Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of:

Mitigation of Orbital Debris In The New Space Age	**)** **)** **)**	**IB Docket No. 18-313**

To: The Commission

COMMENTS OF RADIO AMATEUR SATELLITE CORPORATION

The Radio Amateur Satellite Corporation (AMSAT®), pursuant to Sections 1.415 and 1.419 of the Commission's Rules [47 C.F.R. §§ 1.415 and 1.419], hereby respectfully submits comments in response to the *Notice of Proposed Rulemaking*, FCC 18-159, 84 Fed. Reg. 4742, released February 19, 2019 (the Notice). These comments are timely filed. For its comments, AMSAT states as follows.

I. Background

AMSAT is a scientific and educational non-profit corporation chartered in the District of Columbia in 1969. We design, construct, test, and operate space stations in the amateur satellite service. We also make available a variety of publications, software, educational services, and internet services promoting space science education among radio amateurs and students worldwide[1].

AMSAT has constructed and/or operated 20 amateur satellites, dating to 1970. AMSAT's success constructing and operating small satellites has been a major influence on the "small satellite revolution." In addition to their use as amateur communications satellites, the AMSAT-OSCAR 6 and AMSAT-OSCAR 7 satellites validated the use of Doppler shift analysis to locate ground-based beacons, leading to the COSPAS-SARSAT beacon location system. AMSAT-OSCAR 6 hosted the first mobile-mobile satellite communication in any radio service. The first ground-satellite-satellite-ground

[1] See www.amsat.org

communication in any radio service utilized AMSAT-OSCAR 6 and AMSAT-OSCAR 7.[2,3] Amateur radio operators observing the 435 MHz beacon on AMSAT-OSCAR 6 discovered an "Inverted Doppler" anomaly at UHF frequencies.[4] AMSAT-OSCAR 6 was also used to experimentally relay electrocardiogram data, demonstrating the utility of relaying medical data via satellite.[5] AMSAT-OSCAR 40 carried a GPS receiver to its High Earth Orbit (HEO) and demonstrated the viability of utilizing GPS signals at altitudes above the constellation.[6] As a result of this experiment, future GPS satellites have been designed to a accommodate above-constellation use. Widely used technologies such as battery charge regulators and HELAPS (High Efficiency Linear Amplification by Parametric Synthesis) were developed for and/or proven on AMSAT satellites. Since the launch of OSCAR I over 67 years ago, amateur satellites have both demonstrated the public utility of the amateur satellite service and proved that small, less-expensive satellites could perform useful scientific experiments, providing reliable communication, store-and-forward messaging, and file transfer for a wide variety of missions. Due to these successes, many groups, including government, non-profit, and commercial organizations became interested in developing constellations of small satellites.[7]

AMSAT's current satellite programs include the Fox-1 and GOLF CubeSats. The Fox-1 program consists of a series of five 1U CubeSats. Three Fox-1 satellites are currently in orbit and operational with two awaiting launch. In addition to providing amateur communications services, the Fox-1 satellites carry student-built experiments from several university partners, including Vanderbilt

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2 P. I. Klein and R. Soifer. "Intersatellite communication using the AMSAT-OSCAR 6 and AMSAT-OSCAR 7 radio amateur satellites,." *Proceedings of the IEEE*, vol. 63, no. 10, pp. 1526-1527, Oct. 1975.

3 When illuminated, AMSAT-OSCAR 7 continues to provide amateur communications services to this day — more than 43 years after launch.

4 Ron Dunbar and John Fox. "Preliminary Observations on OSCAR 6 Inverted Doppler." AMSAT Newsletter. Pp. 10-14., June 1973.

5 Joel P. Kleinman. "OSCAR Medical Data" *QST*. Pp 42-43. October 1976.

6 Michael C. Moreau, Edward P. Davis, J. Russell Carpenter, David Kelbel, George W. Davis , and Penina Axelrad. "Results from the GPS Flight Experiment on the High Earth Orbit AMSAT OSCAR-40 Spacecraft." Presented at the ION GPS 2002 Conference, Portland, OR, September, 2002.

7 G. Gould Smith "The Role of AMSAT in the Evolution of Small Satellites." *Small Satellites: Past, Present, and Future*. Henry Helvajian and Siegfried W. Janson, Ed. The Aerospace Press, 2008. pp 137 &143.

University, Virginia Tech, the University of Iowa, and Pennsylvania State University-Erie. The GOLF program will consist of a series of 3U CubeSats designed to operate in a wide variety of orbits, including Low Earth Orbit (LEO), High Earth Orbit (HEO), and beyond, providing communications services for amateur radio operators worldwide. Like the Fox-1 series, GOLF CubeSats will also carry experiments provided by university and other educational partners. These satellite programs are an efficient use of both orbital and radio spectrum resources. Amateur radio operators worldwide are able to utilize the communications services the satellites provide while also collecting telemetry and experiment data for AMSAT and our partners to utilize. In addition to our own satellite programs, AMSAT has partnered with the Husky Satellite Lab at the University of Washington to provide an amateur communications system for its HuskySat-1 CubeSat. This system will provide telemetry and command capability for the satellite and communications services for the worldwide amateur radio community.

AMSAT understands the risks associated with excessive orbital debris. We are committed to being good stewards of orbital resources. However, we also caution against overregulation which would harm the amateur satellite service by imposing excessive costs on amateur satellite operations. We note that AMSAT currently has fewer than 3,500 members and annual gross receipts of less than $600,000. Additional regulatory costs would greatly harm our ability to build, launch, and operate satellites in the amateur satellite service.

II. The Commission should consider the long mission duration of amateur satellites when determining the timeframe required for a satellite to naturally de-orbit or be transferred to a parking orbit.

Amateur satellites often have longer lifetimes than other small satellites. AMSAT-OSCAR 7 is still functioning over 44 years after its launch. Additionally, several other satellites launched by amateur groups have had long lifetimes. One of the most popular amateur communications satellites, the Japan

Amateur Radio League's Fuji-OSCAR 29, has been in service for over 22 years. Contrary to other small satellite missions which may plan for service lifetimes of a few months to a year, AMSAT, and other amateur groups, design and build satellites to function for the longest possible lifetime. AMSAT's Fox-1 satellites are designed to function as amateur repeaters even if the Internal Housekeeping Unit fails.[8] The FUNcube Project's AMSAT-OSCAR 73 is designed to function in sunlight even after its batteries fail. We note that current orbital debris mitigation rules require de-orbiting or transfer to a disposal orbit within 25 years after the end of the mission. However, due to the high failure rate, CubeSat missions are often assumed to have missions lasting "zero years." Due to AMSAT's long track record of successful missions, we would ask for flexibility for a longer orbital lifetime before de-orbit or transfer to a parking orbit on the basis of perhaps a planned five or ten-year lifetime. We also believe that a transfer (or direct launch) to a recognized parking orbit should satisfy the orbital debris mitigation requirements.

III. The Commission should consider alternatives to the proposed rule that appears to restrict the deployment of satellites in low earth orbit planned to be disposed through atmospheric re-entry to orbital altitudes of 650 km or below.

The Commission proposes to amend Section 97.207 of the Commission's rules to require additional information in the debris mitigation disclosure required as part of the written notification by the amateur space station licensee. AMSAT has no objection to requiring this additional information.

We do note, however, that Section 97.207(g)(1)(v)(C)(2) of the proposed rule appears to limit the deployment of amateur satellites planned to be disposed through atmospheric re-entry in low earth orbit to 650 km or below. We believe this is unnecessarily restrictive. Had this rule been in place, we would not have been able to deploy our AMSAT-OSCAR 85 (launched in 2015) or AMSAT-OSCAR 91 (launched in 2017) satellites into their present orbits. Both of these satellites were deployed into

[8] As required by Commission regulations, AMSAT retains the capability to terminate the satellites' transmissions in the event of an IHU failure.

elliptical orbits with apogees of approximately 800 km and perigees of between 450 km and 490 km. This type of orbit allows for periodic longer range communications (for example between the East Coast of the United States and Western Europe) while still ensuring the satellite will naturally re-enter the atmosphere within 25 years (or less). Additionally, AMSAT is currently planning for its GOLF-1 satellite to be deployed to an orbit above 1,000 km. This satellite will employ a drag device to re-enter the atmosphere within 25 years of mission completion. Implementation of this rule would appear to prohibit the deployment of this satellite to an orbital altitude that is highly desired by amateur satellite users worldwide for longer communications ranges than are possible with a satellite deployed into an orbit below 650 km. We urge the Commission to consider alternatives to this rule for amateur satellites deployed in low earth orbits between 650 km and 2,000 km.

IV. The proposed indemnification requirement would likely end the ability of organizations in the United States to launch and operate amateur satellites.

The Commission proposes to amend Section 97.207 of the Commission's regulations to require the amateur license grantee of each space station to "submit an executed agreement indemnifying the United States against any costs associated with claims brought against the United States related to the authorized facilities." While we understand the treaty requirements behind this proposal, we have serious concerns about its implementation in the amateur satellite service.

First, amateur licensees are, under Commission rules, individuals who have no pecuniary interest in the operations of their stations. All licensees and control operators for AMSAT's satellites are volunteers. An indemnification requirement would put them in serious financial jeopardy were there to be a claim against the United States related to an amateur space station operating under their license. It seems unlikely that a volunteer would execute such an indemnification agreement absent an insurance

policy that would cover the costs associated with such a claim. A lack of volunteers willing to become licensees due to these requirements would obviously make it impossible to operate amateur satellites.

The United Kingdom currently requires both indemnification and third-party liability insurance of 60 million GBP for amateur satellite operations[9]. No amateur satellite organization in the United Kingdom has successfully navigated these requirements nor even been able to obtain a quote from an insurance provider to determine how much such a policy might cost. As an alternative to navigating this system, our sister organization, AMSAT-UK, sold their FUNcube-1 spacecraft to AMSAT-Netherlands for 1 EUR prior to launch. The spacecraft was registered as a Netherlands spacecraft, where the total costs are approximately 2,000 EUR per year, including license fees and insurance costs.

We believe that the proposed indemnification requirement would end the ability for organizations in the United States to launch and operate amateur satellites and urge the Commission to consider alternatives. For example, satellite operators could be assessed an annual fee to establish a fund from which any claims against the United States would be paid. We note that we are unaware of any claims against the United States as a result of amateur satellite operations. While the increase in objects in orbit naturally increase the risk of a claim, a fund to pay potential claims would likely be sufficient for many years. However, the fee for amateur satellite operations must be set at a low enough rate to be affordable for amateur satellite operators. As noted above, AMSAT's annual revenue is less than $600,000. Amateur satellite programs at universities, high schools, or other non-profit entities may have even fewer resources.

[9] "Guidance for Licence Applicants Outer Space Act 1986" https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/744428/GUIDANCE_FOR_APPLICANTS_Revised_08-08-2018_sw1.pdf Retrieved 4/2/19

V. The Commission's proposed requirement that telemetry be encrypted if an amateur space station includes an onboard propulsion system is unnecessary and counter to the spirit of the amateur service.

Section 97.201(h)(i) of the proposed rule requires that "operators must encrypt telemetry, tracking, and command communications with the space station." We agree that command communications must be encrypted if a satellite carries onboard propulsion. However, we believe requiring telemetry and tracking communications to be encrypted is unnecessary and counter to the spirit of the amateur service. Additionally, this proposed requirement may result in unneeded cost and complexity for amateur satellites. We also note that Article 25.2A of the ITU Radio Regulations restricts the use of encryption to "control signals exchanged between earth command stations and space stations in the amateur-satellite service."

Amateur radio satellite operators are expected to publish their telemetry specifications openly so all interested amateur operators may decode and study the telemetry. Operators who fail to do this are often criticized by amateur satellite enthusiasts.[10] AMSAT currently publishes all of its telemetry specifications and publishes free, open-source decoding software for our satellites. Additionally, we provide a website that shows the latest telemetry values from each of our spacecraft.[11]

Open access to telemetry values is also critical to the educational component of amateur radio satellites. There are numerous lessons that can be derived from satellite telemetry. For example, a teacher of elementary school students could incorporate the live reception of satellite telemetry into a lesson and have the students plot solar panel voltages, thus demonstrating how a satellite passes in and out of the sunlight on a periodic basis.[12] We urge the Commission to decline to adopt this section of the

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[10] "Satellites for which frequencies that have not yet been coordinated or owners who are unwilling to publish telemetry information." DK3WN SatBlog. http://www.dk3wn.info/p/?page_id=92180 Accessed 4/3/19.

[11] https://www.amsat.org/tlm/

[12] Other examples of educational uses of amateur satellite telemetry can be found at http://www.arrl.org/classroom-library-satellite-communications

proposed rule.

VI. The Commission should exempt amateur space stations co-located on other spacecraft from orbital debris mitigation regulations under Part 97.

We urge the Commission to consider adopting language that would exempt amateur space stations co-located on spacecraft carrying space stations operating in other radio services from both the orbital debris mitigation requirements currently in place in Part 97 of the Commission's rules and those proposed in this rulemaking. AMSAT continues to seek partnerships with other organizations, including commercial organizations and government entities, to fly amateur payloads aboard commercial or government-owned spacecraft. Requiring the amateur licensee for this payload to submit the information required for orbital debris mitigation purposes would be redundant as the primary operator of the spacecraft would already have to demonstrate their compliance with the applicable orbital debris requirements. We ask that the Commission adopt language as part of this rulemaking stating that amateur space stations co-located on spacecraft with space stations authorized under Part 25 of the Commission's regulations or by the National Telecommunications and Information Administration (NTIA) are exempt from the orbital debris requirements, including any adopted indemnification requirement, in Part 97.

VII. Conclusion

Builders and operators of satellites in the amateur satellite service continue to provide immense value to the growing field of small satellites by serving as a platform for experimenters to conduct a wide variety of experiments relating to the radio technique. As noted above, experiments conducted by amateur satellites have informed and continue to inform the development of the commercial small satellite industry. Additionally, student participation in amateur satellite projects provides both inspiration for young men and women to pursue careers in the commercial satellite industry and

practical experience for those careers. AMSAT and other amateur satellite builders directly inspired the creation of this rapidly expanding industry. A strong and robust amateur satellite service will continue to benefit the public interest and inspire future developments in satellite technology. We urge the Commission to carefully consider the impact of these proposed regulatory changes on organizations building and operation space stations in the amateur satellite service.

RESPECTFULLY SUBMITTED,

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