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From: Starfish Space
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To: National Telecommunications and Information Administration

Subject: Development of a National Spectrum Strategy [Document ID: NTIA-2023-0003-0001]

Executive Summary

Starfish Space seeks to provide comments to the National Telecommunications and Information Administration (NTIA) on the Development of a National Spectrum Strategy (Document ID: NTIA-2023-0003-0001 and Docket Number: 230308-0068).

Starfish Space provides on-orbit satellite services to defunct satellites for the purpose of orbital debris cleanup, space traffic management, and life extension of existing satellites in order to reduce the number of derelict objects in Earth's Orbit and Cislunar Space, and to maximize the utility of functional spacecraft. Currently, satellite servicing, projected to be a $14.3 Billion revenue industry,[1] does not have dedicated spectrum allocated for priority use on orbit. This creates a significant administrative barrier to this emerging industry segment. This comment provides Starfish Space's perspective as an industry operator who anticipates providing commercial satellite servicing as soon as 2025. Starfish Space recommends the NTIA review the X-band spectrum allocation for "Earth Observing" to allow for Non-Earth Observing but visually driven satellites, such as servicers, to have access to a frequency that allows for imagery downlink.S-band and UHF are also called for consideration to provide dedicated spectrum for Telemetry, Tracking, and Command (TT&C) functions on these spacecraft.

About Starfish Space

Starfish Space is building the **Otter satellite servicer** to autonomously perform the primary missions of: life extension for satellites in Geostationary orbit (GEO) and disposal of defunct satellites and space debris in Low-Earth Orbit (LEO). The Otter is an ESPA-class vehicle capable of satellite station-keeping, inclination changes, end-of-life satellite and debris disposal, and satellite relocation. **Utilizing electric propulsion allows Otter to be 10x smaller in mass than traditional servicing spacecraft designs, which enables Starfish to build and deploy faster and at a lower cost – significantly less expensive than other options**. With its low mass and high onboard ΔV, the Otter will be capable of multiple servicing missions, maneuvering across a variety of orbits throughout its operational lifecycle.

Figure 1: Diagram of the **Otter** satellite servicer: a low-SWaP spacecraft designed for autonomous capture and maneuver of free-flying objects. Otter features **CEPHALOPOD** autonomous trajectory generation and, **CETACEAN** relative navigation software, and **Nautilus** non-destructive capture mechanism, a hardware solution that does not require pre-configured docking

[1] Halpin, Sarah. "NSR's In-Orbit Services Report Projects $14.3 Billion in Revenues as Non-GEO Constellations Grow Demand." *NSR*, 14 Feb, 2022. https://www.nsr.com/nsrs-in-orbit-services-report-projects-14-3-billion-in-revenues-as-non-geo-constellations-grow-demand/.

Starfish is developing novel Rendezvous, Proximity Operations, and Docking (RPOD) flight software and universally-compatible capture technologies that will be the foundation for future In-space Servicing, Assembly, and Manufacturing (ISAM) systems. Founded in October 2019, Starfish Space has raised over $21 Million in venture capital and has won over $12 Million in US Government contracts across NASA, Space Force, Air Force, and DIU.

Importance of Servicing Mission and Relevance to this Request for Comments

Starfish Space and the ISAM community aim to help build the future space economy and to clean up space by disposing of dead satellites and debris. We will enable timely disposal of satellites that cannot comply with the FCC's 5-year disposal, removing them as a hazard to the orbital environment. Starfish's unique architecture – including a low mass spacecraft enabled by a fully electric-propulsion design and our in-house Nautilus universal capture mechanism – is what drives widespread adoption of our affordable, readily-available system.

We see ourselves as partners with the NTIA and FCC, as we are aligned on growing and maintaining a robust space economy in a safe and sustainable manner that ensures continued access to a clean orbital environment for all space actors. Starfish Space and the satellite servicing industry at large will ensure that satellite operators can provide critical commercial services to people on Earth, that NASA and NOAA can conduct missions related to science and exploration, and that stakeholders in the defense industry can employ missions vital to U.S. national security.

Starfish is seeking access to dedicated spectrum (for Starfish and for all satellite servicing companies) to conduct imagery downloads and telemetry, tracking, and control (TT&C). Satellite servicing is critical for growth and maintenance of the future space economy and cannot exist without allocated spectrum to conduct missions unless spectrum categories are broadened. As emerging satellite servicing technologies rapidly gain market adoption, this need is more urgent than ever.

The ISAM community has national recognition with the Executive Branch's recent publication of the In-space Servicing, Assembly, and Manufacturing National Strategy from the National Science and Technology Council in April 2022[2], but is still struggling with the basics of access to space, of which one of today's primary obstacles is dedicated spectrum for these important missions.

Starfish Space's Responses to Specific Sections in the Request for Comments (questions have been broken up into segments for clarity)

Pillar #1: Spectrum Pipeline To Ensure U.S. Leadership in Spectrum-Based Technologies

Question 1: What are projected future spectrum requirements of the services or missions of concern to you in the short (less than 3 years), medium (3–6 years) and long (7–10 years) term? What are the spectrum requirements for next- generation networks and emerging technologies and standards under development (e.g., 5G Advanced, 6G, Wi-Fi 8)? Are there additional or different requirements you can identify as needed to support future

[2] https://www.whitehouse.gov/wp-content/uploads/2022/04/04-2022-ISAM-National-Strategy-Final.pdf

government capabilities? What are the use cases and anticipated high-level technical specifications (e.g., power, target data rates) that drive these requirements? How much, if at all, should our strategy by informed by work being performed within recognized standards-setting bodies (e.g., 3GPP, IEEE), international agencies (e.g., ITU), and non-U.S. regulators or policymakers (e.g., the European Union)? What relationship (if any) should our strategy have to the work of these entities? Are there spectrum bands supporting legacy technology (e.g., 3G, GSM, CDMA, etc.) that can be repurposed to support newer technologies for federal or non-federal use:?

The projected future spectrum requirements of the services and missions of concern to Starfish Space in the short (less than 3 years), medium (3-6 years), and long term (7-10 years) are listed below:

- Short: frequency for 1-2 revenue-generating Otter satellite servicer spacecraft per year
- Medium: multiple center frequencies, expanding into non-interfering center frequencies due to further coverage of orbital regimes
- Long term: Otter satellite servicer missions in all orbital environments with constellation-like spectrum needs, awaiting activation in standby between missions

In addition to providing value for commercial customers, Starfish Space's technology meets critical DoD needs in life extension, derelict spacecraft disposal, docked maneuver, and other functions of national security importance in both LEO and GEO. In order to conduct our missions, we require imagery download where data rate requirements primarily fall in X-band along with dedicated TT&C to participate in licensing process.

Question 2: Describe why the amount of spectrum now available will be insufficient to deliver current or future services or capabilities of concern to stakeholders. We are particularly interested in any information on the utilization of existing spectrum resources (including in historically underserved or disconnected communities such as rural areas and Tribal lands) or technical specifications for minimum bandwidths for future services or capabilities. As discussed in greater detail in Pillar #3, are there options available for increasing spectrum access in addition to or instead of repurposing spectrum (i.e., improving the technological capabilities of deployed systems, increasing or improving infrastructure build outs)?

Due to the FCC's approach to categorizing frequency, the amount of spectrum currently available is insufficient for satellite servicing missions such as those planned by Starfish Space.

Today, no dedicated category exists to accommodate satellite servicing or the broader ISAM community. Under the current framework, satellite servicing companies must compete for spectrum with government agencies or commercial satellite operators who are firmly entrenched in certain frequency bands. To date, operators have facilitated coordination between ISAM and other space missions by designing spacecraft which piggy-back on their clients' spectrum authorization. However, this is unlikely to be a long-term solution. Or, it means satellite servicing companies must file waivers which delay the licensing process and significantly increase costs.

In particular, Starfish Space's long-term commercial business plan includes responding in near-real-time to the needs of satellite operators in distress, similar to terrestrial on-demand rideshare

and automotive roadside services. As such, this style of advance coordination with existing spectrum authorization will not constitute an adequate long-term framework for spectrum licensing for the type of ISAM operations that ensure the safety and sustainability of the world's most valuable orbits.

It is time to build for the future. The Commission should work to identify a spectrum range, or ranges, where ISAM operators can perform safety-critical operations while protected from interference.

Question 3: What spectrum bands should be studied for potential repurposing for the services or missions of interest or concern to you over the short, medium, and long term? Why should opening or expanding access to those bands be a national priority. For each band identified, what are some anticipated concerns? Are there spectrum access models (e.g., low-power unlicensed, dynamic sharing) that would either expedite the timeline or streamline the process for repurposing the band?

Space is big, but usable space is actually quite small. One of Starfish's services is derelict spacecraft disposal, which will remove hazards in orbit and keep high-value orbits clear. We can only do this if we have the spectrum we need to perform TT&C and image collection. This is a national priority because access to space and growth of space commerce could be inhibited if limits to orbital carrying capacity are reached. The ability to conduct spacecraft disposal and life extension services directly impacts avoiding this limit.

Starfish Space recommends dedicated spectrum prior to analyzing dynamic sharing due to our mission requiring "episodic use of communications. ISAM frequency usage will vary in time, as well as duration. Communication links may be established infrequently during servicer downtimes or between mission operations but may be highly frequent around RPO maneuvers."[3] This will require more detail in how dynamic sharing is practiced that may not initially be appropriate for this capability's rollout.

Question 5: Spectrum access underpins cutting edge technology that serves important national purposes and government missions. Are there changes the government should make to its current spectrum management processes to better promote important national goals in the short, medium, and long term without jeopardizing current government missions?

In order to promote important national goals without jeopardizing current government missions, Starfish Space recommends increasing transparency and communication on NTIA and FCC collaboration with companies undergoing the licensing process. Having dedicated personnel to act as touch points, a streamlined process eliminating the needs for waivers enabled by dedicated spectrum, and insight into the roles and responsibilities of the FCC and NTIA during the licensing process are all methods for meeting this expectation. With the cooperation between industry and government increasing, particularly for emerging space technologies participating in Small

[3] www.satelliteconfers.org/wp-content/uploads/2022/11/CONFERS_Comment_FCC_ISAM_NOI_Oct2022.pdf

Business Research Initiatives (SBIR) and other research and development contracts, differences in licensing can lag behind, causing roadblocks to test and operation.

Starfish Space recommends the NTIA take an approach to spectrum management that anticipates these emerging ISAM technologies and allows for integration of this industry segment. This will enable a more straightforward path for commercial ISAM operations, including the satellite servicing operations planned by Starfish Space. By designating spectrum for these operations, NTIA can provide a spark for economic development, smoothing mission planning with a more predictable spectrum allocation and licensing process, which in turn will remove roadblocks to commercial, civil, and defense partnerships.

Pillar #3: Unprecedented Spectrum Access and Management Through Technology Development

Question 2: What policies should the National Spectrum Strategy identify to enable development of new and innovative uses of spectrum?

The National Spectrum Strategy should broaden categorization of spectrum allocation and ensure that innovative groups such as ISAM have access to streamlined processes.

Views of Others

Starfish agrees with the NTIA that "coordination has [not] been easy for any of the parties, federal or non-federal, or that it can be expected to get easier as demand increases."[4]

Starfish Space is a member of the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) and recognizes many applicable points of view here.

- CONFERS has recommended the FCC and NTIA investigate specific spectrum allocation for On Orbit Servicing in the 399.9-400.5 MHz range.[5]
- "The space operation service is not meant for downlinking ISAM payload data and is largely inaccessible in the United States."[6]
- CONFERS states that spectrum sharing with a Client "…does not work for debris removal and is not a long-term solution."

In Conclusion

[4] "Comments of the National Telecommunications and Information Administration." *ET Docket No. 13-115 RM-11341 Federal Space Station Use of the 399.9-400.05 MHz Band*, September 2021. ntia.gov/sites/default/files/publications/ntia_comments_to_fcc_in_et_dkt_no_13-115_space_launches_09-01-2021_0.pdf.
[5] "Reply Comments of the Consortium for the Execution of Rendezvous and Servicing Operations." *ET Docket No.13-115 RM 11341 Federal Space Station Use of the 399.9-400.05 MHz Band*, September 2021. www.satelliteconfers.org/wp-content/uploads/2022/10/CONFERS_Operating_Practices_REV3_Oct2022.pdf.
[6] ITU RR 1.23; US Table of Allocations (S-band Space Operation Service allocations are all reserved for Federal use or limited to commercial use in launch instances).

Spectrum usage in X-band, S-band, and UHF should be evaluated for broader use to allow for satellite servicers and the ISAM community to field our technologies for the betterment of the space ecosystem. Starfish Space technology will be used by both commercial and government partners around the world to more responsibly use Earth's orbits and alleviate congestion in space. Companies have access and insight into parts of the FCC licensing process, and could use more transparency and communication part of the NTIA coordination. Space usage is an ever evolving field and Starfish Space is eager to work with regulators on the faster fielding of these new technologies.

Starfish Space is excited to engage further with NTIA on this very important issue; please feel free to reach out to us to discuss further.

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