proposed inclusive relay capability to support their far-side landed assets [12].

Despite this burgeoning interest, there is significant risk in relying on commercial vendors for cislunar space when compared to the high demand, near Earth environment. NASA is managing this risk by using a phasing approach to validation that will support industry efforts to build-up, deploy and operate services at the moon. Unlike CSP's approach to near Earth commercial SATCOM, this phasing strategy allows NASA cislunar mission users to be provisionally supported by vendor assets during validation, accelerating access. It also offers commercial service providers financial guarantees for achieving clearly defined capability validation milestones—described as “Capability Validation Task Orders” in the RFP [1]. These sequentially issued task orders compensate vendors for each successful service increment, but do not commit the Agency to pay for subsequent steps if vendor performance is inadequate (e.g., if they fail to demonstrate waveform compatibility with LNIS). Successful completion of all Capacity Validation Task Orders will make a vendor eligible for Operational Services Task Orders. This strategy allows for the gradual increase in capability while reducing the initial burden of requirements for lunar relay services.

4. Summary

The rapid growth of commercial space services is the fulfilment of a vision which has been developing across several Administrations. This changed landscape did not emerge passively, nor overnight. SCA_N has been cultivating a vibrant commercial service environment since 1997, when NASA partnered with commercial industry to operate the Svalbard Satellite Station. The ensuing emergence of viable commercial services for DTE, and the ongoing development of near Earth and cislunar commercial SATCOM, have been supported by focused efforts at SCA_N to ensure the marketplace continues to meet mission needs. It is valuable to reflect on the state of that market, how it can be leveraged most effectively going forward, and what lessons SCA_N can offer for broader commercialization efforts at NASA.

It is often stated that that NASA aims to be just one customer among many. However, NASA remains a uniquely influential customer. Agency users are well positioned to influence the market for space services and ensure emergent mission needs will be met. At the same time, there is a responsibility to ensure nascent industries mature into supplying services to a variety of clients, not just NASA missions. To do this requires compromise between actively prescribing technological requirements and allowing vendors the necessary freedom to cultivate a dynamic commercial marketplace. SCA_N has been striking this balance in a variety of settings. In near Earth space, recent engagements with 3GPP and technological solutions like wideband multilingual terminals will ensure the presence of interoperability and competition for near Earth commercial SATCOM. At the moon, while NASA is taking a leading role in building a foundation of lunar interoperability, in the long-term NASA sees the LNIS being carried forward and maintained by the vendors providing services. These solutions allow SCA_N to meet user requirements while retaining space for the beneficial and disruptive innovation only the marketplace can deliver.

Contract structures and validation approaches present another, even more powerful, opportunity for productive Agency influence. The fixed-price Space Act Agreements (SAA) pioneered by COTS have demonstrated tremendous value, but these are not one-size fits all. When SCA_N sought to create the best conditions possible in the “green field” of cislunar space, it worked with industry to develop lunar relay RFPs that contain a series of “Capacity Validation Task Orders.” This approach similarly aims to ignite a marketplace for the cislunar communications capabilities that the NASA mission community needs, without requiring they be fulfilled in a specific manner.

The varied methods used by SCA_N to expand commercial communication services are providing key opportunities to explore new models for acquisition, service delivery, and ops. This shift to commercial providers is not a single event that has already passed—it is an ongoing process, driven by an active commercial space economy where vendors innovate, learn, and compete for customers every day. To fully benefit from this dynamic marketplace, NASA must continue innovating as well. Only through careful and considered action can we help commercial providers accelerate the emergence of new technologies, lower prices, and help missions across the Agency become more capable. At SCA_N, this stance will ensure an ongoing ability to fulfil communication service needs in new ways—in near Earth space, in cis-lunar, and when the market is ready, into deep space as well.

5. References

- [1] NASA Near Space Network Services – Final Request for Proposals (RFP), March 31, 2023. <https://sam.gov/opp/68866e644d1a447a964fc0bade9adf45/view>
- [2] Werner, Debra. Space News. “Capella Sends First Task Order through Inmarsat Data Relay,” November 23, 2022. <https://spacenews.com/capella-sends-first-task-order-through-inmarsat-data-relay/>
- [3] Potter, Sean. “NASA, Industry to Collaborate on Space Communications by 2025,” April 21, 2022 <https://www.nasa.gov/press-release/nasa-industry-to-collaborate-on-space-communications-by-2025>
- [4] “NASA’s Stakeholder Collaborations Help Inform Moon to Mars Planning” September 20, 2022, <https://www.nasa.gov/press-release/nasa-s-stakeholder-collaborations-help-inform-moon-to-mars-planning>
- [5] NASA Office of Inspector General, “Audit of NASA’s Deep Space Network,” July 12, 2023, <https://oig.nasa.gov/docs/IG-23-016.pdf>
- [6] Schier, James et. al. “A Deeper Dive Into the Meaning and Implications of Interoperability for LunaNet Communications and Navigation Services”
- [7] LNIS Interoperability Specification Draft Version 5
https://www.nasa.gov/directorates/heo/scan/engineering/lunanet_interoperability/
- [8] Satellite Today, “Planet to Support NASA Relay Networks for Telesat, SES,” August 23, 2022
<https://www.satellitetoday.com/government-military/2022/08/23/planet-to-support-nasa-relay-networks-for-telesat-ses/>
- [9] Brukardt, Ryan et. al. McKinsey and Company. “Space: Investment shifts from GEO to LEO and now beyond,” January 22, 2022 <https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/space-investment-shifts-from-geo-to-leo-and-now-beyond>
- [10] Lockheed Martin. “Crescent Space to Deliver Critical Services to a Growing Lunar Economy,” March 28, 2023 <https://www.prnewswire.com/news-releases/crescent-space-to-deliver-critical-services-to-a-growing-lunar-economy-301783435.html>
- [11] Cooper, Keith. Space.com, “What is Intuitive Machines and how is it aiming for the moon?” January 8, 2023 <https://www.space.com/intuitive-machines>
- [12] Foust, Jeff. SpaceNews, “Draper wins NASA contract for farside lunar lander mission” July 21, 2022. <https://spacenews.com/draper-wins-nasa-contract-for-farside-lunar-lander-mission/>

6. Acronyms

Acronym	Definition
3GPP	3 rd Generation Partnership Project
4G	4 th Generation
5G	5 th Generation
APL	Applied Physics Lab
BAA	Broad Agency Announcement
CASQ	Commercial Security Architecture Questionnaire
CCSDS	Consultative Committee for Space Data Systems
CIS	Commercialization, Innovation, and Synergies
CLPS	Commercial Lunar Payload Services
COTS	Commercial Orbital Transportation Services
CSP	Communication Services Project
DSN	Deep Space Network
DTE	Direct to Earth
ESA	European Space Agency
F9	Flight-9
FSAA	Funded Space Act Agreement
GEO	Geostationary Orbit
IDRS	Intersatellite Data Relay Service
KGS	Kuiper Government Solutions
KSAT	Kongsberg Satellite Services
LCOT	Low-Cost Optical Terminal
LEO	Low Earth Orbit
LNIS	LunaNet Interoperability Specification
M2M	Moon to Mars

Acronym	Definition
MEO	Medium Earth Orbit
NASA	National Aeronautics and Space Administration
NextSTEP-2	Next Space Technologies for Exploration Partnerships-2
NSN	Near Space Network
NTN	Non-Terrestrial Networking
PExT	Polylingual Experimental Terminal
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposals
SAA	Space Act Agreement
SATCOM	Satellite Communications
SCaN	Space Communications and Navigation
SOW	Statement of Work
SSC	Swedish Space Corporation
TDRS	Tracking and Data Relay Satellites
TDRSS	Tracking and Data Relay Satellites System
USSF	United States Space Force