Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
SWARM TECHNOLOGIES INC.	)	
	)	
Petition for Declaratory Ruling to	)	File No.
Access the U.S. Market using	)	
NVNG UHF MSS Spectrum	)	

APPLICATION

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APPLICATION

Pursuant to Sections 25.114, 25.137, and 25.142 of the Federal Communications Commission's ("Commission" or "FCC") rules, Swarm Technologies Inc. ("Swarm"), by its attorneys and pursuant to Sections 308 and 309 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 308 and 309, submits this Petition for Declaratory Ruling ("Petition") to serve the United States market using a German-authorized constellation of up to 450 technically identical small low-earth orbit ("LEO") satellites for the provision of non-voice, non-geostationary ("NVNG") mobile satellite services ("MSS") in the 399.9-400.05 MHz (Earth-to-space) and 400.15-401 MHz (space-to-Earth) bands. The planned satellites are expected to launch over the next five years, beginning with the launch of satellites in the third quarter of 2020.

I. INTRODUCTION

Swarm is a Delaware C corporation headquartered in Mountain View, California seeking a Petition for Declaratory Ruling to Access the U.S. Market via a constellation of small two-way communications satellites utilizing Ultra High Frequency ("UHF") band frequencies for communications. Swarm's proposed constellation consists of 450 satellites with deployment altitudes ranging from 325 to 585 km and orbital inclinations ranging from equatorial to polar. The satellites will use frequencies in the 399.9-400.05 MHz band for uplink (Earth-to-space) and in the 400.15-401 MHz band for downlink (space-to-Earth) already allocated to MSS. Through its proposed constellation, Swarm will offer two-way communications services to allow end users to send and receive data anywhere in the world. The Swarm constellation will be deployed rapidly, and begin to offer commercial services even prior to full deployment of the constellation. Swarm leverages an innovative satellite design, advances in small satellite technology, and the increased availability of launch opportunities for small satellites to deliver affordable connectivity services for users and devices in remote and underserved or unserved locations.

II. NARRATIVE INFORMATION REQUIRED BY 47 C.F.R § 25

The sections below contain information required by 47 C.F.R. §25.114(c) that is not captured by the electronic Form 312 Schedule S, as well as information required by 47 C.F.R. §§ 25.114, 25.137, 25.142, 25.164, 25.165, and 25.207.[1]

A. ITU Information: § 25.111

The German Administration submitted a Coordination Request for Swarm's UHF constellation to the International Telecommunications Union ("ITU") Radiocommunications Bureau ("ITU-BR") on February 6, 2020 under Radio Regulation Article No. 9.6.[2] Accordingly, all required ITU-related fees will be paid by way of the German Administration.

[1] The information required by Section 25.114(c) of the Commission's Rules is contained in the Form 312, Main Form and Schedule S, and in the following technical narrative.

[2] *See* Coordination Request under Radio Regulation Article 9.6, Notice ID: 120520019, *ASTROBIENE*, ITU BR Registry Date: Feb. 6, 2020.

B. Description of the Network: § 25.114

Swarm's proposed constellation is comprised of four hundred fifty (450) satellites[3] in LEO that are based on its own flight proven satellite technology. Each satellite has a total mass ranging from 0.3 to 0.6 kilograms, and dimensions of 12x12x2.8 cm (¼U cubesat form factor[4]), excluding the deployable antennas. The Swarm satellites will primarily rely on passive attitude control, but include a magnetorquer assembly for a range of active attitude maneuvers. Once ejected from the launch vehicle, each satellite will be commissioned and its antennas will be released 45 minutes after deployment. Maneuvering capabilities will not be used to prolong the orbital lifetime of the satellites, and will be limited in use to collision avoidance, accelerating deorbit time, and adjusting satellite separation distance in plane.

Swarm proposes a diversity of deployment altitudes ranging from 325-585 km (*see* Section II.B.1). The altitude of Swarm satellites will decrease over time due to natural orbital altitude degradation until the satellites passively re-enter the atmosphere. None of the spacecraft components are expected to survive re-entry or reach the Earth's surface (*see* Orbital Debris Assessment Report). The minimum operational altitude at which Swarm satellites will transmit will be 300 km. Because Swarm satellites will operate at altitudes ranging from 300 to 585 km, calculations of power flux density levels at the Earth's surface were performed for a representative range of spacecraft altitudes, including the worst-case scenario of transmission from an altitude of 300 km.

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[3] The satellites have identical radiofrequency characteristics, including transmit and receive frequencies, antenna gain and patterns, and transmit power. The masses of the satellites range from 0.3 to 0.6 kg.

[4] The CubeSat standard was created in 1999 by California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab. The basic unit for the cubesat form factor ("1U") is a 10x10x10 cm cube weighing less than 1.33 kg. Swarm satellites fit within standard CubeSat deployers.

The orbital period of the satellites upon deployment will be approximately 91 to 96 minutes depending on the deployed altitude. The nominal lifetime of the Swarm satellites is between 2.6 and 4.3 years, depending on ejection altitude and satellite mass (see Table 1, below). The maximum lifetime of any deployed Swarm satellite, including a satellite rendered inoperative, is 4.3 years. As a precaution, all satellite hardware is designed for a reliability and lifetime of 20 years. Table 1 shows the proposed number of satellites in each orbit and the corresponding orbital lifetime range.[5]

Table 1: Overview of Swarm constellation, including proposed number of satellites in each orbit and the corresponding orbital lifetime range.[6]

# Satellites	Max Altitude [km]	Inclination [°]	Min Lifetime [yrs]	Max Lifetime [yrs]
60	585	45	2.7	4.3[7]
60	585	10	2.6	4.2
330	585	97-98 (SSO[8])	2.6	4.1

The ground segment of the system is comprised of a network of ground stations and mobile user terminals located both within and outside of the United States.[9] Swarm has signed contracts with 11 Teleport operators worldwide for its VHF constellation to date, and will leverage this ground network to add additional hardware for UHF communications to the proposed constellation. Ground stations will perform telemetry, tracking, and command ("TT&C")

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5 Swarm will ensure that all FCC requirements are met and future launches will replenish the satellites as needed.

6 Results were generated using the National Aeronautics and Space Administration's ("NASA") Debris Assessment Software ("DAS") version 3.0.

7 A maximum-mass (0.6 kg) Swarm satellite at an altitude of 585 km that was rendered nonfunctional would have an orbital lifetime of less than 4.3 years. Area-to-mass ratios are based on observed flight data of satellites with no active ADCS. *See Exhibit A: ODAR.*

8 Sun Synchronous Orbit ("SSO").

9 Swarm will file separate applications for authority to operate all such ground stations and user terminals with the appropriate administrations.

operations, as well as uplinking and downlinking data to and from satellites as they pass overhead. Mobile user terminals will permit subscribers to send and receive data via the Swarm satellite constellation. Swarm will file separate applications to the FCC for authority to operate any U.S. based ground station at UHF, similar to the process for VHF ground station licenses.[10]

1) Orbital Information

Swarm's anticipated launch plan for initial deployment of its 450-satellite constellation is described in the Form 312 Schedule S submission accompanying the application. However, as a secondary payload customer, Swarm is subject to launch schedule postponements and orbital parameter changes dictated by launch providers and over which Swarm has no control. Swarm therefore requests authorization to deploy and subsequently replenish its constellation on launches with parameters within the following bounds:

- Inclination: equatorial (0 degrees) to polar sun-synchronous (98 degrees)
- Apogee: 325-585 km
- Perigee: 325-585 km
- Orbital period: 91-96 min

Launches will be selected based on availability and with the goal of optimizing global system coverage (see Figure 2, below). This launch strategy will protect the constellation from launch delays and failures, ensuring that Swarm can provide reliable connectivity and geographic coverage to its subscribers. Future launches of technically identical satellites will replenish the constellation of 450 satellites and enable continued operations.

[10] For example, see Application of Swarm Technologies, Inc., IBFS No. SES-LIC-20191022-01365, Radio Station Authorization, Call Sign: E190859, Granted Jan. 13, 2020.

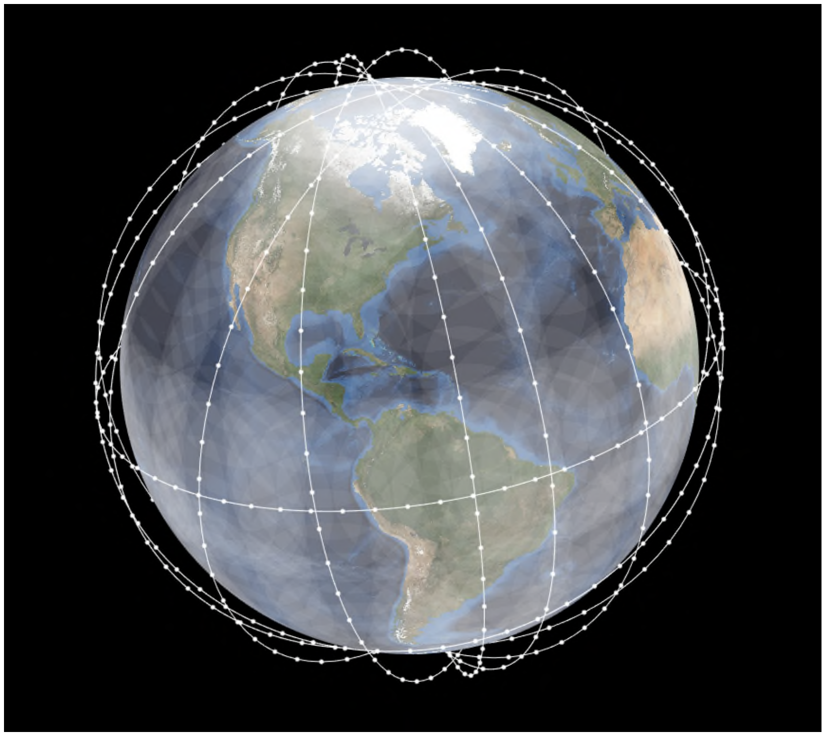

Figure 2: Swarm's proposed 450-satellite constellation will provide global two-way communications services.

2) Operations and Services

Swarm's proposed constellation will provide global two-way communication services, including service for the conterminous United States, Alaska, Hawaii, and U.S. territories.[11] User terminals will allow subscribers to transmit data to Swarm satellites, where the data is processed, downlinked to Swarm ground stations, and transferred via the Internet to a user-accessible web portal. Data can also be sent from a user web portal to a user terminal via the Swarm network. Swarm will provide connectivity services for private sector and government customers, as well as organizations and individuals. Swarm will offer its data services at a significantly lower cost than existing satellite services, providing connectivity to those that need it most, and in locations with poor or no connectivity in the United States and around the world.

11 Pursuant to 47 C.F.R. §25.142(b)(1), voice services will not be provided.

3) Satellite Design

The Swarm satellites use flight-proven software, hardware, and technology, including the following satellite subsystems:

- Flight Computer
    - Onboard processor
    - Memory
    - Temperature, voltage, current sensors

- Attitude Determination and Control
    - Passive attitude stabilization
    - Active magnetorquer system for additional pointing and maneuvering
    - 9 DOF IMU
    - 3-axis magnetometer
    - GPS

- Power System
    - Lithium ion battery for energy storage
    - Solar cells
    - Power control and power distribution

- Communications System
    - Transmitter
    - Receiver
    - Antenna

A rendering of a Swarm satellite is shown in Figure 3. The antennas are released once in orbit.

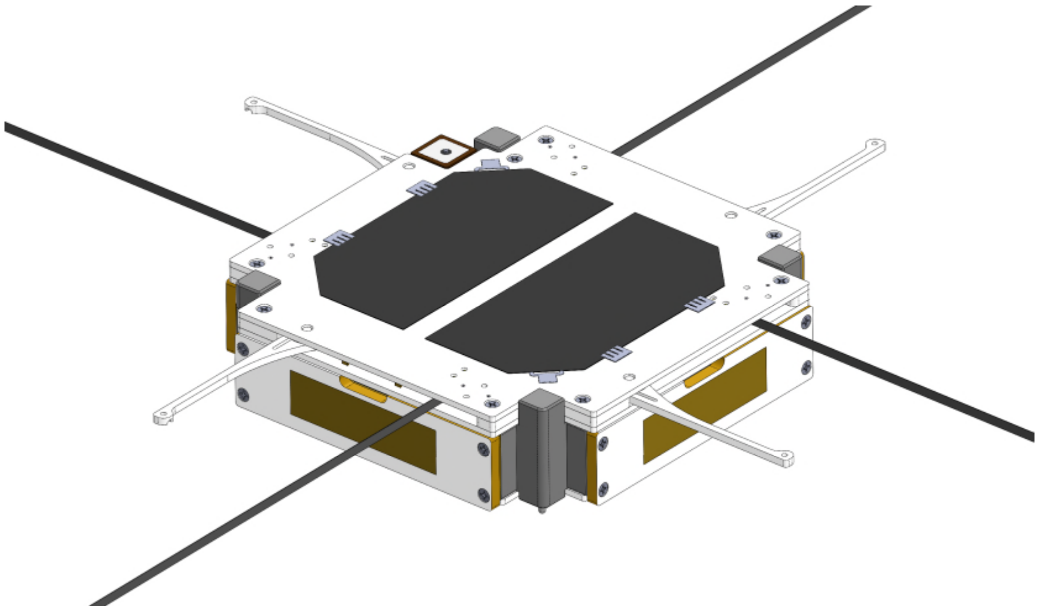

Figure 3: A CAD rendering of the Swarm satellite (antennas are cropped in this rendering). Antennas are 50 cm from tip to tip and are released once in orbit.

4) Communications Links and Frequencies

Swarm proposes to operate its system on the frequencies shown in Table 2, below, using the following communication links for two-way communications services for its customers, two-way data transfer between Swarm-operated ground stations and satellites, and for command and control of its satellites:

(i) Service Links:

The link between the satellites and user terminals will be conducted on selected frequencies within the 400.05-401 MHz band for space-to-Earth communications and the 399.9-400.05 MHz band for Earth-to-space communications (*see* Form 312 Schedule S for detailed frequency, bandwidth, and channel information). The length, interval, data rate, bandwidth, and frequency of broadcasts from satellites and user terminals are configurable by Swarm. The transmissions are sent using specific predefined channels using the F1D digital modulation type. Swarm's proposed terrestrial stations will operate pursuant to the EIRP limits recently adopted at the World Radio Conference 2019 for the 399.9-400.05 MHz uplink band.[12]

(ii) Feeder Links:

Swarm does not propose to operate exclusive feeder uplink and downlink channels within its requested frequency assignment. Instead, customer data will be transferred between Swarm's ground stations and satellites on the uplink and downlink frequencies shown in Table 2, below.[13]

(iii) Telemetry, tracking, and command ("TT&C"):

Swarm does not propose to designate channels for the exclusive purpose of telemetry, tracking, and command ("TT&C").[14] TT&C operations will be conducted on in-band links within the uplink and downlink frequencies shown in Table 2, below.[15] Command signals will be issued from Swarm's mission control centers and uplinked to the satellites from various ground stations that are operated by Swarm.

Table 2: Requested list of frequencies for the Swarm satellite system. Additional details are provided in Form 312 Schedule S.

Lower Frequency (MHz)	Upper Frequency (MHz)	Transmit or Receive Mode	Nature of Service	Operation Location
399.900	400.050	Receive (Earth-to-space)	NVNG MSS	U.S. and abroad
400.505	400.645	Transmit (space-to-Earth)	NVNG MSS	U.S. and abroad

12 See WRC-19, *Provisional Final Acts*, ADD 5A12 and 5B12 (Sharm El-Sheikh 2019).

13 The Form 312 Schedule S software allows only a single designation for each channel ("Feeder Link," "Service Link," or "TT&C"); Swarm requests that each of its uplink and downlink channels be authorized for communications service link operations for customers, feeder link operations between Swarm-operated ground stations and satellites, and TT&C operations.

14 *Id.*

15 Pursuant to 47 C.F.R. §25.202(g), Swarm's telemetry, tracking, and command signals cause no greater interference and require no greater protection from harmful interference than communications traffic on the Swarm network, and therefore may be transmitted in frequencies that are not at a band edge.

5) Bandwidth of communication links

Swarm proposes to operate multiple channels within the requested uplink and downlink frequencies shown in Table 2. As described below, Swarm is capable of varying the bandwidth of transmissions within its requested frequency bands. The data provided in this narrative and in the accompanying Form 312 Schedule S reflect Swarm's nominal initial plan for communications links, which consists of channels with a necessary bandwidth of 41.7 kHz and an assigned bandwidth of 63.0 kHz to account for Doppler shift and frequency tolerance. The proposed frequency assignments for each uplink and downlink channel are provided in the Form 312 Schedule S.

In order to allow Swarm to serve a range of current and future customer requirements, Swarm requests authorization to vary the bandwidth of channels to best address customer needs and maximize spectrum efficiency. Table 3 shows potential options for necessary bandwidth, assigned bandwidth, and power level for transmissions from a Swarm satellite.[16] In each case, the assigned bandwidth includes an appropriate frequency allowance to account for Doppler shift and frequency tolerance. For completeness Table 3 includes all emissions reflected in Swarm's ITU-BR Coordination Request. Swarm acknowledges that emissions may be restricted pursuant to the outcome of the instant processing round and spectrum sharing and coordination obligations.

Table 3 also demonstrates that the proposed emissions will not exceed the -125 dBW/m^2/4kHz power flux density ("PFD") limit specified by the ITU above which coordination

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[16] In the uplink direction, Swarm is also capable of varying the bandwidth of transmissions to address a variety of customer requirements and maximize spectrum efficiency. The potential bandwidths for uplink channels include those described in Table 3, with the exception of the 250 kHz channel which cannot be accommodated in the available uplink bandwidth between 399.9-400.05 MHz. Uplink transmissions from ground devices will comply with all applicable power and out-of-band emissions limits, and Swarm will file separate applications for authority to operate all such ground devices. For completeness Table 3 includes all emissions reflected in Swarm's ITU-BR Coordination Request.

with terrestrial services is required,[17] nor will they exceed the -255 dBW/m^2/Hz limit in the 406.1-410 MHz band for protection of the radio astronomy service.[18] In addition, all emissions will comply with the out-of-band emission limitations specified in Section 25.202(f) of the Commission's rules.

Table 3: Potential bandwidths, power levels, and PFD levels for Swarm satellite transmissions. For completeness Table 3 includes all emissions reflected in Swarm's ITU-BR Coordination Request. Swarm acknowledges that emissions may be restricted pursuant to the outcome of the instant processing round and spectrum sharing and coordination obligations.

Necessary Bandwidth (kHz)	Assigned Bandwidth (kHz)	Power Level (W)	Max PFD[19] (dBW/m^2/4kHz)	Maximum PFD[20] in RAS band (406.1-410 MHz) (dBW/m^2/Hz)
7.8	29.0	0.55	-126.0	-262.1
10.4	32.0	0.75	-125.9	-262.0
15.6	37.0	1.1	-126.0	-262.1
20.8	42.0	1.5	-125.9	-262.0
31.3	53.0	2.2	-126.0	-262.1
41.7	63.0	3.0	-125.9	-262.0
62.5	84.0	4.5	-125.9	-262.0
125.0	147.0	4.5	-129.0	-265.0
250.0	272.0	4.5	-132.0	-268.0

17 *See* 47 C.F.R. §2.106 at International Footnote 5.220 and ITU Radio Regulations, Appendix 5, Annex 1 ¶ 1.1.1.

18 See 47 C.F.R. §2.106 at International Footnote 5.208A and ITU Radio Regulations, Resolution 739 (Rev. WRC-15) and Recommendation ITU-R M.1583. As recommended in ITU-R RA.769-2 Table 1, the threshold for harmful interference is -255 dBW/m^2/Hz at a center frequency of 408.05 MHz.

19 The maximum PFD corresponds to transmissions within the downlink band at the minimum operational altitude of 300 km. PFD values were calculated using the necessary bandwidth to account for the worst-case (highest PFD) scenario.

20 *Id.*

6) Predicted Antenna Gain Contours

The predicted space station antenna gain contours for the transmit and receive beams for a Swarm satellite are shown in Figure 4, below. The antenna gain contours are depicted on a projection of the Earth with the peak antenna gain for a space station pointed at nadir to a latitude and longitude within the proposed service area. The contours are plotted at -2, -4, -6, -8, -10, -15, and -20 dB relative to the peak antenna gain.

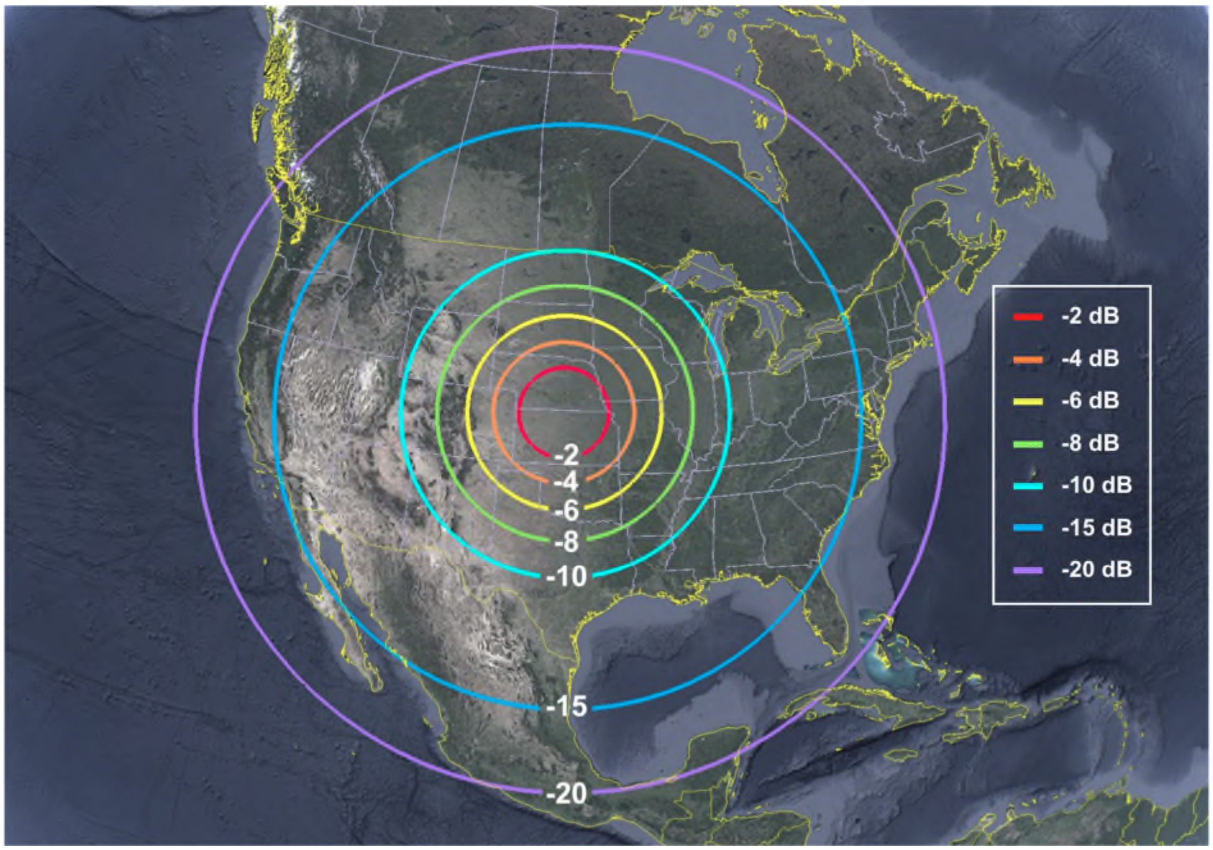

Figure 4. Antenna gain contours for a single Swarm satellite.

C. Orbital Debris Mitigation: § 25.114(d)(4)

1) Assessment and Limitation of Debris During Normal Operation

Swarm has conducted an Orbital Debris Assessment Report ("ODAR") using the National Aeronautics and Space Administration ("NASA") Debris Assessment Software ("DAS") version

3.0. The detailed ODAR is attached as a separate exhibit.[21] As discussed in the attached ODAR, the Swarm system is compliant with all applicable NASA orbital debris requirements. A summary of that report follows.

Pursuant to Section 25.114(d)(14)(i) of the Commission's rules, Swarm will not undertake any planned release of debris, and no debris items are released during deployment from the launch vehicle or release of the antennas. With the exception of the antenna deployment process, there are no moving parts on the satellite, and no flotsam is generated during the antenna deployment. More than 500 tests of antenna deployments were performed in a thermal vacuum chamber to simulate the conditions in LEO.[22] The antenna deployment mechanism currently has a 100 percent success rate, and no debris was generated during any of the antenna deployment tests. Seven Swarm satellites currently on orbit used this antenna release mechanism successfully, and the proposed satellites use a similar mechanism and build upon this flight heritage technology for their antenna deployment hardware.

Post-mission disposal is accomplished with via natural atmospheric drag forces. In the scenario of natural atmospheric drag, the satellite does not require any of the satellite subsystems to be operational, and naturally de-orbits within 4.3 years. The satellite totally demises in the upper atmosphere upon re-entry.

2) Assessment and Limitation of Accidental Explosions

Swarm has assessed and minimized the probability of accidental explosions before, during, and after the completion of the mission operations. The Swarm satellites do not have momentum wheels onboard. The only source of stored electrical energy on the Swarm satellites is a single

21 *See Exhibit A: ODAR.*

22 Tests were conducted at vacuum pressure and thermal environments representative of LEO.

rechargeable lithium ion battery. At the end of life of the satellite, the battery will be put into a permanently discharged mode. The lithium ion battery has been tested extensively in a thermal vacuum chamber with over 500 thermal cycles and more than 500 charge/discharge cycles at more extreme temperature ranges than are experienced in LEO. Lot and batch testing are also performed by the manufacturer for UN 38.3 certification, and acceptance testing was performed at Swarm's testing facilities on all batteries used for spaceflight.

3) Assessment and Limitation of Collisions

As required under Sections 25.114(d)(14)(i) and 25.114(d)(14)(iii) of the Commission's rules, Swarm has assessed the probability of the satellites becoming sources of debris by collision with both small and large objects, and an assessment using NASA's DAS tool has found Swarm's constellation to be fully compliant. In every scenario evaluated, including the worst case (longest lifetime) scenario of a maximum mass satellite deployed in a 585 km orbit, the lifetime probability of collision for any individual Swarm satellite was less than 2e-7. In addition, the aggregate probability of collision for the constellation, including the initial deployment of 450 satellites and the subsequent deployment of satellites required to maintain the 450-satellite constellation over the 15-year license term, was assessed. The aggregate probability of collision for the constellation was found to be 0.00023, significantly lower than the maximum value of 0.001 set forth in NASA Requirement 4.5-1.[23]

To the extent possible, Swarm will select orbits that are dissimilar to the orbits of other satellites in LEO. Because Swarm proposes to deploy a number of its satellites into sun-synchronous orbits that may have an increased likelihood of congestion, Swarm is willing to coordinate with other satellite operators in these and any other populated orbits. Swarm does not

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23 *See Exhibit A: ODAR.*

rely on coordination with other satellite operators for avoidance maneuvers, but will do so to the extent possible. Swarm will provide other satellite operators with a point of contact that will be available twenty-four hours per day, seven days per week to relay the information needed to assess risks and coordinate collision avoidance measures. The Swarm satellites can perform collision avoidance maneuvers using an onboard magnetorquer system that allows the satellite to maneuver into a high- or low-drag state (see Figure 5, below).

Swarm is in contact with the Combined Space Operations Center ("CSpOC") to receive conjunction threat reports for all of its satellites in orbit currently, and Swarm will continue to remain in contact with CSpOC to coordinate conjunction events with all current and future satellites.[24] Swarm will also actively track its satellites with onboard Global Positioning System ("GPS") receivers, with such GPS data transmitted to the Swarm ground stations at regular intervals. Swarm has an ongoing contract with LeoLabs, a private company offering space situational awareness data and reports, and will continue to contract with LeoLabs for additional and supplemental space tracking data, situational awareness, and collision threats. Swarm will provide both active and passive tracking data to other satellite operators upon request.

Swarm will take precautions to reduce the probability of collision with the International Space Station ("ISS") and reduce the need for avoidance maneuvers. As described above and in further detail in the attached *Orbital Debris Assessment Report*, the summed, aggregate probability of collision between the entire Swarm satellite constellation and any trackable object over the duration of the 15-year license term is 0.00023. This is significantly less than the 0.001 value established in NASA Requirement 4.5-1. To reduce the probability that the ISS will have to

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[24] As a supplemental step, Swarm has contracted with LeoLabs, a private company specializing in the tracking of satellites and orbital debris, to provide a second source of tracking and potential collision data that can supplement the data provided by the Space Surveillance Network.

perform a Debris Avoidance Maneuver ("DAM") due to a Swarm satellite, Swarm satellites will go into a high drag configuration as they pass through the ISS altitude band. This will minimize the time that Swam satellites spend at those altitudes. This operation is above and beyond the typical protocol for satellite avoidance of the ISS. Swarm will also work closely with CSpOC and the ISS program to respond to conjunction warnings and, if necessary, coordinate avoidance maneuvers. The orbital data provided by LeoLabs will also provide advance warning of potential conjunctions between Swarm satellites and the ISS.

Each ¼U Swarm satellite is highly trackable in LEO. A detailed analysis of the trackability of Swarm's ¼U satellites is attached as a separate exhibit,[25] which demonstrates that the Swarm ¼U satellites can be persistently detected and persistently tracked with comparable precision to a standard 1U satellite by normal means through the Space Surveillance Network ("SSN"). The satellites can also be tracked by normal means through the LeoLabs radar network.[26] Swarm's ¼U satellites have a radar cross-sectional area that is equal to, or larger than, ½U Aerospace Corporation satellites (NORAD IDs 40045 and 40046) and 1U STEP CUBE LAB (NORAD ID 43138) and 1U FOX-1D (NORAD ID 43137) satellites. In addition, the Swarm satellites have detection rates and orbit accuracies that are equal to, or greater than, the aforementioned ½U and 1U satellites.[27]

The orbits of the Swarm satellites will naturally decay over time due to atmospheric drag. No efforts will be made to maintain the initial orbital parameters from launch. Swarm has chosen to deploy its constellation with a maximum apogee and perigee altitude of 585 km, partially to

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25 *See Exhibit B: Trackability Analysis*.

26 LeoLabs conducted radar measurements and analyzed the trackability and detectability of Swarm's ¼U satellites currently on orbit. A report from LeoLabs regarding the trackability and detectability of the satellites is attached as a separate exhibit. *See Exhibit C: LeoLabs Report*.

27 *Id.*

avoid the orbital altitudes of some existing and proposed satellite constellations. According to analysis with NASA's DAS program, the maximum lifetime of a Swarm satellite with an apogee and perigee altitude of 585 km altitude is 4.3 years (see Table 1, above), which is less than the NASA standard for maximum orbital lifetime of 25 years[28] and less than the FCC commercial grant timeline of 15 years.[29] Swarm takes advantage of the natural atmospheric drag at the proposed altitudes to ensure that no satellite malfunction will render a satellite unable to de-orbit in a timely fashion. If any Swarm satellite is rendered inoperative, it will always passively de-orbit in 4.3 years or less.

Swarm satellites are able to use the onboard magnetorquer to maneuver into a low-drag or high-drag state. These states will be actively maintained, and can change the drag on the satellite by a factor of 3.3:1 (see Figure 5, below). If a functional Swarm satellite is commanded to de-orbit faster, it can be maneuvered into the high-drag state and deorbit in 3.6 years from the maximum 585 km altitude orbit. The low-drag state would be used specifically for collision avoidance scenarios, in situations where it will maximize the satellite's miss distance from the secondary object at the time of closest approach.

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28 *See* NASA-STD-8719.14A, Process for Limiting Orbital Debris, Requirement 4.3-1a.

29 *See* 47 C.F.R. §25.121(a)(1).

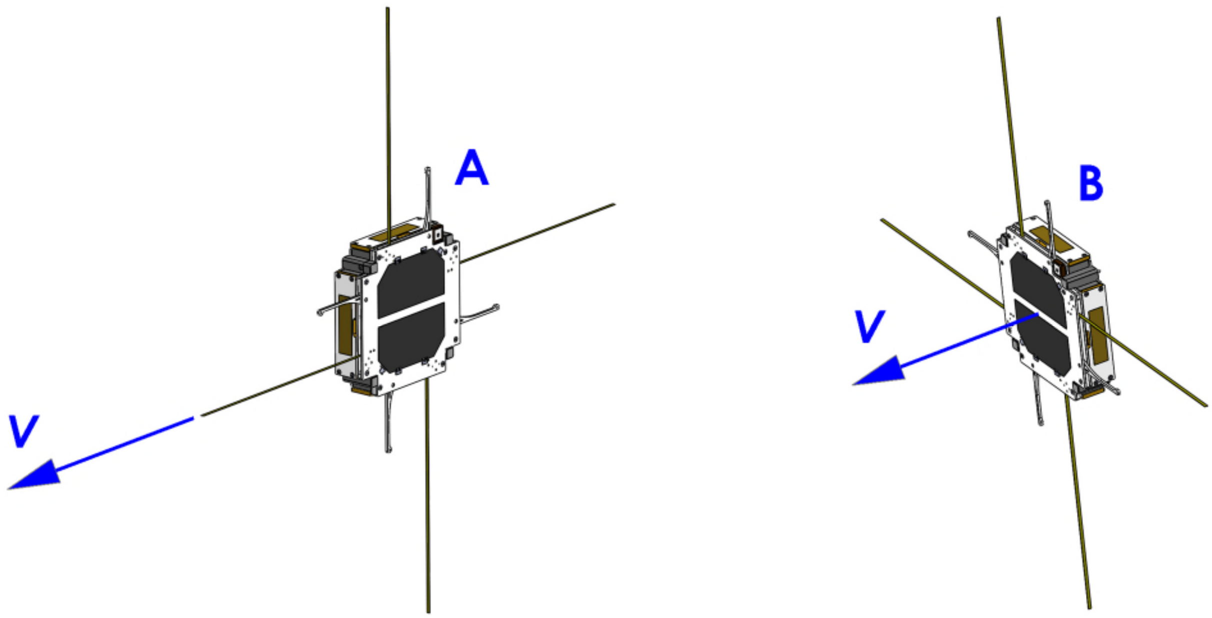

Figure 5. Flight configurations for a Swarm satellite, where "v" represents the velocity vector. (A) A Swarm satellite in the edge-on configuration, which may be actively commanded over short intervals for space debris avoidance via differential drag. (B) A Swarm satellite in high-drag flight configuration to de-orbit more rapidly.

4) Post-Mission Disposal Plans

With respect to the post-mission disposal plan, Swarm has chosen an altitude of 300 km as the end of life altitude. This altitude is stable for the Swarm satellites for approximately 1 to 3 months before a passive atmospheric re-entry occurs. At 300 km, the onboard lithium ion battery will be put into a discharge state, and the transmitter will be commanded to cease all transmissions.

Swarm has conducted a risk analysis using NASA's DAS tool to assess spacecraft re-entry hazards. As described in greater detail in the attached ODAR, none of the components of the Swarm spacecraft will survive re-entry and reach the surface of the Earth. Swarm is therefore fully compliant with the casualty probability requirements, which requires a probability of less than 1/10,000.

D. NVNG MSS Requirements: § 25.142(a)

1) Demonstration of Non-Interference

Swarm's satellites are designed to limit out-of-band emissions to prevent interference with operations in adjacent bands, as well as terrestrial, radio astronomy, and Federal government operations (vide *infra*). The power flux density at the Earth's surface from Swarm's downlink transmissions in the 400.15-401 MHz band will not exceed -125 dBW/m^2/4kHz, and emissions into the 406.1-410 MHz radio astronomy service band will not exceed -255 dBW/m^2/Hz. Furthermore, the spectrum mask for Swarm emissions complies with the limits set forth in Section 25.202(f) of the Commission's rules.

2) Power Flux Density

Swarm's proposed downlink (space-to-Earth) operations will be conducted in the 400.15-401 MHz MSS band (*see* Form 312 Schedule S for specific frequencies). Section 25.142(a)(2) of the Commission's rules requires Swarm to identify the power flux density produced at the Earth's surface by each space station in the system to allow determination of whether coordination with terrestrial services is required.

Swarm proposes to deploy its constellation of technically identical satellites in orbits with altitudes of 325-585 km. Natural orbital altitude degradation will occur over time, resulting in Swarm satellites operating at altitudes below 325 km. The minimum operational altitude at which a Swarm satellite will transmit is 300 km. Power flux density calculations were therefore conducted for a satellite operating at orbital altitudes of 300 km, 400 km, 500 km, and 585 km to reflect the range of potential power flux density values.

Power flux density values for a Swarm satellite as a function of elevation angle are specified below in Table 4 and Figure 6.[30] The power flux density values shown in Table 4 were calculated using the following parameters:

- Necessary bandwidth: 41.7 kHz
- Transmitter power: 3.0 W
- Maximum antenna gain: *see* Table 4
- Orbital altitude: 300, 400, 500, 585 km
- Bandwidth of interest: 4 kHz

Table 4. Power flux density values as a function of elevation angle.[31]

		Maximum PFD (dBW/m²/4kHz)			
Elevation angle	**Max. Gain (dBi)**	**300 km orbit**	**400 km orbit**	**500 km orbit**	**585 km orbit**
0-5°	-3.5	-129.4	-131.9	-133.9	-135.2
5-10°	-3.4	-129.4	-131.9	-133.8	-135.2
10-15°	-3.3	-129.2	-131.7	-133.6	-135.0
15-20°	-3.1	-129.0	-131.5	-133.5	-134.8
20-25°	-2.8	-128.8	-131.3	-133.2	-134.6
25-90°	0.0	-125.9	-128.4	-130.4	-131.7

The ITU specifies that space stations transmitting in the 400.15-401 MHz band require coordination with terrestrial services only if the PFD produced by the space station exceeds -125 dBW/m^2/4kHz at the Earth's surface.[32] As shown in Table 4 and Figure 6, transmissions from Swarm satellites will not exceed this threshold in any angle of arrival for any operational altitude.

30 The power flux densities provided below represent a worst-case (highest PFD) scenario. The PFD values do not account for additional real-world losses that will result in further attenuation of the PFD level at the Earth's surface.

31 PFD values were calculated using the necessary bandwidth (41.7 kHz) to account for the worst-case (highest PFD) scenario.

32 *See* 47 C.F.R. §2.106 at International Footnote 5.264 and ITU Radio Regulations, Appendix 5, Annex 1 ¶ 1.1.1.

In addition, the PFD limits specified in Section §25.208 are not applicable to the 400.15-401 MHz band.

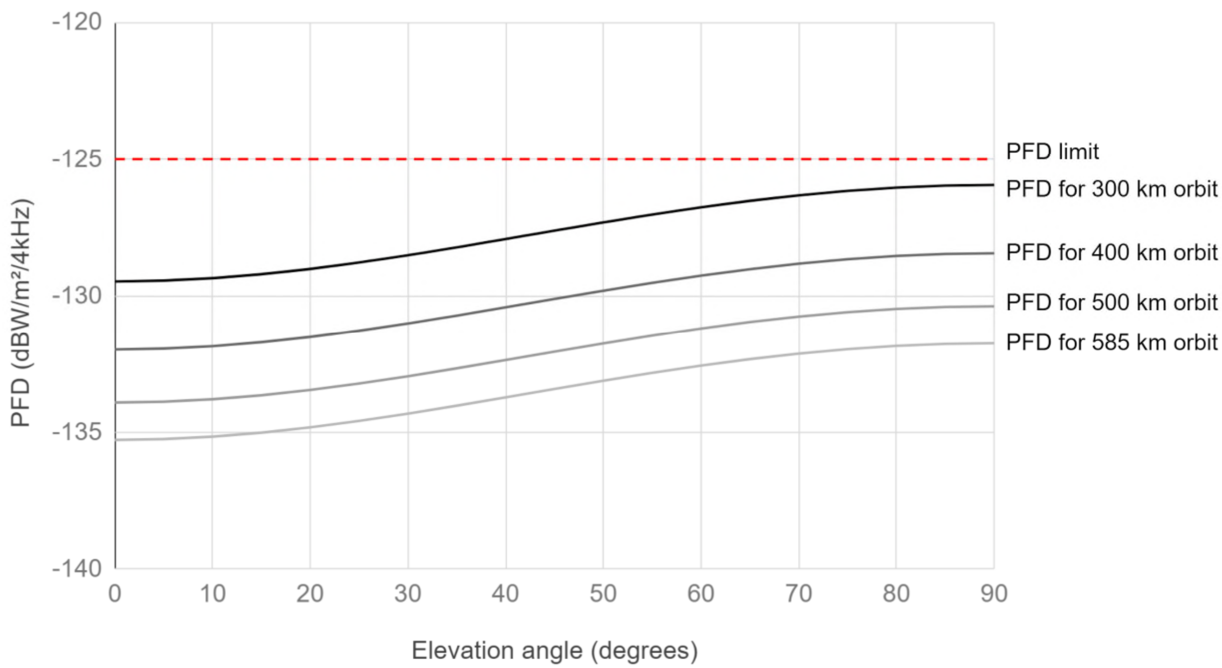

Figure 6. Power flux density at the Earth's surface as a function of elevation angle.[33]

3) Radio Astronomy Protection

Section 25.142(a)(2) of the Commission's rules requires Swarm to identify measures employed to protect the radio astronomy service ("RAS") in the 406.1-410 band. Swarm's satellites transmit only in select frequencies in the 400.15-401 MHz band, and out-of-band emissions are minimized by a combination of digital modulation techniques and filtering. These factors result in at least 100 dB spectral roll-off in the 406.1-410 MHz band, resulting in a power flux density at Earth's surface not exceeding -262 dBW/m^2/Hz for the worst case scenario of a 300

[33] PFD values were calculated using the necessary bandwidth (41.7 kHz) to account for the worst-case (highest PFD) scenario.

km orbital altitude, thereby meeting the radio astronomy service protection criteria specified by the ITU of -255 dBW/m^2/Hz (see Table 5).[34]

Table 5. Calculation of out-of-band emissions from the Swarm system into the RAS band, for an example necessary bandwidth of 41.7 kHz.

Out-of-Band Emissions into Radio Astronomy Services Band (406.1-410 MHz)	
Maximum EIRP (W)	3.0
Maximum EIRP (dBW)	4.8
Necessary Bandwidth (kHz)	41.7
Maximum PFD[35] (dBW/m²/4kHz)	-126
Bandwidth Conversion	-36
Maximum PFD[36] (dBW/m²/Hz)	-162
Spectrum Roll-off Mask in RAS Band (dBc/m²/Hz)	-90
System Filtering in RAS Band (dBc/m²/Hz)	-10
Power Density in RAS Band (dBW/m²/Hz)	-262
RAS Protection Criteria (dBW/m²/Hz)	-255

4) Emission Limitations

A spectrum mask for a representative downlink transmission from a Swarm satellite is shown below in Figure 7. These spectrum masks demonstrate that Swarm's satellites comply with the out-of-band emission limitations specified in Section §25.202(f) of the Commission's rules.

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34 *See* 47 C.F.R. §2.106 at International Footnote 5.208A and 5.208B and ITU Radio Regulations, Resolution 739 (Rev. WRC-15) and Recommendation ITU-R M.1583. As recommended in ITU-R RA.769-2 Table 1, the threshold for harmful interference is -255 dBW/m^2/Hz at a center frequency of 408.05 MHz.

35 The maximum PFD at the Earth's surface corresponds to transmissions within the 400.05-401 MHz band at the minimum operational altitude of 300 km. PFD values were calculated using the necessary bandwidth (41.7 kHz) to account for the worst-case (highest PFD) scenario.

36 *Id.*

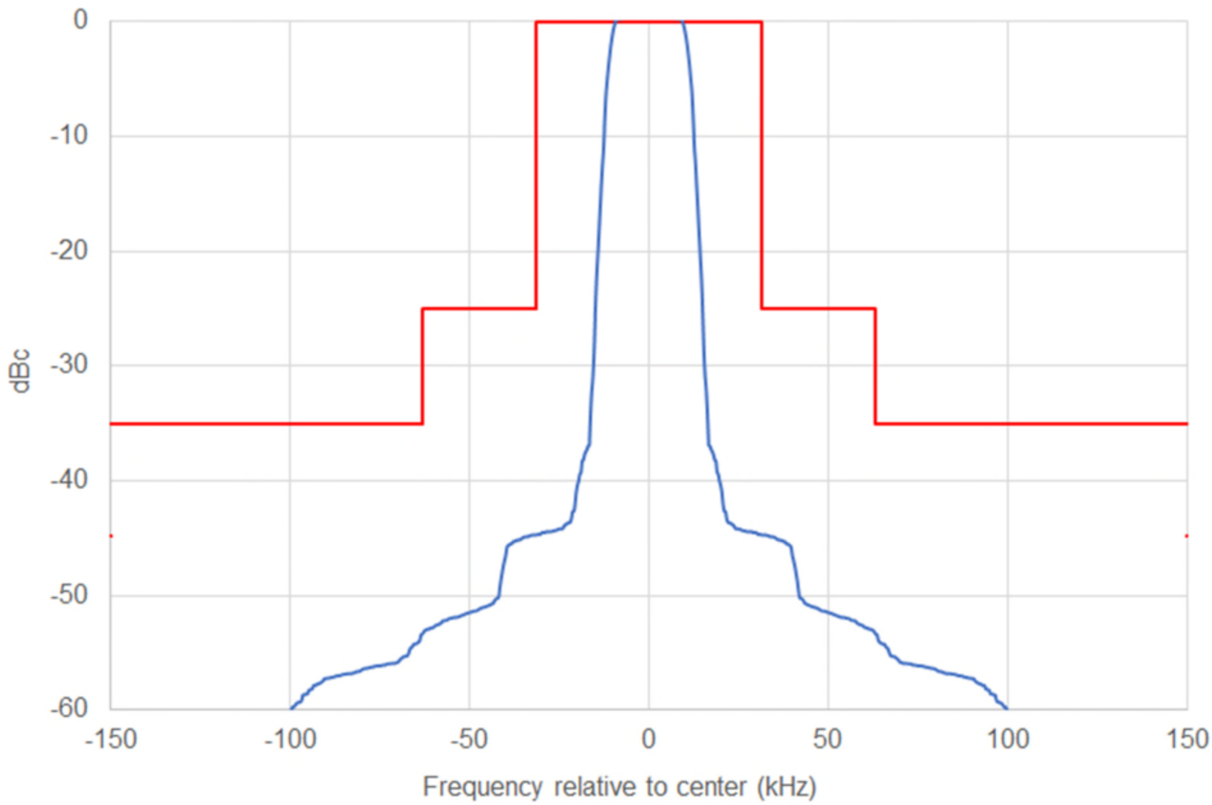

Figure 7. Spectrum mask for an example Swarm emission, in this case a 41.7 kHz emission.

In addition, the carrier frequency of each Swarm satellite will be maintained within 0.002% of the reference frequency as required by Section 25.202(e) of the Commission's rules.

5) Limits on Re-Transmission of Signal

Swarm's satellites comply with the requirement specified in Section 25.142(a)(3)(ii) of the Commission's Rules that no signal received by satellites from sources outside of the system shall be retransmitted with a PFD level exceeding the limits specified in Section 25.142(a)(2). Swarm's satellites employ onboard processing and do not utilize "bent-pipe" transponders. Signals received by a satellite that originate from Swarm user terminals and ground stations are demodulated and processed. An appropriate response is then generated, modulated, and transmitted by the satellite. Unknown or incompatible signals received by a satellite are ignored and do not result in a transmission response, ensuring that signals originating from sources outside of the Swarm network are not re-transmitted.

E. Operating Conditions and Coordination: § 25.142(b)

1) No Voice Services

Swarm will not be providing voice services with its satellite constellation.

2) Coordination with Federal Government Users

Swarm commits to coordination with all Federal Government users and is aware of the variety of existing Federal services in both the 399.9-400.05 MHz and 400.15-401 MHz bands. Swarm notes that users of this spectrum include the U.S. Army, U.S. Air Force, U.S. Navy, National Oceanic and Atmospheric Administration ("NOAA"), National Aeronautics and Space Administration ("NASA"), and Department of Energy ("DoE"). Swarm notes that uses of the spectrum include land fixed and mobile radio services, meteorological aids, atmospheric measurements, space-to-space communication systems, and space-to-Earth satellite communications. Swarm is capable of complying with the regulations described in Section 25.260 to protect Department of Defense ("DoD") operations in the 400.15-401 MHz band.[37]

Swarm has a history of successful and expedient coordination with numerous government departments and administrations in relation to its Very High Frequency ("VHF") U.S. Space Station Authorization,[38] including the National Telecommunications and Information Administration ("NTIA"), U.S. DoD, Federal Aviation Administration ("FAA"), and NOAA.

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[37] *See* 47 C.F.R. §25.260.

[38] *See* Application of Swarm Technologies, Inc., IBFS File No. SAT-LOA-20181221-00094, *Memorandum Opinion, Order and Authorization*, DA 19-1044 (Int'l Bur. Oct. 17, 2019) ("*Swarm Grant*"). See also Swarm Technologies, Inc., Application for Authority to Launch and Operate Non-Voice, Non-Geostationary Lower Earth Orbit Satellite System in the Mobile-Satellite Services, IBFS File No. SAT-LOA-20181221-00094 (filed Dec. 21, 2018) ("*Space Station Application*").

Swarm remains in regular contact with the U.S. Air Force Spectrum Management Office, the Spectrum Policy and Programs at U.S. DoD, the NTIA satellite office, the FAA, and NOAA about ongoing VHF coordination matters. Swarm commits to continuing close communication with these offices during the coordination phases of any FCC decision regarding these bands as well as during operations.

Outside of the U.S., Swarm is actively coordinating with many countries in the European Conference of Postal and Telecommunications Administrations ("CEPT") through various Electronic Communications Committee ("ECC") working groups, including Spectrum Engineering ("SE 40") Space Service Compatibility Issues and Frequency Management ("FM 44") Satellite Communications. The goal of this work is to coordinate new MSS in the VHF and UHF bands through the ECC process.

Finally, Swarm will provide any additional information requested by the Commission, such as electromagnetic compatibility analysis and coordination,[39] as may be required for coordination of the satellite system with other Federal Government users.[40]

3) Coordination with NVNG MSS Systems

Swarm remains committed to coordinating with all planned and operational satellite systems in the NVNG UHF band.

With respect to planned systems in NVNG UHF band, concurrently with the submission of the instant application Swarm provided Hiber, Kinéis, Myriota, and Spire with a pre-coordination meeting request to discuss spectrum sharing strategies and techniques.

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[39] *See* U.S. Footnote 324.

[40] *See* 47 C.F.R. §25.142(b)(2)(ii).

With respect to the sole operational system in the NVNG UHF band, ORBCOMM, Swarm similarly sent a pre-coordination meeting request concurrently with the submission of the instant application. Swarm is already actively working with ORBCOMM to coordinate our respective operations in the NVNG VHF band, and will strive to streamline discussions regarding the NVNG UHF band into this ongoing effort.

Given the operational characteristics of Swarm's proposed NVNG UHF system, Swarm anticipates successful coordination with ORBCOMM. Specifically, Swarm requests assignment of a subset of frequencies in the Little LEO NVNG UHF bands[41] that are not currently assigned to ORBCOMM on a primary basis. ORBCOMM was granted primary assignment of frequencies as a result of a processing round and rulemaking in 1997 and 1998,[42] and was granted primary assignment of additional "System 1" frequencies in 2008.[43] ORBCOMM was granted authorization to operate on a non-harmful interference basis using frequencies other than its primary assigned frequencies in the Little LEO bands, but upon commencement of operations by another U.S.-licensed NVNG MSS operator, ORBCOMM is limited to operating in its primary assigned frequency bands.[44] Therefore, should Swarm's license application be granted, ORBCOMM and Swarm would not be required to share frequencies in the Little LEO bands, limiting the risk of harmful interference between the systems. In addition, the measures Swarm employs to limit out-of-band emissions will protect ORBCOMM operations in neighboring bands.

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[41] "Little LEO" commonly refers to NVNG MSS operations in low-Earth orbit using the 137-138 MHz, 148-150.05 MHz, and 400.15-401 MHz frequency bands.

[42] See *Amendment of Part 25 of the Commission's Rules to Establish Rules and Policies Pertaining to the Second Processing Round of the Non-Voice, Non-Geostationary Mobile Satellite Service,* Report and Order, 13 FCC Rcd 9111 (1997).

[43] See *Applications by ORBCOMM License Corp., Order and Authorization,* 23 FCC Rcd 4804 (IB, OET 2008) (ORBCOMM 2008 Order).

[44] *Id.* at ¶ 11.

Pursuant to §25.142(b)(3), Swarm is willing to coordinate its proposed frequency usage with ORBCOMM to prevent harmful interference and ensure efficient use of the radio spectrum.

F. Construction Milestones: § 25.164

All of Swarm's four hundred fifty satellites will be constructed and launched within the milestone schedule specified in Section 25.164(b)(1) of the Commission's rules.

G. Surety Bonds: § 25.165

Within thirty days of grant of this application, Swarm will post the full amount of the bond required under Section 25.165(a)(1).

H. Cessation of Emissions: § 25.207

Each Swarm satellite can be turned off upon telecommand from a Swarm ground station. This ensures definite cessation of emissions as required by Section 25.207 of the Commission's rules. Each Swarm satellite has a hardware and software watchdog timer that resets the satellite if the satellite enters an anomalous condition or is subject to an upset from radiation (total ionizing dose or single event upset). Each Swarm satellite is also programmed with a 72-hour "dead-man's switch," which turns the satellite off every 72 hours. Each Swarm satellite must receive a "heartbeat" command from a Swarm earth station once every 72 hours to remain on and continue transmitting.

III. PUBLIC INTEREST BENEFITS

The grant of this application will permit Swarm to launch and operate a state-of-the-art two-way communications satellite system that empowers end users to send and receive data anywhere in the world at a fraction of the cost for comparable existing satellite services.[45]

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[45] The potential commercial and societal impact of Swarm's satellite system was recognized by two Small Business Innovation Research (SBIR) grants from the National Science Foundation (NSF). See Award 1647553 and Award 1758752.

Considerable demand exists for low-cost global satellite data services in industries including the automotive, agricultural, financial, technology, maritime, and telecommunications sectors, among others.[46] Swarm's proposed constellation is well-positioned to address these unmet needs by leveraging recent advances in small satellite technology as well as decreases in launch-related costs to provide global, low-cost connectivity.

A. Swarm Will Facilitate Communications to Underserved or Unserved Communities

The demand for remote communications[47] has created an urgent need for a low-cost satellite-based transmission medium for end users operating in underserved or unserved rural areas

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[46] *See* Comments of Aclima, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 30, 2019) ("Aclima Comments"); Comments of Arable Labs Inc., IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Arable Comments"); Comments of Arch Systems, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Arch Comments"); Comments of Autonomic, LLC, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Autonomic Comments"); Comments of Bluetown, IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) ("Bluetown Comments"); Comments of DroneSeed, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 31, 2019) ("DroneSeed Comments"); Comments of Ford Smart Mobility, LLC, IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) ("Ford Comments"); Comments of Foss Maritime Company, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Foss Maritime Comments"); Comments of The Freshwater Trust, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Freshwater Trust Comments"); Comments of Greenridge Sciences, IBFS File No. SATLOA-20181221-00094 (filed Apr. 3, 2019) ("Greenridge Comments"); Comments of Heather Mariash, IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 5, 2019) ("Mariash Comments"); Comments of Hivemind, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Hivemind Comments"); Comments of Hopkins Marine Station of Stanford University, IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) ("Stanford University Comments"); Comments of Lower Yukon School District, IBFS File No. SATLOA-20181221-00094 (filed Apr. 1, 2019) ("Lower Yukon Comments"); Comments of Social Capital, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Social Capital Comments"); Comments of Sofar Ocean Technologies, IBFS File No. SAT-LOA20181221-00094 (filed Apr. 1, 2019) ("Sofar Comments"); Comments of SweetSense, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("SweetSense Comments"); Comments of Tule Technologies Inc., IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 2, 2019) ("Tule Comments"); Comments of the University of Houston, IBFS File No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("University of Houston Comments"); Comments of Vodafone Group, IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) ("Vodafone Comments").

[47] Swarm's proposed constellation supports narrowband communications, including basic Internet connectivity (e.g., downloading a Wikipedia page), text messaging, and various developing Machine-to-Machine ("M2M") and Internet-of-Things ("IoT") applications.

of the United States and around the world.

For example, earlier this year the Commission extolled the important public interest benefits of remote patient monitoring in underserved low income and rural areas, explaining that pilot programs in Louisiana and Mississippi allowing medical professionals to remotely monitor blood pressure and other patient parameters had the ability to dramatically improve health outcomes for individuals with life threatening conditions.[48] At the same time, the Commission acknowledged that underserved rural and low income areas may not be able to access such telehealth applications due to a lack of infrastructure.[49] Alternatively, many companies are increasingly deploying Machine-to-Machine ("M2M") and Internet of Things ("IoT") technologies in rural environments to collect and analyze data that improves operational efficiencies. Among other examples, precision agriculture made possible by M2M and IoT applications has improved overall crop productivity in the U.S. by 15% in recent years, providing a competitive edge to U.S. farmers.[50] Given that existing satellite data services are prohibitively expensive, however, the M2M and IoT deployments necessary to support precision agriculture are often restricted to the geographic footprint of cellular networks.

Swarm's proposed constellation will provide a cost effective, global satellite transmission medium that facilitates a diverse range of data driven applications, including both of the above use cases, and allows consumers and business customers to fully leverage the benefit of these rapidly developing technologies.

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48 *See In the Matter of Promoting Telehealth for Low-Income Consumers*, Notice of Inquiry, WC Docket No. 18-213, ¶ 5 (rel. Aug. 3, 2018) ("*Telehealth NOI*").

49 *See Telehealth NOI* at ¶¶ 9-10.

50 *See* Kurt Marko, Forbes, Precision *Agriculture Eats Data, CPUC Cycles: It's a Perfect Fit for Cloud Services* (Aug. 25, 2015), *available at*: http://www.forbes.com/sites/kurtmarko/2015/08/25/precision-ag-cloud/.

B. Swarm Will Improve Low-Cost Satellite Connectivity Across Diverse Industries

Swarm's proposed constellation will address the significant—and rapidly growing—demand for low-cost satellite connectivity in the U.S. and worldwide. In point of fact, this demand is so great that Swarm has already developed relationships with several prominent businesses in the United States, including two U.S.-based Fortune 100 companies, that view satellite connectivity through our proposed network as a competitive advantage.

First, Swarm is working with a top automaker and other transportation companies to address connectivity solutions for connected cars, trucking, and fleet monitoring use cases. Swarm's proposed system will provide satellite connectivity for small, low-power ground devices that are ideally suited to track mobile vehicles and/or equipment in addition to static assets. Second, Swarm is working with both large agribusinesses and small precision agriculture technology startups alike to improve agricultural productivity by deploying sensors with satellite connectivity throughout U.S. farmland located outside of cellular network coverage. Third, operators in the maritime industry have expressed strong interest in adopting a low-cost solution for container tracking, crew communications, emergency response, and port operation activities. Moreover, Swarm is also developing additional commercial applications, including: pipeline monitoring, asset tracking, equipment diagnostics, weather monitoring, animal tracking, disaster detection, remote backhaul, scientific research, and emergency response services.

C. Swarm Technology Will Enhance National Security Initiatives

Swarm provides considerable public benefit by offering services that support national security operations. M2M technologies as well as personnel communications can be used in applications ranging from marine operations and ground coordination to border patrol and homeland security. Swarm has engaged with U.S. government organizations to provide connectivity services that will help strengthen our communications resiliency both domestically and around the world.

D. Swarm Increases the Impact of U.S. and Global Development Initiatives

Affordable connectivity is vital to U.S. and global development initiatives. Specifically, IoT devices using Swarm's system as a transmission medium will be capable of supporting applications that monitor air and water quality, facilitate emergency communications, and track vital weather and climate changes. Swarm-based satellite services will also support text message platforms that can connect individuals in locations without cellular or WiFi coverage. Swarm will also provide low-cost connectivity to non-governmental organizations ("NGOs"), nonprofits, and humanitarian organizations in regions with poor communications infrastructure both in the U.S. and abroad.

For example, Swarm has partnered with SweetSense, a U.S.-based company providing remote sensors for the global development sector. SweetSense plans to use Swarm's network for projects in the United States and worldwide, including monitoring groundwater resources for farmers in California and tracking the function of water pumps in East Africa to ensure uninterrupted access to clean drinking water for communities in need.

Swarm's affordable connectivity services will enable companies such as SweetSense to expand the deployment of connected sensors that monitor and evaluate the efficacy of remote water, energy, and infrastructure projects. The grant of Swarm's application will therefore support humanitarian efforts and maximize the impact of investment in U.S. and global development initiatives.

E. Swarm Will Promote Competition

One of the most important public interest considerations for Swarm's proposed constellation is enhanced competition. The Commission has long held that in evaluating market access applications where applicants are non-U.S. satellites licensed by World Trade Organization ("WTO") members to provide WTO-covered services within the U.S., it will apply a presumption that market entry would enhance competition in the U.S. satellite services market.[51] In fact, the Commission has stated that such applications are presumed to "satisfy the competition component of the public interest analysis."[52] Here, Swarm's satellite system is authorized by a WTO member, and seeks authority to provide satellite services covered by the U.S. commitments under the WTO Basic Telecom Agreement.

Even absent this presumption, however, Swarm's satellites will improve competition, and in particular for data services between satellite platforms. Although other satellite operators presently provide data services comparable in some ways to Swarm's future offerings, these operators employ older architecture developed by traditional aerospace and satellite companies that involves large on-orbit platforms that cannot cost effectively serve the communities in the U.S. and abroad that most need lifeline communications. Grant of the instant application will allow Swarm to offer an alternative service using a state-of-the-art and cost-effective platform that will enable commensurate reduction in prices for end users, which will benefit end users that have an urgent need for connectivity for telehealth, agricultural or infrastructure projects, but that cannot afford a high-cost service.

For the reasons above, grant of this application serves the public interest.

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51 *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, 12 FCC Rcd. 24094, ¶ 30-39 (1997)

IV. REQUESTED WAIVERS

A. Legal Standard

The Commission has a longstanding and well-established "obligation to seek out the 'public interest' in particular, individualized cases."[53] Accordingly, the Commission may grant waivers of its rules "on its own motion or on petition if good cause therefore is shown."[54] To successfully demonstrate good cause, a petitioner must show that: (1) the rule is inconsistent with the public interest; and (2) relief will not undermine the policy objective of the rule.[55] Waivers are appropriate where special circumstances "warrant a deviation from the general rule and such deviation will serve the public interest."[56] Courts have recognized that a rule "may not be in the 'public interest' if extended to an applicant who proposes a new service that will not undermine the policy, served by the rule that has been adjudged in the public interest."[57] The Commission will also take into consideration "hardship, equity, or more effective implementation of overall policy" on an individual basis.[58]

B. Waiver of Section 25.155(b)

Swarm requests waiver of Section 25.155(b) of the Commission's rules, which limits comparative consideration of NGSO-like satellite operations to applications received by the "cut-off" date specified in a public notice.[59] Grant of the instant waiver would not prejudice third

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52 *Id.* at ¶ 39.

53 *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).

54 47 C.F.R. § 1.3.

55 *See WAIT Radio*.

56 *Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

57 *WAIT Radio.* at 1157.

58 *Id.* at 1159.

59 47 C.F.R. § 25.155(b). The Commission established a cut-off date of October 15, 2019 for additional applications petitions for operations in the 399.9-400.05 MHz and 400.15-401 MHz frequency

parties, including existing applicants for NGSO-like satellite operations in the UHF bands; would not undermine the purpose of the Commission's processing round framework; and would serve the public interest.

First, no parties will be prejudiced by grant of the waiver. To begin with, Swarm is willing to operate on a non-interference basis with other users of the spectrum. At the time of this filing, the Commission has not granted any applications in the processing round, and no coordination efforts have concluded. In fact, other pending applicants have indicated that their proposed systems can "operate harmoniously" with other NVNG MSS systems in the UHF band.[60] For example, Kinéis stated that "its very limited bandwidth requirement can be easily coordinated with other systems in the band."[61] Similarly, Hiber asserted that because its satellites only transmit during short periods of times, its system is "fully capable of sharing with current and future NGSO systems operating in the same frequency bands, and thus there is no mutual exclusivity."[62] And Myriota attested to the flexibility and spectral efficiency of its satellites, which can vary the bandwidth of their emissions and employ frequency hopping to decrease interference potential.[63]

Likewise, Swarm's satellites feature technical characteristics that permit frequency and bandwidth flexibility, and thereby facilitate spectrum sharing as well. From the beginning,

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bands by NVNG MSS systems. See Public Notice, In the Matter of Myriota Pty. Ltd. Petition Accepted for Filing, Report NO. SPB-277, DA-19-779 (rel. Aug. 15, 2019).

60 *See* Petition for Declaratory Ruling, Legal Narrative, *Petition for Declaratory Ruling Granting Access to the U.S. Market for Non-Voice, Non-Geostationary Satellite System* at 11 ("Myriota Petition"); Petition for Declaratory Ruling, Exhibit 1, *In re the Matter of Kinéis Petition for Declaratory Ruling Pursuant to Section 25.137 of the Commission's Rules Requesting Access to the U.S. Market for a Non-Voice, Non-Geostationary Satellite Network*, at 12 ("Kineis Petition").

61 Kineis Petition, Legal Narrative at 12.

62 *See* Petition for Declaratory Ruling, *In the Matter of Hiber Inc. Petition for Declaratory Ruling to Access U.S. Market Using the Hiberband Low-Earth Orbit System* at 8.

63 Myriota Petition, Legal Narrative at 10-11.

Swarm's satellite system has been designed to coexist with other users and avoid interference to existing operations in its assigned uplink and downlink bands. Swarm uses a Carrier-Sense Multiple Access ("CSMA") media access control ("MAC") protocol with Collision Avoidance ("CSMA/CA"). With CSMA, a transmitter on the ground uses a "listen-before-talk" protocol and verifies the absence of other traffic before transmitting on a given channel. A Swarm transmitter, using a carrier-sensing mechanism, determines whether another transmission is in progress before initiating a transmission. If a carrier is sensed, the transmitter waits for the transmission in progress to end before initiating its own transmission. Therefore, using the CSMA protocol, multiple carriers on the ground can send and receive on the same channel. There is inherently a low probability of signal collision because of the low duty cycle and distributed geography of the anticipated customer deployments. CSMA/CA protocols are commonly used in many spectrum sharing environments (e.g., Wi-Fi) and have a track record of successful operations, both technically and in the marketplace. Additionally, Swarm's anticipated customer deployments (including remote agriculture, livestock monitoring, and energy applications) are largely located outside of urban areas and are geographically separated from other users. Swarm's Internet of Things ("IoT") data services are designed to send short and infrequent bursts of data rather than continuous transmissions. It is expected that most devices will transmit far less than 1% of the time (i.e., a 1% duty cycle). To ensure that services in neighboring bands are protected from interference, all emissions will comply with the out-of-band emissions limits specified in the FCC's rules. As such, Swarm's satellites are fully capable of sharing with current and planned NGSO-like systems in the UHF band and raise no exclusivity concerns.

Second, waiver of Section 25.155(b) is consistent with the Commission's policy objectives in establishing processing round rules, which were to expedite the provision of satellite services to customers and create opportunities for competitive entry.[64] The Commission has noted that the purpose of the processing round is to "prevent one applicant from unreasonably precluding additional entry by other operators in the requested frequency band."[65] More recently, the Commission clarified that the processing round framework exists to establish a sharing environment and to provide certainty in lieu of adopting an open-ended requirement to accommodate all future applicants.[66] The Commission has in some instances waived the processing round all together when parties have demonstrated that their satellites "would not preclude future entrants from using the same spectrum."[67] Here, Swarm and other applicants in the processing round have expressed a commitment to spectrum sharing, as well as an ability and readiness to accommodate future entrants in the UHF band.

In addition, as the Commission has itself recognized, the number of pending applications for NGSO-like satellite systems far exceed the number of systems that are ultimately likely to be deployed and become operational.[68] The Commission has previously permitted treatment of later applicants to approved systems on a case-by-case basis for this very reason.[69] Indeed, it would be contrary to the Commission's policy objectives to reserve spectrum and preclude additional entrants during the pendency of initial applications, and in particular where satellite systems can

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[64] *Amendment of the Commission's Space Station Licensing Rules and Policies, First Report and Ord*er, 18 FCC Rcd 10760 (2003); *see also Amendment of the Commission's Space Station Licensing Rules and Policies*, 31 FCC Rcd. 9398, FCC 16-108 (rel. Aug. 16, 2016) at ¶ 7.

[65] *In the matter of Iridium Constellation LLC Application for modification of License to Authorize a Second-Generation NGSO MSS Constellation*, 31 FCC Rcd 8675 (2016) at ¶ 41.

[66] *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, FCC 17-122 (rel. Sep. 27, 2017) at ¶ 61.

[67] *Streamlining Licensing Procedures for Small Satellites*, Notice of Proposed Rulemaking, FCC 18-44, (Apr. 17, 2018) at ¶ 42.

[68] *Id.*

[69] *Id.*

reasonably coexist with each other *and* additional entrants. Thus, consideration of Swarm's petition as a comparative application in the processing round would encourage the most efficient use of the spectrum. More importantly, it will not frustrate the Commission's goals in Section 25.157.

Third, grant of the waiver in the instant case will serve the public interest by allowing Swarm to expeditiously deploy an innovative, cost-effective network that provides global, continuous coverage, including critical and affordable lifeline communications services[70] to underserved areas of the U.S. across a broad range of commercial applications. Swarm's unique form factor allows for it to deploy and commence services on an unprecedented timescale. But timely access to spectrum is critical for Swarm to remain competitive.

As described in Section III, above, Swarm intends to provide services to the U.S. market across a broad range of commercial applications. These include but are not limited to logistics support, weather monitoring, disaster detection and recovery, emergency response services, and scientific research. Swarm's services will support customers such as agribusiness and precision agricultural companies, maritime operators seeking low-cost solutions for tracking and communications, logistics companies tracking shipments in and out of the U.S., and U.S. automakers looking to maintain a competitive edge in connected cars. Importantly, Swarm's satellites, ground stations, and user devices will cost a fraction of the price of current competitors, thus providing immediate and tangible benefits to individuals and companies who need it most. For example, Swarm's affordable rates will allow customers attempting to supplement inadequate or unreliable communications infrastructure to do so without discontinuing a legacy service that

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[70] The Commission has historically referred to "lifeline communications" as poor or underserved communities with a heavy reliance on satellite transmission for basic communications. *See, e.g., FCC Report to Congress as Required by the Orbit Act Sixteenth Report*, 30 FCC Rcd. 6644, fn. 7 (2015).

may have meaningful utility.[71] In addition, some Swarm customers in areas nearly or completely unserved by terrestrial communications networks may already subscribe to an MSS service, but may not be satisfied with the price, performance or customer support offered by their existing service provider. In this vein, Swarm's inventive systems will also promote competition and encourage innovation by adding a much needed market entrant, to the benefit of the U.S.

V. ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application and that it is complete and accurate to the best of my knowledge and belief.

/s/ Kyle Wesson
Kyle Wesson, Ph.D.
Regulatory Engineer
Swarm Technologies, Inc.

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[71] One real world scenario would be a rural customer that wants to maintain a cellular service that is effective in town but has gaps in geographic coverage when the customer travels to more remote sites for work or recreation. In such a scenario Swarm's network may serve as a cost-effective supplemental transmission medium that does not require the customer to discontinue their existing cellular service economy at large.