The Implications of Private-Public Partnerships for Communications and Navigations Networks and the Impact on Operations in Near-Earth Space

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Abstract

The National Aeronautics and Space Administration (NASA) Space Communications and Navigation (SCaN) program serves as the enterprise responsible for enabling high speed, robust, secure, and cost-effective space communications and navigation services to missions, as well as providing support to our international and strategic partners as needed. SCaN shares the commitment with our science and exploration partners to ensuring mission success now, and in the future. Consistent with National Space Policy, NASA is seeking commercial services to meet current and future mission requirements in both near-Earth and cislunar space. In near-Earth, where an established market exists and is evolving, SCaN will participate 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. In the lunar region, NASA intends to contribute to building a robust commercial ecosystem similar to the growing market that exists in near-Earth space. As SCaN works to establish operational commercial communications services for users, there is an opportunity to establish best practices for collaboration with industry to enable more resilient space systems, improve future space sustainability, and address the intersection of interests across civil space, commercial, international, and other government agencies.

This paper will describe current planning and drivers influencing the strategic commercial transition within SCaN. An integral piece of ensuring success will be to define the ideal method of provider market interaction which will ensure current mission needs are met and the ecosystem is conducive to meeting NASA's goals into the future. SCaN's historical models of industry interaction have focused on either the procurement of entire application specific systems or space-as-a-service models based on scalable contracting for products and services provided by industry. SCaN is anticipating the need for a new, collaborative approach to industry partnership in the space between these extremes. Expanding knowledge and understanding of industry partners' markets and business models will be foundational to facilitating a sustainable commercial transition. This must account for the varying market environment based on the region of space, for example, the radically different approaches required for the already robust near-Earth market vs. the emerging market for Lunar commercialization. SCaN's efforts in near-Earth space with the Communications Services Project, as well as pursuit of Lunar Exploration Ground Segment capabilities and Lunar Relay services will be explored in this paper. SCaN will be executing toward a future operational state where established processes allow NASA to collaborate seamlessly with partners in any domain to acquire services, meet commitments, and promote a healthy space market.

Acronyms/Abbreviations

Acronym	Definition
3GPP	3rd Generation Partnership Project
15 USC	Title 15 of the United States Code
51 USC	Title 51 of the United States Code
APL	Applied Physics Laboratory
BAA	Broad Agency Announcements
C&N	Communications and Navigation
CAN	Communications Architecture and Networks
CSP	Communications Services Project
DSN	Deep Space Network
DTE	Direct to Earth
EHP	Extravehicular Activity & Human Surface Mobility Program
FAR	Federal Acquisition Regulation
FFP	Firm Fixed Price
FFRDCs	Federally Funded Research and Development Centers
FSAA	Funded Space Act Agreements
GOCO	Government-owned and Contractor-operated
IDIQ	Indefinite Delivery Indefinite Quantity
IOC	Initial Operating Capability
KaSTLE	Ka-Steerable Terminal for Lunar Environments
KSAT	Kongsberg Satellite Services
LEGS	Lunar Exploration Ground Site
M2M	Moon to Mars
NASA	National Aeronautics and Space Administration
NSN	Near Space Network
O&M	Operations and Maintenance
PExT	Polylingual Experimental Terminal
R&D	Research and Development
RFI	Requests for Information
RFP	Request for Proposal
SAA	Space Act Agreements
SATCOM	Satellite Communications
SBIR	Small Business Innovation Research
SCaN	Space Communications and Navigation
SSC	Swedish Space Corporation
STTR	Small Business Technology Transfer
TDRS	Tracking and Data Relay Satellites
TRL	Technology Readiness Level
TOs	Task Orders
UARCs	University Affiliated Research Centers

1. Introduction

NASA's Space Communications and Navigation (SCaN) Program provides critical communications and navigation services to both our operational missions and those of our partners. SCaN engages with the space communications and navigation (C&N) industry to develop capabilities that support mission needs, are globally competitive, and advance the development of new markets. This engagement is being undertaken in compliance with National Space Policy and in alignment with NASA strategic objectives. SCaN is actively working toward transitioning to the use of commercial space C&N services to the greatest extent possible over the next decade. During this transition, SCaN has executed and planned various strategies for acquiring and utilizing commercial services, while identifying the challenges associated with each and outlining methods to ensure successful engagement and results. These strategies reflect the unique considerations of different regimes, with a focus on commercialization in the Earth and Cislunar regimes. SCaN is seeking further industry engagement to refine and formalize frameworks for acquisition and collaboration, ensuring they can be leveraged in the future.

2. Industry Contractual Framework

In the history of SCaN's partnerships and contracts with industry, various methods and options have been used to structure these partnerships. Currently, SCaN's partnership landscape includes several contract types and structures, as outlined below:

- Indefinite Delivery Indefinite Quantity (IDIQ) (FAR 16.5) contracts are a type of negotiated contract that provides for indefinite quantity or supplies or services during a fixed period. Supplies and services will be available at agreed upon pricing throughout the length of the contract. IDIQ contracts may be made with a single supplier (IDIQ Single Award) or multiple suppliers (IDIQ Multi-Award).
- Space Act Agreements (SAA) (51 USC 20113(e)) represent the most common method for formulating and structuring partnerships within the Agency. These partnerships allow for a flexible basis of interaction with industry with options for non-reimbursable, reimbursable, funded, and unfunded Space Act Agreements. NASA leverages Space Act Agreements to allow for collaborative research and development with industry. [1]
- Broad Agency Announcements (BAA) (FAR 35.016) may be used by agencies to fulfil their requirements for scientific study and experimentation directed toward advancing the state-of-the-art or increasing knowledge or understanding rather than focusing on a specific system or hardware solution related to a specific requirement. The BAA technique is advantageous when meaningful proposals with varying technical/scientific approaches can be reasonably anticipated.
- SBIR/STTR Programs (15 USC 638):
    - Small Business Innovation Research (SBIR) is a competitive program that encourages small businesses to engage in Federal Research and Development (R&D) with the potential for commercialization to stimulate innovation.
    - Small Business Technology Transfer (STTR) is a program to facilitate cooperative R&D between small business concerns and non-profit U.S. research institutions with the potential for commercialization of innovative technological solutions.

As NASA and SCaN become more deeply involved in the expanding market of space C&N services and technologies, there is an emerging need to mature a framework that guides commercial service acquisition, benefiting both NASA mission stakeholders and industry partners. Current and past procurement methods and acquisition strategies offer valuable lessons learned, which inform future decisions. The goal is to use this experience to shape future acquisition strategies, improving the efficiency of decision-making on a case-by-case basis. In this context, we will explore each of SCaN's current commercial partnership approaches, evaluate the strategies used to interact with industry, and identify the lessons that can be applied to future initiatives.

3. Direct Operational Service Buy

The initial infusion of commercial services into NASA's C&N networks began in the 1990s with the opening of the Svalbard Satellite Station. At that time, initial government-owned, contractor-operated (GOCO) assets became operational through NASA investment, providing direct-to-Earth (DTE) services for Earth-regime missions. From these initial GOCO assets, space communications services began to expand as new users and commercial providers entered the market. By 2012, NASA no longer owned assets in commercial antenna locations, and operations had fully transitioned to commercially owned and operated services. Commercial DTE services were procured through SCaN's main Operations and Maintenance (O&M) contractor for near-Earth C&N assets, with services provided to missions by the pass.

In February 2023, the Near Space Network (NSN) released a Request for Proposals (RFP) [2] for a Firm Fixed Price (FFP) IDIQ multi-award contract with service categories for near-Earth DTE services. A subset of these DTE services is an evolution of the previous model by which SCaN leveraged commercial DTE. In December 2024, Kongsberg Satellite Services (KSAT), Swedish Space Corporation (SSC), and Viasat were awarded task orders for operational DTE services in the contract sub-category associated with Earth-proximity DTE. Starting in 2025, the new DTE providers will begin executing mission support under their Operational Service Task Orders (TOs). Services under these TOs will be scheduled and priced per minute. Previously, missions using SCaN commercial

DTE services scheduled 30-minute passes, with a per-pass fee charged back to SCaN. Although the new contract offers some advantages in precision of cost, SCaN's ultimate interest is to align the pricing structure to industry preferences. For example, SCaN is looking to evaluate alternatives and gather industry feedback to determine if vendors prefer a per-month, per-pass, or per-minute fee for services.

Additionally, with over 20 years of mission support experience, DTE services for Earth-regime missions will be ready for operational use immediately, without the need to validate commercial capabilities first. The decision to directly procure operational services was the right choice, given the existing and robust market.

4. Funded Space Act Agreements for service development with following IDIQ Acquisition

Space relay services for in-space users have historically been a government-developed and customized capability, with origins in supporting human spaceflight. NASA's Tracking and Data Relay Satellite (TDRS) system is at a critical juncture with aging infrastructure, declining capacity, and no future path for replenishment of the network as it currently exists. The final TDRS was launched in 2017, and after the spacecraft's commissioning, the TDRS Project Office was formally closed. The focus then shifted to exploring and engaging with the commercial market for satellite communications (SATCOM) capabilities. In November 2024, a decision was made in the Agency to cease offering TDRS services to future missions, thereby preventing new demands on the network as it continues to decline. This decision sends a clear demand signal to the commercial sector that NASA is committed to and ready for the transition to commercial services.

Although the commercial SATCOM market is robust, it has historically concentrated on delivering services to terrestrial, aeronautical, and maritime markets, as such the introduction of space-based users presents new challenges and considerations. Initial industry studies and engagement led to a strategic decision to pursue demonstration and development activities to build confidence in the industry's ability to meet NASA mission use cases and needs. In 2022, Funded Space Act Agreements (FSAA) were awarded, aiming to balance risk and cost between NASA and the commercial demonstration awardees.

The FSAA approach provides a pathway to adopt the existing capabilities of commercial space relay services. As NASA's Communications Services Project (CSP) structured the solicitation, generalized mission use cases were developed based on historical TDRS usage, with the intent of capturing the needs of NASA users rather than the specifications for the services. This approach allowed industry to propose solutions based on the suitability of their planned and existing infrastructure. Consequently, the CSP's vendor services and architectures vary, as shown in Figure 1. As of the end of February 2025, FSAA partners, as a cohort, have completed approximately 59% of the planned demonstration activities.

Partners	Service Type Demonstration	Use Case	Band	Architecture
amazon | project kuiper	File Delivery	Science data	Optical	LEO
SPACEX	File Delivery	Mission data	Optical	LEO
Viasat +Inmarsat	File Delivery	Science data	Ka	GEO
	Direct Access	LEOP and TT&C	L	GEO
SES	File Delivery	Science data	Ka	MEO
	Direct Access	LEOP and TT&C	C	GEO
TELESAT	File Delivery	Science data	Ka	LEO
	Direct Access	LEOP and TT&C	C	GEO

Figure 1. Communications Services Project FSAA Partners are demonstrating services through a wide range of architectures.

While the demonstrations are ongoing, CSP is defining the path to operational commercial space relay services provided by SCaN to the NASA mission community. One key aspect of this path is determining the appropriate acquisition strategy for integrating these services into the network. In 2023, a study was conducted to evaluate viable acquisition approaches and recommend the most suitable option. The evaluation identified an IDIQ Multiple Award contract as the most viable choice. This contract structure allows for a portfolio of commercial space relay providers to be selected and promotes competitive pricing. The solicitation for the IDIQ acquisition will be publicly released, with proposals and awards open to any capable vendor—not limited to current FSAA partners. The structure will facilitate competition for specific mission support tasks under the umbrella of the parent IDIQ contract. As a result, acquiring services for a specific mission will occur at the Task/Delivery Order level, where missions provide service requirements for vendors to bid on. Additionally, the IDIQ structure offers the flexibility to add new providers as necessary to address emerging mission needs and industry evolution.

To shape the content of the future RFP, NASA uses Requests for Information (RFI) to gather industry feedback on aspects related to the future on-ramping of commercial SATCOM services. The Spring 2025 RFI includes two packages designed to capture: (1) formal market research in advance of the CSP service solicitation, and (2) industry approaches to addressing a limited set of TDRS backward compatibility requirements. The scope of the RFI questions is not limited to technical service offerings. NASA is also interested in feedback regarding business preferences, such as whether providers prefer to sell services via monthly or annual subscriptions instead of other pricing schemes. Additionally, SCaN is interested in understanding vendor preferences regarding engagement and interaction with SCaN, the structure of service level agreements with missions, and other aspects of service provision and execution. This feedback will be essential in shaping the acquisition strategy.

5. IDIQ with development, validation, and operational service acquisition

In the Cislunar regime, the acquisition of commercial space relay services will be developed without the foundation of an existing market for C&N networks and capabilities. There has been significant industry interest and involvement throughout the planning period for the Artemis campaign, driving an engagement strategy focused on stimulating the emerging commercial market in cislunar space. In September 2024, Intuitive Machines, Inc. was awarded a contract to provide commercial lunar orbiting relay services to NASA users. This award was made under the cislunar relay service sub-category of the NSN services IDIQ FFP contract.

In structuring the procurement, NASA acknowledged the lack of previously proven commercial cislunar relay capabilities. As a result, the initial contract phase includes a development and service validation period. The

validation phase is divided into three increments: Alpha, Bravo, and Charlie. Sub-tasks and capability validation milestones will facilitate incremental payments to the vendor as development progresses. Intuitive Machines will work toward an Initial Operating Capability (IOC), expanding services and capabilities in each increment to reach operational readiness at the end of the validation period. A key benefit of this approach is that cost and technical risks are shared between NASA and its commercial partner during the development and deployment of the capability. Once validation is complete, operational service tasks will be awarded. Given the significant effort, investment, and risk involved in building new infrastructure, the contract also includes a minimum guaranteed service buy.

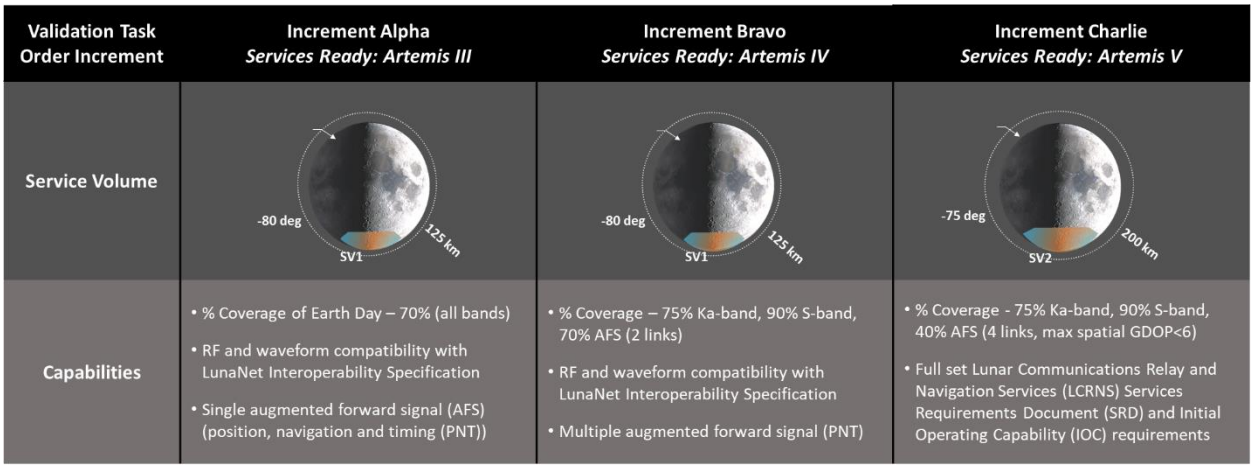

Figure 2. Commercial lunar relay capability is validated incrementally, with distributed milestone payments reflecting a commitment to share cost and risk between NASA and our commercial partner.

The validation strategy and service needs were defined based on a minimum set of requirements and specifications included in the solicitation for proposals from industry. These requirements were developed through successful collaboration with the user community and were driven by a set of fundamental goals, as follows:

- Provide largest communication coverage (Initially Lunar South Pole, expand with time)
- Improve Artemis Mission Availability by providing C&N at landing sites without DTE visibility
- Improve NASA Network Loading minimizing the impact to NASA's Deep Space Network (DSN)
- Support Precision Surface Navigation, Science Needs, & Long-Distance Roving
- Enhance Safety and Response to Contingencies (e.g., Landing Outside Zone)
- Use interoperable standards to support across various Cislunar users (NASA Exploration Systems Development Mission Directorate, NASA Science Mission Directorate, NASA Space Technology Mission Directorate, International Partners, etc.)

User needs were further refined through engagement with NASA's internal and external stakeholders and were documented in two key documents included in the procurement for the lunar relay award: the Service Requirements Document and the LunaNet Interoperability Specification. These documents provide success criteria for the validation phase leading to full IOC. However, they are not intended to prescribe the implementation approach to be taken by the awarded vendor, Intuitive Machines.

6. IDIQ with limited validation and operational service acquisition

An additional sub-category of services in the NSN Services RFP was designed to procure DTE services suitable for users in the Cislunar regime. Awards for lunar DTE services were announced in December 2024, with two vendors, KSAT and Intuitive Machines, selected. The initial awards are for limited-scope validation task orders aimed at confirming that the minimum performance criteria, services, and attributes are available for missions.

In contrast to the lunar relay case, where capability is still being developed and has not yet been proven, DTE communications are well established and present lower risk. This difference is reflected in the contract structures,

with the lunar relay awards having an order-of-magnitude greater minimum guaranteed value. Based on proven industry capability, SCaN's goal was to use the tailored acquisition to validate capability quickly and transition to operations, ensuring vendors start receiving revenue as soon as possible.

Commercial lunar DTE capabilities will be validated against the Lunar Exploration Ground Site (LEGS) system specifications, which were included in the solicitation. KSAT and Intuitive Machines are not required to meet the service specifications with a specific asset architecture but are instead free to structure services and assets as needed to meet the success criteria for their validation task orders. Once validation is complete, the awardees will be eligible for operational task orders. The pricing and details for operational services will be defined as part of the transition from validation to operations.

7. Technology Partnerships

SCaN has a long history of fostering emerging technologies, guiding them from the conceptual phase through demonstrations and mission integration. Currently, SCaN leverages BAAs and SBIR/STTR programs to conduct studies, co-invest in new technologies, and evaluate options for future network capabilities and services. Examples of these investments are summarized in Table 1.

Table 1: Recent BAA and SBIR activities

Type	Year	Topic or Study Area	Partner(s)
SBIR	2020-2022	SBIR Phase II and Phase IIE (Topic Areas: (1) Long-Range Optical Telecommunications, (2) Flight Dynamics and Navigation Technologies, and (3) Cognitive Communication)	Fibertek, Inc., Starfish Space, Inc., AiRANACULUS, Physical Sciences, Inc., and Relative Dynamics
BAA Study	2022	Capability Studies – I (Study Areas: (1) RF Compatibility Testing and Future Innovation, (2) Planning and Scheduling, (3) Integration of Optical Terminal into Network Operations, and (4) Digital Signal Processing in the Cloud)	KSAT and SpaceLink Corp.
BAA Study	2023	Capability Studies – II (Study Areas: (1) Wideband Satellite Communications, (2) Phased Array Ground Systems, and (3) Constellation Topology Analysis)	CesiumAstro, SSC, Intuitive Machines, and MTI Systems
SBIR	2023	SBIR Phase II (Topic Area: (1) Long-Range Optical Telecommunications, (2) Flight Dynamics and Navigation Technologies, and (3) Lunar 3GPP Technologies)	3d-SensIR, Advanced Space, Xanalytix Systems, MTI Systems, Inc., EpiSys Science, and REMCOM, Inc.
BAA Study	2024	Capability Studies -III (Study Areas: (1) Lunar Surface User Terminals, and (2) Network Orchestration and Management systems)	Aalyria and Intuitive Machines
SBIR	2024	SBIR Phase I (Topic Areas: (1) Flight Dynamics and Navigation Technologies, and (2) Lunar 3GPP Technologies)	XAnalytix Systems LLC, Rogue Space Systems Corporation, Nabla Zero Labs, Astranis Space Technologies Corp., A10 Systems Inc. d/b/a AiRANACULUS, and SPATIAM CORPORATION

In technology development, we collaborate with our partners in various ways to achieve development and demonstration goals. A selection of technology projects, showcasing different partnership styles, can be highlighted from the current SCaN Technology Portfolio.

Ka-Steerable Terminal for Lunar Environments (KaSTLE): The KaSTLE project leverages phased array hardware developed through a multi-phase SBIR activity. Co-investment for a single-beam, time-division duplex, Ka-Band phased array began with a Phase I SBIR activity with CesiumAstro Inc. and continued through Phase II E and Phase III. The CesiumAstro phased array has been tested for near-Earth applications and qualified to Technology Readiness Level (TRL)-6, indicating a starting TRL of approximately 4 for lunar applications. Advancing this technology for lunar use opens a new market for CesiumAstro, while ensuring suitable capabilities are available for NASA's target users.

Wideband Multilingual User Terminals (PExT): In addition to partnerships with U.S. industry, NASA also collaborates with research institutions, colleges, and universities, and other non-profit or non-industry entities to achieve mission objectives. Federally Funded Research and Development Centers (FFRDCs) and University Affiliated Research Centers (UARCs) are not-for-profit, private-sector organizations which augment NASA and other government agency capabilities for research and development. John's Hopkins Applied Physics Laboratory (APL) is a UARC partnering with NASA across a variety of projects and technology development efforts. In the SCaN portfolio, APL is executing a wideband polylingual terminal flight demonstration, known as the Polylingual Experimental Terminal (PExT), which is scheduled to launch no earlier than May 2025. This terminal will demonstrate operations with multiple commercial space relay providers, in addition to NASA's TDRS system, over a one-year demonstration. The lessons learned from this demonstration will help SCaN reduce the risk of vendor lock-in as missions transition to using commercial space relay services in the near future.

Lunar 3GPP: Increasing lunar activity highlights the need for new and advanced communications, navigation, and networking capabilities to support exploration objectives. In the Moon to Mars (M2M) Program Office, the Extravehicular Activity & Human Surface Mobility program (EHP) is working to provide surface mobility to future Artemis astronauts. EHP is partnered with Axiom Space to build the new lunar spacesuits. A demonstration during the Artemis III mission will test the capabilities of terrestrial 3GPP standards and technology for lunar surface applications. This demonstration will focus on communications between spacesuits and the lunar lander, with closely coordinated development between the vendors for these systems and NASA [3]. SCaN is collaborating with M2M EHP to ensure the system and architecture evaluated in the demonstration are suitable for the surface communications application.

Partnerships for technology development are efficient and mutually beneficial for both SCaN and its industry partners. The focus for technology projects moving forward is to answer key questions and resolve strategic uncertainties on the path to implementing major new network capabilities. Based on the intention to integrate commercial partners and solutions into new implementation efforts and associated acquisitions, commercial partnerships should be seeded early in the technology efforts.

8. Conclusion

Working with commercial partners allows SCaN to tap into the innovation of both existing and emerging members of the space market. As SCaN continues to engage with industry through Requests for Information, BAAs, SBIRs, and acquisitions, we welcome partner feedback on how to shape or refine our approach and on the types of partnerships that are mutually beneficial. The ideal future approach will maximize outcomes for our end users, accelerate industry evolution, and foster the growth and expansion of commercial markets.

Robust markets and communities enable SCaN to advance into new regimes, paving the way for industry to move into these markets alongside the agency. For NASA, the next horizon is the Mars and Deep Space regime, where the robotic science community has already been active, but there is a shared ambition for human exploration. In 2024, NASA's Science Mission Directorate partnered with industry to conduct various studies aimed at accelerating progress toward expanded exploration of Mars and Deep Space. However, further support and engagement from the broader space community are essential to realize the goal of human Mars exploration and to continue advancing our scientific understanding of the universe.

At the core of these goals is the need for a robust and reliable infrastructure of communications and navigation capabilities to transmit discoveries back to Earth and ensure the safety and success of missions. Increased commercialization across the portfolio emphasizes the need for SCaN to optimize industry interactions and

partnerships for maximum effectiveness and efficiency. SCaN aims to incorporate partner perspectives to improve processes and outcomes and eliminate obstacles to successful collaboration. As such, SCaN is actively seeking engagement across the space community to define the future of partnerships for Communications and Navigation.

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