Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the Matter of	)	
	)	
Space Innovation	)	IB Docket No. 22-271
	)	
Facilitating Capabilities for In-space Servicing,	)	IB Docket No. 22-272
Assembly, and Manufacturing	)	
	)	

COMMENTS OF THE CONSORTIUM FOR THE EXECUTION OF RENDEZVOUS AND SERVICING OPERTIONS

The Consortium for the Execution of Rendezvous and Servicing Operations (CONFERS) is pleased to provide this comment to address the Commission's above-captioned proceeding on *Space Innovation; Facilitating Capabilities for In-Space Servicing, Assembly, and Manufacturing*.[1] We thank the Commission for the opportunity to provide further information to help create a smoother and more predictable process for licensing of current and future commercial satellite servicing activities.

[1] Space Innovation & Facilitating Capabilities for In-space Servicing, Assembly, and Manufacturing, Notice of Inquiry, IB Docket Nos. 22-271 & 22-272, 87 Fed. Reg. 56365 (Sept. 14, 2022) [hereinafter ISAM NOI].

I. Introduction

CONFERS is an industry-led advocacy organization to enable to proliferation of ISAM activities and make space more sustainable. This includes standards development, norms of behavior, awareness, and international policy dedicated to on-orbit servicing (OOS) and rendezvous and proximity operations (RPO). Since its initiation in 2017, CONFERS has grown to represent sixty-two international member organizations across the range of in-space servicing, assembly, and manufacturing.[2] As the Commission orients itself to begin work on in-space servicing, assembly, and manufacturing (ISAM), CONFERS looks forward to regular engagement in support of this topic.

II. Spectrum and ISAM Missions

Much like the umbrella of ISAM includes diverse and discrete applications, the variety of radiocommunication links involved in ISAM missions also encompass a wide range of possibilities across many different types of missions. Even within the same ISAM mission, the spectrum needs may vary widely depending on the specific mission phase. This makes spectrum allocations for ISAM missions fundamentally different than many other satellite missions and difficult to explicitly define. Instead, we suggest using the following attributes to help identify a regime to coordinate ISAM frequency usage.

Qualifiable attributes:

- ***Priority level of communications***. Varying phases of space operations may necessitate different priority levels of communication. For example, communications are a "high" priority during RPO, when proximity to another satellite means certain communications may need to be prioritized over others to ensure spaceflight safety, compared to normal station keeping operations.
- ***Time criticality of communications***. Similar to considerations of priority levels, there are delineable times during some ISAM operations for which stable communications are key.

[2] An updated list of CONFERS members can be found at https://www.satelliteconfers.org/members/

These may include scheduled communications that relay specific go/no-go decisions at waypoints.[3]

Quantifiable attributes:

- ***Duration of communications***. Discrete phases of an ISAM mission operation may implicate varying spectrum usage. For example, communication links needed during RPO may involve longer, constant communication links (eg. twenty-four hours) than links for nominal telemetry, tracking, and command (TT&C) operations that are only needed intermittently.
- ***Episodic use of communications***. ISAM frequency usage will vary in time, as well as duration. Communication links may be established infrequently during servicer down-times or between mission operations but may be highly frequent around RPO maneuvers.
- ***Throughput of communications***. During RPO phases, sensors that underly spaceflight safety will require communication links with a relatively high throughput. This is in opposition to other mission phases, when sensors – or other instruments that downlink large quantities of data compared to TT&C – are not in use.
- ***Communication directionality***. ISAM missions are anticipated to operate Earth links (both uplinks and downlinks), space-based links, and even links to or around celestial bodies (e.g. cislunar, lunar). Space-based links can include servicer to client linkages, WiFi-like links, and more.

Given the many qualifiable and quantifiable attributes of ISAM spectrum usage listed above, it is apparent that there will not be a one-size-fits-all approach to ISAM communications. As a baseline, CONFERS urges the Commission to not prohibit ISAM missions from using any standard radiocommunication bands.

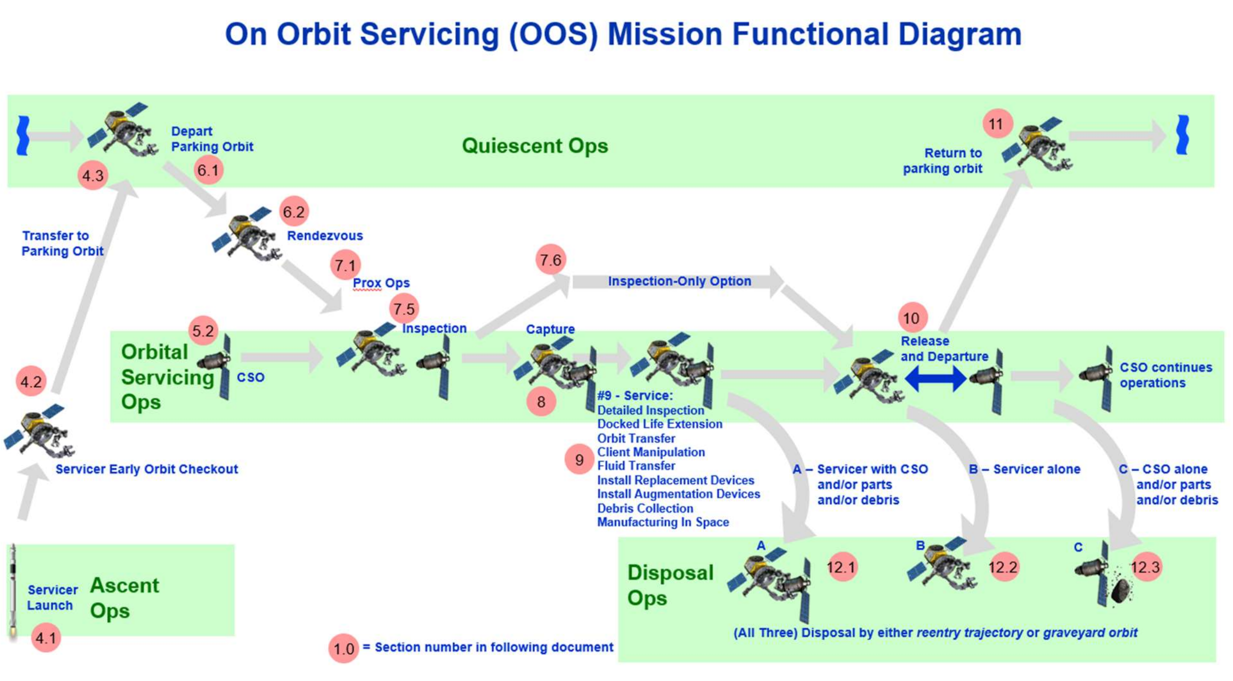
A. "Typical" ISAM Spectrum Usage

[3] https://www.satelliteconfers.org/wp-content/uploads/2019/10/OOS_Mission_Phases.pdf

As stated above, there are many types of ISAM missions, and each will have a varying communications profile. This makes defining the "typical" spectrum usage[4] a feat in frustration, but one we have nonetheless attempted. The following will relay "typical" spectrum use by data type and mission stage to the best of our ability at this time. Additional details on some specific examples of current or past commercial ISAM missions are also provided in Annex A to this submission.

First, it is possible to identify three major transmission elements for "typical" ISAM spectrum usage. An ISAM mission will need to: (1) collect data (e.g. sensing); (2) transmit operational data; and (3) perform TT&C functions. Recalling the above, each of these will likely have a different bandwidth requirement (throughput of communications). Overall, CONFERS would posit that "typical" ISAM spectrum use will be split between sensing and TT&C operations.

Second, "typical" spectrum usage can also be broken down usefully by mission stage. The CONFER mission function diagram (figure 1) provides relatively synonymous ISAM mission stages, to which spectrum use is correlated.



[4] ISAM NOI, *supra* note 1, at ¶ 12.

Figure 1. On-orbit servicing mission functional diagram with added spectrum usage during mission phases.[5]

From the above figure, several conclusions can be reached. First, spectrum usage will be mostly short term – on the order of days – from initiation of RPO to confirmation of mated operations, and again during release and departure. This is also when spectrum use may be deemed "high" priority communications and may involve higher bandwidth usage. Additionally, there is less-intensive use of bandwidth around the launch and early orbit phase (LEOP), routine operations, and the end-of-life operation phase. During these times, spectrum use is ripe for coordination with other operators, and could be a lower-priority communication.

i. Special Considerations – Communications During Mated Operations / Proximity Operations

To-date, most spacecraft communications have been to and from Earth. However, with the rise of ISAM – including the introduction of several private space stations – new attention should be paid to space-based, proximity communications.[6]

The Commission should encourage the development of an industry standard space-to-space proximity communications system. This will provide critical navigation and data coordination for both space station visiting vehicles and satellite-to-satellite proximity operations and servicing attachment. Furthermore, low-power, local-networking and point-to-point communications in space will decrease frequency coordination complexity and lower implementation and operations cost compared to solutions that would require industry-wide or global allocations.

Future standards work should consider the need for links established over Wifi, 5G, or optical communications or optical communications[7]. The link may have the capacity to "close" or

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[5] CONFERS On-Orbit Satellite Servicing Mission Phases (Updated 1 Oct 2019), https://www.satelliteconfers.org/wp-content/uploads/2019/10/OOS_Mission_Phases.pdf

[6] *See, e.g.,* Comments by the Aerospace Corporation, IB Docket Nos. 22-271 & 22-272 at 10-11 (filed Oct. 21, 2022) (noting there may be need for communication between two or more ISAM spacecraft supporting the same mission).

[7] (*Spacecraft Onboard Interface Services - High Data Rate 3GPP And Wi-Fi Local Area Communications CCSDS 883.0-B-1*) and CCSDS Standards on Optical Communications in the 141 series

establish a bi-directional handshake within 15 km of separation, to provide final navigation solutions and abort authority. Power levels, modulation schemes, and beamwidth should be chosen to minimize interference with other space-to-space links and prevent any space-to-ground interference. Also, proximity operations may use RFID for spacecraft identification.

Commission support to the development and widespread adoption of such a standard is key to assure full compatibility across all domestic and foreign spacecraft.

B. ISAM and Radiocommunication Services

CONFERS believes that an assured and efficient pathway to secure access – including by relevant proactive action in the ITU World Radiocommunication Conference 2023 (WRC 2023) proceedings – to TT&C frequencies for ISAM missions is an enabler for a reliable, sustainable, and thriving space industry which also promotes the sustainable use of the space environment. This section will address ISAM missions, and the presently defined radiocommunication service regime established by the ITU, highlighting that the FCC must work both domestically and internationally to ensure spectrum access.

ISAM missions' spectrum use overall[8] does not fit well with any of the currently-defined radiocommunication services.[9] The space operation service is not meant for downlinking ISAM payload data, and is largely inaccessible in the United States.[10] The fixed-satellite service offers the possibility of coordinated spectrum usage with some clients,[11] but is optimally used for high-bandwidth, high-coverage communications.[12] Finally, the Earth-exploration satellite service is

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[8] Note that many ISAM sensors and imaging equipment used for RPO and inspection/SSA operate in frequencies outside the typical communication frequencies. To date, these remote sensing capabilities are overseen and authorized by NOAA.

[9] ISAM NOI, *supra* note 1, at ¶ 13. *See also* Comments by the Aerospace Corporation, IB Docket Nos. 22-271 & 22-272 at 11-14 (filed Oct. 21, 2022).

[10] 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).

[11] For example, many potential geostationary clients for servicing (life extension) operations operate in fixed-satellite service bands. MEV-1 and MEV-2 both took advantage of this fact and use FSS spectrum.

[12] ITU RR 1.21.

intended for Earth-centric sensing, and not aligned with imaging artificial resident space objects or performing inspection services.[13]

The lack of fitting radiocommunication service leaves ISAM missions to creatively argue into a potential service, or – unenviably – to face the situation where spectrum usage is non-conforming.[14] It is not reasonable to authorize certain safety-related phases of ISAM missions – like RPOs – on non-interference, unprotected basis.[15]

CONFERS agrees with ClearSpace that, "The licensing process at the national level and the filing process at the ITU level should consider the peculiarity of IOS [in-orbit servicing], with missions spanning various orbital regimes, having short periods with critical communications needs, and servicing different client objects. These processes should make sure missions that support safe and sustainable operations have assured spectrum access..."[16] While coordination has been shown to be effective and should be embraced by satellite operators to the full extent possible, this approach is not adequate for all ISAM missions in the near term or future.[17] Such conditions will greatly inhibit growth and decrease the probability of a successful ISAM sector developing. Further, ISAM missions will move across orbits making the ITU filling and coordination process very cumbersome.

At minimum, the FCC must define a clear domestic path to spectrum access for ISAM missions, considering the high-priority communications necessary to mission safety during certain phases. CONFERS urges the Commission to engage internationally as well as domestically; the ongoing preparation for WRC23 offers a timely forum to raise these considerations and work towards global solutions.

C. Coordinating for ISAM

[13] *See* appendix of Turion, noting that they were required to use EESS spectrum on a non-interference basis.

[14] 47 C.F.R. § 2.102(a),(b) (specifying that authorized uses of frequencies for radiocommunication shall be in accordance with the Table of Frequency Allocations); 47 C.F.R. § 2.106 (Table of Frequency Allocations).

[15] ISAM NOI, *supra* note 1 at ¶ 13

[16] ClearSpace Today Ltd, Comment Letter to UK Office of Communications regarding Consultation: Space Spectrum Strategy (2022), https://www.ofcom.org.uk/__data/assets/pdf_file/0016/241900/ClearSpace-Today-Ltd.pdf

[17] *See* appendix of ELSA-d, where a 2-week coordination requirement was unworkable for contingency operations.

Existing architectures should be taken into account when making way for the future.[18] ISAM services have historically been expected to continue to utilize existing commercially available TT&C services. Any required operational changes will result in significant cost escalations and reduce the viability of ISAM missions.

However, CONFERS would caution that pursuit of coordination must be tempered by operational understanding. To date, operators have facilitated coordination between ISAM and other space missions by designing spacecraft which piggy-back on their clients' spectrum authorization.[19] When possible, this is a good tactic, as it does not alter the already-coordinated spectrum environment. However, *this does not work for debris removal and is not a long-term solution*. It is naïve to think that an ISAM operator will always know their client – and client's frequencies – enough in advance to impact an ISAM mission's design, particularly as the ISAM industry matures and moves towards more ad hoc services in support of customer needs in the moment.

The Commission must work to identify a spectrum range, or ranges, where ISAM operators can perform safety-critical operations while protected from interference.

D. Communication Beyond Earth's Orbit

ISAM missions will support communication links throughout space, and not necessarily to Earth. The Commission may require standards, when appropriate, for orbiting and surface-based networks and arrays on other celestial bodies to facilitate ISAM.[20] In addition to any undertaken standards work, the Commission should also work with other international bodies – like the ITU – to establish such standards.

III. Licensing ISAM Missions

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[18] ISAM NOI, *supra* note 1, at ¶ 14

[19] *See* MEV 1 & 2. *See also* Comments by the Aerospace Corporation, IB Docket Nos. 22-271 & 22-272 at 14 (filed Oct. 21, 2022) ("One concept for consideration is to authorize the operation of the ISAM systems for servicing missions within the [radiocommunication] service of the client spacecraft.").

[20] ISAM NOI, *supra* note 1, at ¶ 15.

CONFERS offers the following suggestions regarding licensing of ISAM missions.[21] CONFERS encourages the Commission to use these broad strokes of a proposed licensing regime to open a Notice of Proposed Rulemaking and determine a precise mechanism for ISAM licensing in the United States.

First, ISAM operations should be licensed under Part 25, as is appropriate for commercial missions.[22] At the same time, CONFERS cautions against removing Part 5 as a pathway for experimental licensing. Part 5 is an important pathway for hardware, and services, to become commercial. For instance, given the development timeline of ISAM missions overall, "servicing" may no longer require Part 5 to develop while "assembly" or "manufacturing" are still at a lower technology readiness level (TRL). The Commission should continue to allow operators to elect the Part 5 or Part 25 licensing as is appropriate for the stage of development of their ISAM operation.

Second, the Commission should create a regime in which an ISAM mission is license for a *category or categories* of services.[23] For example, a "servicer spacecraft" should be licensed to perform services within the specified categories (e.g. docked life extension, relocations, inclination pull downs, repair, augmentation, etc) rather than requiring a separate license for each service performed. The spacecraft license application, relative to communication needs, should identify all categories that the vehicle will perform including identification of known risks and mitigations. The license should specify the boundary conditions for use of all frequencies that meet the typical use cases of the spacecraft. If operations require exceedance of these boundary conditions, then the operator is obliged to inform the commission. Licensing by "category" of service may also alleviate the need to fit into the traditional NGSO or GSO regime, instead freeing the Commission to establish a new order that permits ISAM spectrum usage.

In addition to the above suggestions, CONFERS would also offer that the Commission may guide ISAM applicants using Guidance Circulars, or similar document. The Guidance Circulars released by NOAA's Office of Commercial Remote Sensing Regulatory Affairs (CRSRA), and Advisory Circulars released by the Federal Aviation Administration (FAA), have

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[21] ISAM NOI, *supra* note 1, at ¶ 16-22.

[22] ISAM NOI, *supra* note 1, at ¶ 17.

[23] ISAM NOI, *supra* note 1, at ¶ 18.

both been helpful to industry in interpreting their new regulations. As always, this carries the disclaimer that official Guidance should not be used as an alternative way to regulate.

A. Licensing Process – Satellite Servicing Missions

As a first note, the Commission and its statutory authority is concerned with efficient use of a limited resource, spectrum, for the public benefit.[24] Any questions that approach "authorization" or "continuing supervision" for the FCC to license servicing missions[25] are beyond the scope of the authority delegated to the FCC, and beyond concerns about spectrum use.[26]

The FCC should limit any international showings or documents required for servicing to those currently required for similar co-location scenarios between international assets. From a communications perspective, the client spacecraft is already licensed. There should be no need for client to obtain a license revision for the servicing mission unless the client spacecraft using new or unlicensed frequencies during or following the service.

The FCC should also consider cases where the servicer spacecraft and the client space object are owned by the same entity, such as a transportation service provider with space tugs and propellant depots or other in-space facilities. This customer should be able to get a single license for their communications between their vehicles and facilities. They may still need a different license to cover communications between their systems and clients.

B. Licensing Process – Assembly, Manufacturing, and Other Activities

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[24] *See* 47 U.S.C. §§ 301, 303 (2022).

[25] ISAM NOI, *supra* note 1, at ¶ 23.

[26] *See* Off. Sci & Tech. P., Exec. Off. Of the President, Letter to Chairman Thune and Chairman Smith (Apr. 4, 2016), https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/csla_report_4-4-16_final.pdf ("The unprecedented commercial space activities…such as activities on the Moon…implicate provisions of the Outer Space Treaty in ways **not clearly addressed by the existing licensing frameworks**. While existing licensing frameworks provide clear means to address certain aspects of these activities, they do not, by themselves, provide the United States Government with a straightforward means to fulfill its treaty obligation to ensure the conformity of these activities with the provisions of the Outer Space Treaty.") (emphasis added).

It is too premature to establish prospective requirements for assembly and manufacturing.[27] However, they should follow standard license requirements of debris mitigation, spectrum use, remote sensing, etc. Any orbital debris requirements that are made with ISAM in mind should be performance-based.

C. Licensing Process – International Considerations

CONFERS encourages the USG, with support from the Commission, to communicate internationally about licensing considerations for ISAM.[28] These conversations could be formalized in an Accord, or other international instrument, and address items such as communication frequency use, remote sensing use, and liability during the service. This would prevent the need to require State to State negotiations for each servicing mission with each State.

When satellite servicing involves a U.S.-registered and a non-U.S.-registered satellite, consent from the State of Registry of the serviced satellite must be secured. In the absence of an international instrument in place between the two states involved, an efficient process to request and secure consent from the State Department in case a non-U.S.-registered satellite wants to service a U.S.-registered satellite should be in place. Similarly, a process to request and secure consent from a foreign state though the State Department should be established in case a U.S.-registered satellite is contracted to service a non-U.S. registered satellite.

D. Orbital Debris Mitigation & Remediation

The advent of ISAM technologies and services to extend the efficiency and operational lifetimes of client satellites also expands the toolkit of options for satellite operators to mitigate and remediate orbital debris, even in the event of anomalies or other unforeseen circumstances.

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[27] ISAM NOI, *supra* note 1, at ¶ 24.

[28] ISAM NOI, *supra* note 1, at ¶ 26. It is CONFERS understanding that any agreement between States/Administrations is required to be managed by the State Department.

Overall, it is imperative that the Commission ensure any orbital debris mitigation rules imposed on commercial operations such as OOS are performance-based, not prescriptive.[29] Such rules should also be traceable to industry best practices and standards, and adhere to international guidelines and standards, like those stemming from the Inter-agency Space Debris Coordination Committee (IADC), United Nations Committee of the Peaceful Uses of Outer Space (UN COPUOS), and the International Organization for Standardization (ISO).

The United States Government should recognize that developing standard servicing interfaces that can be adopted industry-wide will be an iterative exercise in norms-building over a multi-year period. CONFERS is confident that with the freedom to innovate outside of specific hardware mandates, ISAM providers will develop interfaces which, when included on spacecraft, serve as a best practice for mitigation of debris.[30] In tandem with other modular design approaches, the development and adoption of common inter- and intra-system interfaces of various kinds, such as for docking, refueling, power, and data connections, will accelerate the maturation of commercial ISAM servicing solutions from costly, experimental, and customized to services that are affordable, routine, and more widely applicable.

Preparing for servicing (e.g., upgrade, power and data transfer) and preparing for removal can employ differing technologies. While the former indirectly mitigates space debris as it enables to make the most of assets already in space, the latter is key to reduce the cost of removal of failed satellites and can directly help improve space safety and sustainability. While several docking interface concepts to facilitate life extension and post-mission disposal services have been publicly released, the industry has not yet coalesced around a single interface as solely applicable across enough use cases to merit mass adoption. Indeed, given the complexity and unknown unknowns involved in standing up an efficient and well-coordinated ISAM ecosystem, mandated adoption of

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[29] For example, the FAA re-write of Part 450 in 2020 was meant to move towards regulations that were performance-based, rather than prescriptive. *See* Marcia Smith, *FAA's Modernized Space Launch and Reentry Regulations Promise Flexibility*, SPACEPOLICYONLINE (Oct. 15, 2020), https://spacepolicyonline.com/news/faas-modernized-space-launch-and-reentry-regulations-promise-flexibility/; *see also* FED. AVIATION ADMIN., U.S. DEP'T TRANSP., AC NO. 450.167-1, TRACKING FOR LAUNCH AND REENTRY SAFETY ANALYSIS (Sept. 29, 2022) (releasing guidance on a possible way that performance regulations for measuring position and velocity of a launch or reentry vehicle in flight may be met).

[30] ISAM NOI, *supra* note 1, at ¶ 28.

specific hardware interfaces too soon has the potential to stifle growth and mission success. At the same time, operators are offered few incentives, positive or negative, to even consider the adoption of such interfaces, largely because current post-mission disposal standards are not strictly enforced by the regulators. Therefore, even though adoption of interfaces would improve space safety, mitigate the generation of orbital debris, and reduce the cost and risks of servicing operations, we feel its too early to mandate specific interfaces.

Additionally, CONFERS members recognize there will be a measurable amount of risk for operating in the space environment and this risk should be well understood given the increasing amount of congestion and debris present.

Finally, CONFERS urges the Commission to recognize the ISAM missions can support adherence to orbital debris mitigation requirements. When evaluating the debris mitigation plans of license applicants, the Commission should regard applicants that disclose a contract with an end-of-life servicing provider as evidence that the applicant is dedicated to full compliance with Commission standards even in the event of operational conditions outside of its control.[31] Additionally, technologies such as refueling and life extension or relocation enable licensees to comply with disposal or maneuverability requirements. The Commission should make clear that third-party options for achieving compliance are available, and operators should include consideration and preparation for the utilization of those options as part of its overarching debris mitigation planning process.

E. Activities Beyond Earth's Orbit

While CONFERS appreciates the Commission's attention to important matters such as planetary protection, the 2020 National Space Policy calls for development of these guidelines by the Director of the Office of Science and Technology Policy, in coordination with NASA, Commerce, and other agencies as appropriate.[32] It is unclear why the Commission has raised

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[31] ISAM NOI, *supra* note 1, at ¶ 30; Space Innovation IB Docket No. 22-271 Mitigation of Orbital Debris in the New Space Age IB Docket No. 18-313, Second Report and Order (September 29, 2022)

[32] Donald Trump, "The National Space Policy", *White House* (December 9, 2020) https://www.federalregister.gov/documents/2020/12/16/2020-27892/the-national-space-policy

planetary protection in this NOI.[33] CONFERS advises the FCC to align with the National Space Policy and develop policies with the rest of the USG, rather than raise the issue separately within this NOI.

IV. ISAM Into the Future

The commercial space industry is rapidly maturing – what is currently a USD $400 billion-dollar industry is projected to generate more than USD $1 trillion in revenue by 2040.[34] To support the increased number of satellites placed into orbit and ensure the continuity of critical space-based services, a wide variety of in-space services are being proposed and starting to be offered – including by CONFERS member companies. Subsequently, the ISAM market is currently projected to have USD $14.3 billion in revenue cumulatively to 2031.

CONFERS offers that the Commission may review the Executive Order on Promoting Competition in the American Economy[35] as an initial resource on encouraging investment and expansion in the space industry.[36] Currently the insurance industry views the ISAM industry as high-risk, and it is difficult and expensive for ISAM mission programs to secure the needed insurance. If the Commission implements a smooth and sustainable policy for spectrum allocation to ISAM missions, particularly with dedicated allocation for high-risk phases of the mission, then the perception that ISAM missions are high risk may be abated, and innovative startup companies will have an easier time securing the needed insurance policy, in turn convincing backers to invest in their program. For both new and established companies, this will help foster the developing ISAM industry, and securing a foothold for US companies.

As our nation enters a new era of space marked by exploration, technology and achievements that exceed the wildest imaginations of previous generations, CONFERS members are playing a critical role in shaping this groundbreaking next chapter. One important requirement

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[33] ISAM NOI, *supra* note 1, at ¶¶ 32, 34-6.

[34] Michael Sheetz, "The space industry is on its way to reach $1 trillion in revenue by 2040, Citi says," *CNBC* (May 21, 2022) https://www.cnbc.com/2022/05/21/space-industry-is-on-its-way-to-1-trillion-in-revenue-by-2040-citi.html

[35] Joseph R. Biden, "Executive Order on Promoting Competition in the American Economy," *The White House* (July 9, 2021) https://www.whitehouse.gov/briefing-room/presidential-actions/2021/07/09/executive-order-on-promoting-competition-in-the-american-economy/

[36] ISAM NOI, *supra* note 1, at ¶¶ 39.

for growing the next generation space workforce is taking action to foster an inclusive industry where the best and brightest minds of all backgrounds can break boundaries. A new space workforce development coalition, announced by Vice President Harris and the National Space Council was introduced this year. This industry partnership is the latest effort to train, recruit, retain and develop the skilled talent needed to make the space industry competitive. CONFERS members see the Commission's role here is to foster spectrum engineering and legal expertise through internships that will support the growing ISAM ecosystem. Achieving our nation's ambitions in space will require the knowledge, passion and commitment of diverse and talented minds, and this latest partnership is an important step towards making inclusivity a hallmark of our industry.

V. Conclusion

CONFERS thanks the Commission for its service, and for the opportunity to highlight the great benefit that adapting the regulatory environment to empower on-orbit servicing will have.

Respectfully submitted,

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ANNEX A

EXAMPLES OF ISAM MISSION PROFILES AND SPECTRUM USAGE

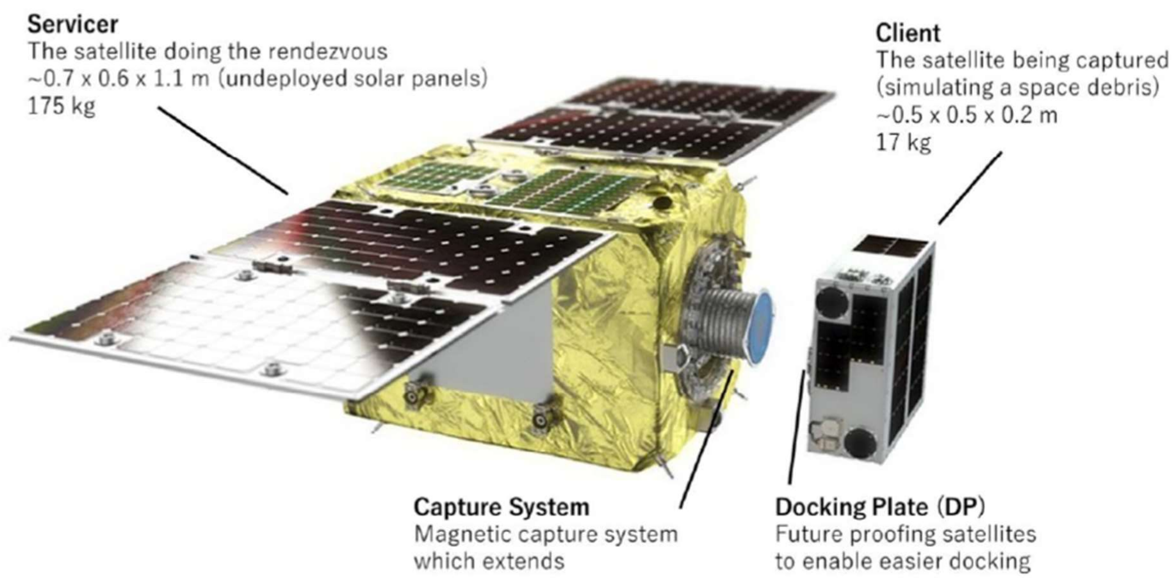
In this Annex, CONFERS members wish to showcase examples of FCC licensing experiences with ISAM activities thus far. These examples do not represent what the future may hold but give a data point of where ISAM operations have found an initial pathway in the hopes that further pathways will become more certain. The two examples provided come from Astroscale (ELSA-d) and Turion (Space Droid).

ASTROSCALE'S ELSA-D DEMONSTRATION MISSION

I. Overview of Mission

The End of Life Services by Astroscale-demonstration ("ELSA-d") mission is the first ever commercial demonstration of end-to-end orbital debris removal. The ELSA-d mission is made up of two separate spacecraft, launched jointly: a servicer satellite, ~175 kg, ("Servicer"), and an initially attached small, deployable client satellite, ~17 kg, ("Client"). The Client simulates space debris, for which the Servicer would perform removal.

The goals of ELSA-d were to demonstrate Rendezvous and Proximity Operations ("RPO") through: (1) client search; (2) inspection; (3) rendezvous and approach; (4) docking; and (5) de-orbit. To this end, the Servicer is equipped with rendezvous guidance, navigation, and control ("GNC") technologies, and a magnetic docking mechanism. The Client is equipped with a docking plate ("DP"), allowing it to be re-captured by the Servicer after deployment. These RPO demonstrations enabled the maturation of key technologies and capabilities necessary for furthering space sustainability practices.



The ELSA-d mission launched on March 22, 2021, into a 550 kilometer sun-synchronous orbit, with S- and X-band radiocommunications equipment. Each mission phase for ELSA-d is designed to generally increase in complexity, ensuring less risky demonstrations are attempted first. In August 2021, ELSA-d demonstrated its first successful undocking and docking between the Servicer and Client. The Servicer briefly released the Client, allowing it to separate a short distance. The Servicer subsequently captured the Client without issue. This validated the Servicer's magnetic capture system. In January 2022, the ELSA-d Servicer released the Client, again, and began testing its autonomous relative navigation system, maintaining a constant and safe distance from the Client for several hours, over multiple orbits, as designed. Unfortunately, ELSA-d suffered from some technical propulsion-related issues in early 2022. Despite these, in May 2022, with the capture and navigation systems validated, ELSA-d successfully completed a complex rendezvous operation guided by Space Surveillance and Tracking ("SST") providers, approaching from a far-range and switching to local relative sensors and navigation, which are key sequences in orbital rendezvous.

II. Licensing and Article VI Authority

a. Spacecraft Registration and Licensing

ELSA-d is operated by Astroscale's United Kingdom Office and received operational licensing through the United Kingdom's Civil Aviation Authority. ELSA-d is registered with the UN as a Japanese mission with Japan's Ministry of Internal Affairs and Communications handling International Telecommunications Union coordination and licensing.

Astroscale's third-party ground station providers in the United States (Denali-Brewster (Servicer only), Miami-CSTARS (Servicer only), and Pendergrass (Client only)[37]) also received STA licensing from the Federal Communications Commission to connect with the servicer and client on an unprotected, non-interference basis, including with respect to authorized federal stations. Astroscale was required to provide 2 weeks' notice and coordination to federal users of the spectrum bands requested.

Beyond the United States, ELSA-d has been licensed to communicate with ground stations in the following countries:

- Antarctica (Troll)
- Argentina (Cordoba)

[37] See FCC IBFS : SES-STA-20200113-00043, SES-STA-20200117-00055, SES-STA-20200811-00859

- Australia (Dongara; Alice Springs)
- Canada (Inuvik)
- Chile (Punta Arenas; Santiago)
- Japan (Totsuka)
- Norway (Svalbard)
- Sweden (Esrange)
- Thailand (Si Racaha)
- United Kingdom (Guildford)

b. Radiocommunication Needs

1. Frequency bands used/purpose (Telemetry D/L, Command U/L, Payload D/L)
    a. Servicer:
        i. 8450-8500 MHz: Payload Downlink (and TM downlink)
        ii. 2200-2290 MHz: Telemetry Downlink
        iii. 2025-2110 MHz: Command Uplink
    b. Client:
        i. 2200-2290 MHz: Telemetry Downlink
        ii. 2025-2110 MHz: Command Uplink

Servicer Spacecraft

Band (Allocation)	Center Frequency	Bandwidth	Data Rate	Purpose
8450-8500 MHz	8470 MHz	8.333 MHz	~ 8 Mbps	Downlink – payload data, telemetry
2200-2290 MHz	2275 MHz	16 – 256 kHz	4 - 64 kbps	Downlink - telemetry
2025-2110 MHz	2095 MHz	4 – 100 kHz	4 kpbs	Uplink - command

Client Spacecraft

Band (Allocation)	Center Frequency	Bandwidth	Data Rate	Purpose
2200-2290 MHz	2251 MHz	61 - 184 kHz	39 – 115 kbps	Downlink - telemetry
2025-2110 MHz	2073 MHz	61 kHz	~39 kbps	Uplink - command

III. Lessons Learned

ELSA-d's ground station needs are global in nature therefore a rather lengthy process was required to secure access to ground stations, particularly in the United States. While the ELSA-d spacecraft were not under the jurisdiction of any regulatory body in the United States, Astroscale Ltd. provided information above and beyond what typical foreign operators provide to a licensing administration when seeking temporary access to conduct limited transmissions. This information included a market access waiver request, market access information, an orbital debris mitigation plan, and extensive CONOPS information (including multiple discussions). These added requirements took more time and resources to work through compared to other jurisdictions globally and were duplicative at times.

Of several conditions for STA licenses through U.S. ground station providers, Astroscale was required to coordinate with federal users two weeks in advance to ensure no interference took place during operations. Federal users were very responsive in coordination efforts, however, there were segments of the mission where 2 weeks' notice was not possible. Hence, for these periods, U.S. ground stations were not used, reducing the number of up and down link opportunities during rendezvous and proximity operations.

Further, the U.S. ground station provider licensing grants for the ELSA-d mission states that "[Ground station provider Denali] shall be aware that long term or operational use of the 2200-2290 MHz frequency band by non-Federal stations in the United States is highly unlikely, and [Denali] shall have no expectations that future requests for operation or renewal of licenses in this band will be approved"[38]. This signals that S-band use for ISAM Space Operations is not likely to be an option for operators and ground station providers, whereas in the rest of the world, it remains an option.

[38] Ibid.

TURION SPACE DROID

I. Overview of Mission

Turion Space (Turion) is building satellites focused on orbital domain awareness and satellite servicing. The company's first mission (DROID.001) will observe active spacecraft and derelict objects to help map the orbital environment and assist in satellite servicing. DROID.001 will be launched in May 2023 into a 550 km sun-synchronous orbit. Turion has applied to launch DROID.001 using the FCC's streamlined smallsat application process and applied to frequency bands in both S- and X-band.

II. Licensing and Article VI Authority

Turion's streamlined application has been accepted by the FCC and is currently on public notice. DROID.001 will use S-band for TT&C and X-band to downlink high-throughput payload data. Turion applied for a 50 MHz band in the X-band to facilitate image downlinking. Additionally, NOAA has granted Turion a Tier 1 license, allowing DROID.001 to image other objects in space without restriction.

The X-band frequency (8025-8400) was the most difficult part of the application. For SSA and SDA missions, X-band is required because of the large amounts of sensor data that is generated. High-throughput communication links are required for this type of mission. However, this band is currently reserved for Earth observation missions, and because DROID.001 is only taking images of objects in orbit, and not of Earth, Turion Space had to apply on a secondary non-interference basis. This put considerable strain on the application process because Turion had to perform interference analysis on multiple constellations in-orbit to show that DROID.001 had a minimal chance of interfering with primary frequency users. The whole process added weeks of work and additional cost to the application that a typical earth observation applicant wouldn't have to do.

1. Mission phase by band table (eg).

Mission Phase	Command Uplink/bandwidth	Telemetry Downlink/bandwidth	Payload Downlink	Ground Stations used	Timeline and Cadence (continuous or limited)
LEOP	2049 .8 MHz	2220 1 MHz		Various spread around the world	
Transfer to final orbit	2049 .8 MHz	2220 1 MHz		Various spread around the world	
Final Orbit	2049 .8 MHz	2220 1 MHz	8162.5 50 MHz	Various spread around the world	

III. Lessons Learned

Overall, the streamlined licensing process worked well. The FCC has been very responsive, and the licensing process has moved along smoothly since Turion Space's application has been submitted.

However, we believe the drawbacks of applying for non-Earth observation missions are putting unnecessary strain on upcoming ISAM missions. Because the 8025-8400 MHz range is reserved for Earth observation missions, Turion Space was forced to apply on a secondary non-interference basis, which translated into additional legal and technical work, increasing the cost of the overall effort. We believe this puts us, as a startup with limited resources, at a disadvantage to other companies that are deploying Earth observation satellites.

Turion Space relies on this X-band range to downlink all images DROID.001 takes. High-throughput communication links are required for this type of mission to downlink all the sensor data that is generated. The FCC can help by supporting flexible allocation in X-band for different ISAM mission types, including SSA and SDA data collection.