# *Framework for NASA Space Relay Satellite Services over the Next Decade: "Development and Demonstration of the Commercial Successors to TDRS "*

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## Abstract

The United States National Space Policy provides guidance and directives for U.S. Government agencies to purchase commercial space services and capabilities to the maximum extent practical. In alignment with this guidance, the Agency has no plans to replenish the Tracking and Data Relay Satellite System (TDRSS) fleet operated by the Space Communication and Navigation Program (SCaN) and will instead pursue commercial services for communications with spacecraft in near-Earth orbit. The Communications Services Project (CSP) at GRC is leading this commercialization effort and in May 2022 it awarded six contracts to commercial SATCOM companies to demonstrate and validate commercial SATCOM capabilities for future NASA and near space user missions. The responses from the vendors indicated a strong interest in providing commercial services to NASA's missions and included a wide range of proposed architectures and demonstrations concepts. Overall, the responses indicated that a mature and healthy competitive environment exists with traditional satellite operators and constellation developers to provide NASA and future near space users with commercial communication services in the next five years. This paper will present an overview of the proposed capability coverages, risk spread, and US domestic market stimulation, along with common themes and conclusions. The result of these demonstrations will serve as the basis for acquisition and provision of operational SATCOM services for NASA missions.

## 1 Introduction

NASA's current missions rely on the communications networks operated by the Space Communication and Navigation (SCaN) Program. Per Administration Policy and Congressional Direction, the Agency currently has no plans to replenish the Tracking and Data Relay Satellite System (TDRSS) fleet and will instead pursue commercial services for communications with spacecraft in near-Earth orbit. SCaN network capacity will meet NASA mission needs for at least several more years, allowing NASA to plan for commercial services. NASA's Space Operations Mission Directorate (SOMD) formulated the Communications Services Project (CSP) at Glenn Research Center (GRC) to establish partnerships with commercial satellite communications (SATCOM) companies. The goal of CSP is to develop and demonstrate the feasibility of providing SATCOM capabilities that could potentially be offered as a service for future spacecraft users in near-Earth orbit. The benefits of successful demonstrations are expected to include: the availability of flexible, reliable, and robust, cost-effective, state-of-the-art SATCOM services to space based users in near-Earth orbit; and promoting a diverse and growing commercial SATCOM industry.

Building upon prior studies [1][2][3][4] NASA pursued an Announcement of Proposals (AFP) in 2021 soliciting proposals for the development and demonstration phase of the CSP. Proposals were received from the following fourteen (14) offerors: Atlas Space Operations; Viasat Inc.; Hedron, Inc.; BizTek International, LLC; SES Government Solutions, Inc.; SpaceLink Corporation; SpaceX; Kuiper Government Solutions (KGS), LLC; Astranis Space Technologies, Corp.; Telesat U.S. Services, LLC; Inmarsat Government, Inc.; Solstar Space Company; CesiumAstro, Inc.; and Laser Light Federal.

The Participant Evaluation Panel (PEP) appointed to evaluate the proposals completed a rigorous evaluation and due diligence process in accordance with the procedures and evaluation criteria set forth in the AFP and its accompanying evaluation plan. The PEP team developed and recommended

a portfolio of six (6) vendors that best met the objectives described in the AFP. Considerations for the selection process included capability coverage, levels of confidence, risk spread, U.S. domestic market stimulation, price, and NASA's budget. In determining the number of awards that best met the goals of the AFP, the Selection Authority Official also considered CSP's total anticipated funding. The selected portfolio of the six (6) vendors included Viasat, SES Government Solutions, SpaceX, Kuiper Government Solutions, Telesat U.S. Services, and Inmarsat Government. The six (6) selected vendors received funded Space Act Agreements (SAAs) over a performance period of up to five (5) years from the award date of May 31, 2022. The combined value of the agency's CSP funded agreements is $278.5 million. NASA expects each company to match or exceed agency contributions during the five-year development and demonstration period, totalling more than $1.5 billion of cost-share investment.

With the awarded agreements NASA intends to establish multiple public-private partnerships (PPPs) between NASA and commercial SATCOM companies to develop and demonstrate end-to-end operational capabilities that can potentially meet the needs of both Government and private sector customers. These partnerships are intended to bolster American industry, significantly reduce the cost of communication services, and maximize interoperability between Government and commercial service providers while promoting a diverse commercial market.

This paper presents an overview of the capability coverages proposed by the selected vendors and includes a discussion of the risk spread, US domestic market stimulation, common themes, and conclusions, as well as next steps and recommendations)

## 2. Assessment and Analysis

After a thorough analysis and evaluation of the proposals, a portfolio of six SATCOM service providers were selected for award. The portfolio included four RF SATCOM service providers (Viasat, SES Government Solutions, Telesat U.S. Services, and Inmarsat Government), and two Optical service providers (SpaceX, Kuiper Government Solutions). This was the portfolio that best met the AFP's objectives when considering capability coverage, risk spread, levels of confidence, U.S. domestic market stimulation, price, and NASA budget, as determined by the Selection Authority. The following sections provide an overview of the assessment and analysis done on capability coverage, risk spread, and US domestic market stimulation.

### *2.1 Capability Coverage*

With respect to capability coverage no single proposal on its own provided full capability coverage but all together the six selected proposals complemented a portfolio that best addressed the Use Cases, Capability Goals, and satellite classes identified in the AFP. The following sections provide an overview of the assessment and analysis done on the Use Cases and the Capability Goals.

#### *2.1.1 Use Cases*

The AFP described the six (6) Use Cases that NASA was seeking. Figure 1 lists the six (6) categories: Launch Support; Launch and Early Operations Phase (LEOP); Terrestrial Support; Low Data Rate Routine Missions; High Data Rate Routine Missions; and Contingency. The Use Cases represent a synthesis of current operational users and their communications and navigation needs. The reference illustration provides the mission type, launch vehicle, number of missions, and communication data rates for each use case

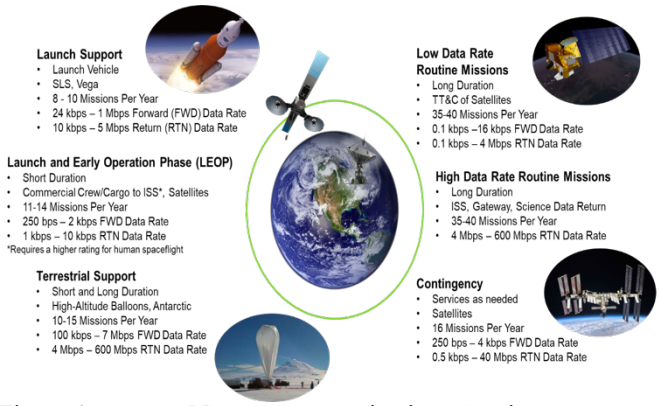

Figure 1: Current NASA Communications Services

In addition to the Use Cases shown in figure 1, the AFP provided a set of reference data as appendices to support the AFP participants in developing their proposals. The reference data was for context only and did not communicate additional requirements for any unique solutions. The appendices included:

1. SCaN Future Mission Space Communication and Navigation Needs - Described NASA mission categories through use cases which provides context for types of future potential missions.
2. Network User Data Volume – Provided the total usage of NASA space communication services provided to NASA missions.
3. User Technical Data – Provided service use data on the current SCaN communications service type and usage broken down by each NASA mission.

The portfolio selected provided a diverse set of SATCOM service providers that covered all Use Cases identified in figure 1 and the AFP. Viasat, SES Government Solutions, Telesat U.S. Services, and Inmarsat Government offered an RF solution. SpaceX and Kuiper Government Solutions offered an Optical solution. The optical solution augmented the portfolio's global coverage with a spectrum choice free of regulatory obstacles and the portfolio as a whole provided redundancy in the Contingency, Launch and LEOP Use Cases. Three (3) vendors proposed to demonstrate the Low Data Rate Missions, four (4) proposed to demonstrate the

High Data Rate Missions, three (3) proposed for the contingency case with one demonstration, three (3) proposed for the launch case with one demonstration, three (3) proposed for the LEOP case with one demonstration, and three (3) simply proposed for the terrestrial case with no demonstration. This set of SATCOM providers addresses all Use Cases identified in the AFP with redundancy and guarantees full global optical and RF coverage at the various near-earth orbits (LEO/GEO/MEO) with hybrid architectures consisting of both Space Relay and Direct-to-Earth communication capabilities.

### 2.1.2 Capability goals

The AFP identified nine (9) Assured Data Delivery Capability goals, seven (7) File Data Delivery and Networking Capability goals, four (4) Enhanced Capability Goals, and sixteen (16) Operational Requirements. These Goals are intended for demonstrating comparable performance to the existing NASA systems but were not to be construed as requirements on the performance of the service. Participants were encouraged to select goals based upon their business thrusts and interests and plans for offering future commercial SATCOM services**.** Capabilities projections for the Assured Data Delivery and File Data Delivery and Networking Service Missions (missions projections for the present time and the near future, mission count range, passes per day, service time per year range, services type (Direct-to-Earth, Space Relay, and Launch Events)) were also provided to support participants in developing and conducting the demonstrations.

The Assured Data Delivery Capability Goals provide assured access to spacecraft for critical data transmissions (command and telemetry) from near-Earth orbiting spacecraft through a commercial communications system interface. These goals addressed altitude (closing the link), inclination, link availability, data volume (forward and return), bit error rate, hands-off approaches, latency, and Quality of Service (QoS).

The File Delivery and Networking Capability Goals provide the ability to deliver telemetry and science data to a Mission Operation Center (MOC) or Principal Investigator (PI) and links typically support larger data file transmission (higher data rates) that can tolerate higher latencies. These goals addressed altitude (closing the link), inclination, link availability, data volume (forward and return), bit error rate, hands-off approaches, and latency.

The Additional Enhanced Goals that could be offered or demonstrated by the participants included Proximity (Automated Rendezvous and Docking, satellite servicing), Demand Access Request to the MOC and/or Satellite-to-Satellite relay links, File Delivery with less than 300 msec latency, and Positioning, Navigation and Timing (PNT).

The Operational Requirements addressed cybersecurity, protection of information, mission planning functions, coordination of regulatory / spectrum management issues, demonstrating compatibility, demonstrating provisioning of performance metrics to enable service quality assessment and cost accountability, and demonstrating a plan on how the future service-level-agreements will be structured after the capability development and demonstration phase.

The selected Portfolio included the six (6) vendors that best covered All Capabilities and Goals identified in the AFP. With the four (4) RF and two (2) Optical SATCOM service providers, full coverage of all capabilities was achievable with redundancy. Two of the RF service providers (SES and Telesat) proposed an integrated architecture approach toward implementing the Assured Data Delivery and File Delivery and Networking capabilities. Their proposed architecture integrates two satellite services (Telesat: C-band GEO Satellite service with Ka-Band MEO satellite service/SES: offered the MEO Ka-Band Relay Services with GEO C-band Relay Services) at two different orbits into a single operational service offering. Their unique approach combines the benefits of two capabilities into a single operational service offering allowing global coverage for both primary proposed capabilities. One of the RF service providers (Telesat) added near-term RF coverage of the polar regions as well as redundancy for the direct satellite-to-satellite communications thus providing a significant compliment to the mix. The two (2) Optical service providers (Kuiper and SpaceX) met all capabilities and added to the mix a global optical solution which augmented the portfolio's global coverage with a spectrum choice, not contained in the other proposals.

## 2.2 Risk Spread

With respect to risk spread, the portfolio selected took into consideration implementation risks, programmatic risks, regulatory risks, technology risks, and heritage risks. The portfolio selected included:

1. Two (2) Optical service providers with high risk but high technology reward
2. Four (4) RF service providers with three (3) high data rate and three (3) low data rate
3. RF and Optical Spectrum choice. (Ka, L, C, Ku, S and Optical)
4. Four (4) service providers with well-established heritage and two emerging optical service providers.

The combination of the four (4) RF service providers presents low risk of successful execution. Each of these companies have a robust managed communication services in place with good Technology Readiness Level (TRL) and global infrastructure. In addition, the four (4) RF service providers have considerable experience in regulatory licensing and coordination. They proposed using their existing spectrum allocations and offered to work with the regulatory framework to seek regulatory recognition and approval to operate their network for the demonstration.

The two optical service providers proposed a global optical solution which would augment the portfolio's global coverage with a spectrum choice free of regulatory obstacles. Thus, not only would these proposals increase capability coverage, but they would also significantly augment the

portfolio's risk spread. Having a redundant optical service provider would also help mitigate the risks inherent in a developing technology.

All six providers included adequate plans that identified engineering and risk mitigation tasks associated with their proposed demonstrations. They provided sufficient details regarding risk management, TRL maturity, best practices, safety and mission assurance, and provided an optimal level of diversity and redundancy.

## 2.3 US Market Stimulation.

One of the main objectives of the AFP is to establish public-private partnerships ("PPPs") with multiple providers that will stimulate the U.S. commercial communications industry and create a market for commercial SATCOM services that will be available to both Government and private-sector customers. The AFP treated US market stimulation as the extent or degree to which a participant's approach will result in providing or bolstering a competitive edge of U.S. domestic industry.

Three of the selected companies (Viasat, Kuiper, SpaceX) are wholly owned and operated U.S. companies with no foreign sub-participants. Their manufacturing, development, and eventual operational service revenue would directly stimulate US industry and bolster a competitive edge of U.S. domestic industry for future SATCOM services. All these entities have substantial infrastructure in place that they will leverage to address all aspects of the capability development and demonstration and stimulate the US industry**.** The three other companies (Inmarsat, SES, and Telesat) are U.S. domestic entities as defined in the AFP, but indirect subsidiaries of foreign entities. They identify US domestic market stimulation through partnerships with other US domestic entities such as US launch service providers and US-based satellite manufacturers and providers of user terminals.

All the participants have facilities and workforce available to support the proposed capability development and demonstrations with plans to expand this support by hiring more people and developing the necessary technologies, manufacturing, and space environmental testing capabilities to support the development and test of key hardware components of this effort in the US.

# 3 Common Themes, and Conclusions

Two common themes were identified by the selected SATCOM service providers.

The first theme was ensuring NASA as one of many customers and creating a market for commercial SATCOM services that will be available to both government and private-sector customers. All six (6) vendors identified their existing customer base (non-NASA customers) to which they are already providing services and key potential markets that could help reduce NASA's share of capital expenses and ensure competitive market-based pricing for the future commercial SATCOM service.

The second theme was managing the capability development and demonstration. All selected participants had a strong management team and management/organizational structure in place that will have positive impact on the success of the demonstrations. Those that had partners showed strong arrangements with well defined-roles and responsibilities across an executable schedule. All the participants regardless of NASA's involvement, have a substantial ground and space-based infrastructure in place that will have positive impact on the successful execution of the demonstrations and the establishment of the Commercial SATCOM services.

In conclusion, and based on the depth and complexity of the existing SCaN user market and services required, it is obvious that "one size cannot fit all". Instead, a collection of technologies and SATCOM communication services is needed to be developed and demonstrated to provide future communications services for NASA's missions. The selected portfolio of Viasat, Inmarsat, SES, Kuiper, SpaceX, and Telesat best meets the objectives described in the AFP. These six proposals address all capability goals and use cases identified in the AFP in a comprehensive, global manner. With respect to risk spread, they provide an optimal level of diversity and redundancy, and provide or endorse a competitive edge to US. Domestic entities, with three exclusively involving U.S. entities and the other three utilizing US based companies for technology development and demonstrations.

Each company will complete technology development and in-space demonstrations by 2025 leading to a service acquisition approach for buying commercial SATCOM services. As these demonstrations unfold, NASA will be evaluating the best service acquisition strategies as well as the optimal transition plans with a goal of having services in operation by the end of the decade. NASA intends to seek multiple long-term contracts to acquire services for near-Earth operations by 2030, while phasing out NASA owned and operated systems

# 4 Recommendations and Next Steps

As the selected participants engage in developing and conducting the demonstrations a series of logical, orderly steps, leading to the establishment of the operational SATCOM service are recommended to take place:

1. SCaN/CSP needs to engage the Mission User Community to capture, evaluate and validate future Near-Earth Mission User Needs such things as: use of a relay versus direct-to-ground spacecraft communications services, definition of low/high/ultra-high data rates & volumes, data latency requirements, timing requirements, tracking, ranging & navigation services, expendable launch vehicle support, LEOP support, end-to-end security support, contingency support, etc.

2. SCaN/CSP should consider how to integrate these disparate services into a more cohesive, interoperable service from both a technical and enterprise management approach.

3. SCaN/CSP needs to work closely with the participants to develop and define the interface requirements for integrating the payloads (e.g., optical intersatellite link systems/payloads) from one service provider with another satellite. The integration process on 2nd or 3rd party platforms could present unforeseen integration challenges and/or requirements creep. Similar challenges could be present when one provider is conducting a demonstration with multiple partners.

4. SCaN/CSP needs to continue to collaborate with the DoD and other government agencies (OGAs) to share information, plans, studies, reports, technology, and other materials relating to topics of mutual interest.

5. SCaN/CSP needs to play an active role to obtain RF spectrum access for commercial space-to-space links. (Regulatory recognition for Satellite-to-Satellite operations in the fixed-satellite service (FSS) and/or mobile-satellite service (MSS) frequency allocations)

## 5 Acknowledgements

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