

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of)	
)	
SWARM TECHNOLOGIES INC.)	
)	
Application for Authority to Launch)	File No.
and Operate a Non-Voice, Non-Geostationary)	
Lower Earth Orbit Satellite System)	
in the Mobile-Satellite Services)	

APPLICATION

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December 21, 2018

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APPLICATION

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, hereby requests authority to launch and operate a constellation of one-hundred and fifty (150) technically identical non-voice, non-geostationary (“NVNG”) satellites in Low Earth Orbit (“LEO”) for the provision of mobile-satellite services (“MSS”).

I. INTRODUCTION

Swarm is a California-based corporation seeking to deploy a constellation of small two-way communications satellites utilizing Very High Frequency (“VHF”) band frequencies for communications. Swarm’s proposed constellation consists of 150 satellites with deployment altitudes ranging from 400 to 550 km and orbital inclinations ranging from equatorial to polar. Swarm requests authority to deploy its proposed constellation and launch additional satellites, as necessary, to maintain its on-orbit fleet of 150 satellites. The satellites will use frequencies in the 137-138 MHz band for downlink and in the 148-149.95 MHz band for uplink. 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, 25.142, 25.164, 25.165, and 25.207.¹

A. ITU Information: § 25.111

Swarm understands that the International Telecommunication Union (“ITU”) will impose cost-recovery fees for the ITU filing and accepts the requirement to reimburse the Commission for any and all cost-recovery fees associated with this ITU filing. A declaration acknowledging this responsibility and providing contact information for cost recovery inquiries and ITU correspondence will be submitted under separate cover. Swarm has also prepared and submitted an appropriate Coordination Request for its proposed system, including appropriate SpaceCap files required under Appendix 4 for coordination or notification of a satellite network.

B. Description of the Network: § 25.114

Swarm’s proposed constellation is comprised of one hundred fifty (150) satellites² in LEO. Each satellite has a total mass ranging from 0.31 to 0.45 kilograms, and dimensions of 11x11x2.8

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 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 0.31 to 0.45 kg.

cm ($\frac{1}{4}$ U cubesat form factor³), excluding the deployable antennas. The Swarm satellites will be stabilized using passive stabilization for coarse pointing⁴ and a magnetorquer assembly for higher-precision pointing. Once ejected from the launch vehicle, each satellite will be commissioned and its antennas will be released 45 minutes after deployment. The satellites do not have active propulsion, but can perform station keeping and collision avoidance maneuvers using differential drag.

Swarm proposes a diversity of deployment altitudes ranging from 400-550 km (*see* Section II.B.1). The altitude of Swarm satellites will decrease over time due to natural orbital altitude degradation until the satellites ultimately 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 550 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.

The orbital period of the satellites upon deployment will be approximately 92 to 96 minutes depending on the deployed altitude. The nominal lifetime of the Swarm satellites is between 2.5 and 12.2 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 12.2 years. As a precaution, all satellite hardware is designed for a reliability and lifetime of 20

³ 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.

⁴ See United States Patent Application No. US 2018/0346155 A1.

years. Table 1 shows the proposed number of satellites in each orbit and the corresponding orbital lifetime range. Future launches will replenish the satellites to ensure continued operation for at least 15 years under the proposed commercial license.

Table 1: Overview of Swarm constellation, including proposed number of satellites in each orbit and the corresponding orbital lifetime range.⁵

# Satellites	Altitude [km]	Inclination [°]	Min Lifetime [yrs]	Max Lifetime [yrs]
20	450	45	2.5	2.9
20	500	10	3.5	4.3
62	500	SSO (97.4)	3.5	4.3
48	550	SSO (97.6)	5.6	12.2 ⁶

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.⁷ Ground stations will perform telemetry, tracking, and command (“TT&C”) 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 does not propose to use inter-satellite links.

1) Orbital Information

Swarm’s anticipated launch plan for initial deployment of its 150-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

⁵ Results were generated using the National Aeronautics and Space Administration’s (NASA) Debris Assessment Software (DAS) version 2.1.1.

⁶ A Swarm satellite at an altitude of 550 km that was rendered nonfunctional or intentionally de-orbited by Swarm would have a lifetime of less than 4 years. *See Exhibit A: ODAR.*

⁷ Swarm will file separate applications for authority to operate all such ground stations and user terminals with the appropriate administrations.

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: 400-550 km
- Perigee: 400-550 km
- Orbital period: 92-96 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 150 satellites and enable continued operations. All Swarm satellites will be launched to a lower altitude than the operational satellites belonging to ORBCOMM, Iridium, and Globalstar; and would pose no debris or collision risk for those satellite operators.

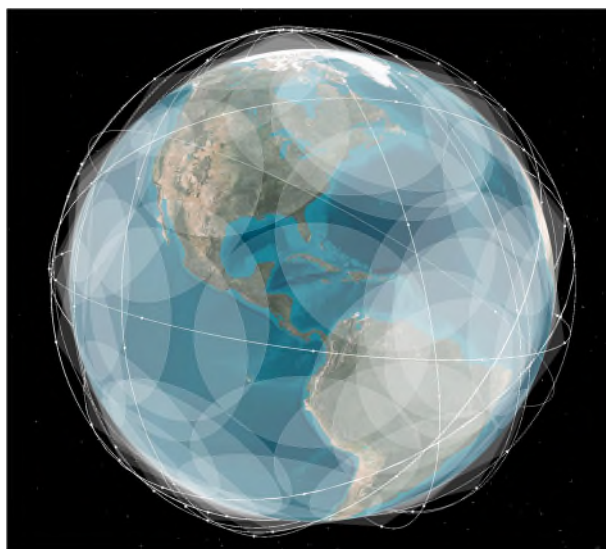


Figure 2: Swarm’s proposed 150-satellite constellation will provide global two-way communications services.

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.⁸ 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.

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 for coarse pointing
 - Active magnetorquer system for fine pointing and maneuvering
 - 9 DOF IMU
 - 3-axis magnetometer
 - GPS
- Radar reflectors

⁸ Pursuant to 47 C.F.R. §25.142(b)(1), voice services will not be provided.

- Four passive radar retro reflectors to increase radar cross-section⁹
- 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.

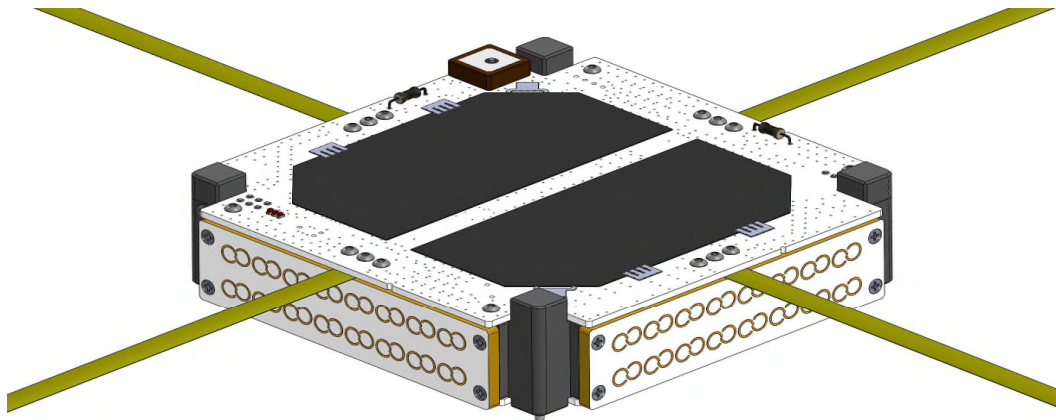


Figure 3: A CAD rendering of the Swarm satellite (antennas are cropped in this rendering). Antennas are 114 cm from tip to tip and are released once in orbit.

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-

⁹ The Swarm satellites were designed to accommodate four specially-designed passive Van Atta array radar retro reflectors. The radar retro reflectors make the Swarm satellites have a larger radar cross section (“RCS”) than a 1U satellite on average when integrated over all angles. The radar retro reflectors were developed by the Space and Naval Warfare (“SPAWAR”) Systems Center in San Diego under a Cooperative Research and Development Agreement (“CRADA”) with Swarm.

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 137-138 MHz band for space-to-Earth communications and the 148-149.95 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.

(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.¹⁰

(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”).¹¹ TT&C operations will be conducted on in-band links within the uplink and downlink frequencies shown in Table 2, below.¹² Command signals will be issued

¹⁰ 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.

¹¹ *Id.*

¹² 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.

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
137.0250	137.1750	Transmit	NVNG MSS
137.3275	137.3750	Transmit	NVNG MSS
137.4725	137.5350	Transmit	NVNG MSS
137.5850	137.6500	Transmit	NVNG MSS
137.8125	138.0000	Transmit	NVNG MSS
148.2500	148.5850	Receive	NVNG MSS
148.6350	148.7500	Receive	NVNG MSS
149.9000	149.9500	Receive	NVNG MSS

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 20.8 kHz and an assigned bandwidth of 30.0 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.¹³ In each case, the assigned bandwidth includes an appropriate frequency allowance to account for Doppler shift and frequency tolerance.

Table 3 also demonstrates that the proposed emissions will not exceed the -125 dBW/m²/4kHz power flux density (“PFD”) limit specified by the ITU above which coordination with terrestrial services is required,¹⁴ nor will they exceed the -259 dBW/m²/Hz limit in the 150.05-153 MHz band for protection of the radio astronomy service.¹⁵ 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.

Necessary Bandwidth (kHz)	Assigned Bandwidth (kHz)	Power Level (W)	Max PFD ¹⁶ (dBW/m ² /4k Hz)	Maximum PFD ¹⁷ in RAS band (150.05-153 MHz) (dBW/m ² /Hz)
7.8	16.0	0.55	-126.0	-262.1
10.4	20.0	0.75	-125.9	-262.0
15.6	24.0	1.1	-126.0	-262.1

¹³ 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. In addition, Swarm is requesting sufficient spectrum to accommodate an uplink channel with a necessary bandwidth of 250 kHz and an assigned bandwidth of 258 kHz. 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.

¹⁴ See 47 C.F.R. §2.106 at International Footnote 5.208 and ITU Radio Regulations, Appendix 5, Annex 1 ¶ 1.1.1.

¹⁵ 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 specified in ITU-R M.1583, the protection criteria is -238 dBW/m² in a 2.95 MHz reference bandwidth, and as recommended in ITU-R RA.769-2 Table 1, the threshold for harmful interference is -259 dBW/m²/Hz at a center frequency of 151.525 MHz.

¹⁶ The maximum PFD corresponds to transmissions within the 137-138 MHz 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.

¹⁷ *Id.*

20.8	30.0	1.5	-125.9	-262.0
31.3	40.0	2.2	-126.0	-262.1
41.7	50.0	3.0	-125.9	-262.0
62.5	72.0	4.5	-125.9	-262.0
125.0	134.0	4.5	-129.0	-265.0

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.

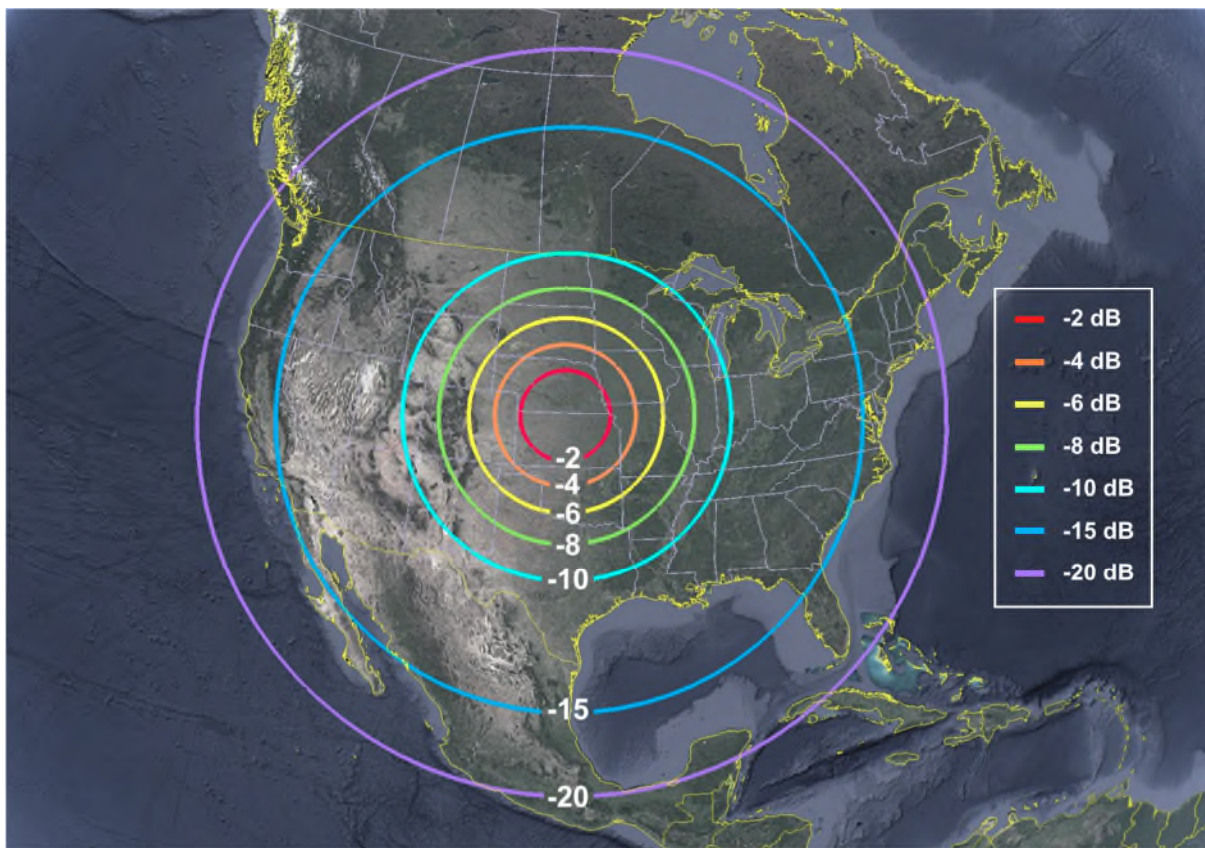


Figure 4. Antenna gain contours for a single Swarm satellite.

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 2.1.1. The detailed ODAR is attached as a separate exhibit.¹⁸ 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.¹⁹ 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.

Post-mission disposal is accomplished via natural atmospheric drag forces and does not require that any of the satellite subsystems be operational. This ensures timely de-orbiting in all potential mission scenarios.

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 propulsion

¹⁸ See Exhibit A: ODAR.

¹⁹ Tests were conducted at same vacuum pressure level and thermal environment present in LEO.

nor momentum wheels onboard. The only source of stored energy on the Swarm satellites is a single 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 satellite deployed in a 550 km orbit, the probability of collision for a Swarm satellite was sufficiently small that the simulation performed using the DAS 2.1.1 software returned a probability value of 0. In addition, the aggregate probability of collision for the constellation, including the initial deployment of 150 satellites and the subsequent deployment of satellites required to maintain the 150-satellite constellation over the 15-year license term, was assessed. The aggregate probability of collision for the constellation was found to be significantly lower than the maximum value set forth in NASA Requirement 4.5-1.²⁰

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

²⁰ See Exhibit A: ODAR.

coordinate with other satellite operators in these and any other populated orbits. Swarm does not 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 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 its 4 experimental ¼U satellites and 3 experimental 1U satellites currently on-orbit, and Swarm will continue to remain in contact with CSpOC to coordinate conjunction events with all current and future satellites.²¹ Swarm will also actively track its satellites with onboard GPS, with such GPS data transmitted to the Swarm ground stations at regular intervals. 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 in further detail in the attached *Orbital Debris Assessment Report*, the probability of collision between a Swarm satellite and any trackable object during the satellite’s orbital lifetime is sufficiently small that the simulation performed using the DAS 2.1.1 software returned a probability value of 0. From 2016 to 2018, the ISS has maintained an altitude between 401 and 406 km, and during most years the ISS maintains an altitude band of +/-4 km. To reduce the probability that the ISS will have to

²¹ 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 in the 401 km to 406 km altitude band (or whichever band the ISS is in at the moment when Swarm satellites are present). This will minimize the time that Swarm 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 Swarm satellite incorporates four passive radar retro-reflectors in order to increase the radar cross section (“RCS”) to improve trackability. A detailed analysis of the trackability of Swarm’s ¼U satellites is attached as a separate exhibit,²² 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.²³ 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.²⁴

²² See *Exhibit B: Trackability Analysis*.

²³ 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*.

²⁴ *Id.*

As discussed previously, the Swarm satellites do not have onboard propulsion. 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 550 km. According to analysis with NASA's DAS program, the maximum lifetime of a Swarm satellite with an apogee and perigee altitude of 550 km altitude is 12.2 years (see Table 1, above), which is less than the NASA standard for maximum orbital lifetime of 25 years²⁵ and less than the FCC commercial grant timeline of 15 years.²⁶ In the nominal case, most satellites will deorbit in less than 5 years. 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 12.2 years or less.

Swarm satellites are able to use the onboard magnetorquer to maneuver into a low-drag or high-drag state, which can change the drag on the satellite by a factor of 4.3:1 (see Figure 5, below). If a functional Swarm satellite is commanded to de-orbit faster, it can be commanded to enter a high-drag mode and deorbit in 3.1 years from a 550 km altitude orbit, and in 1 to 3 years from the other proposed lower orbits.

²⁵ See NASA-STD-8719.14A, Process for Limiting Orbital Debris, Requirement 4.3-1a.

²⁶ See 47 C.F.R. §25.121(a)(1).

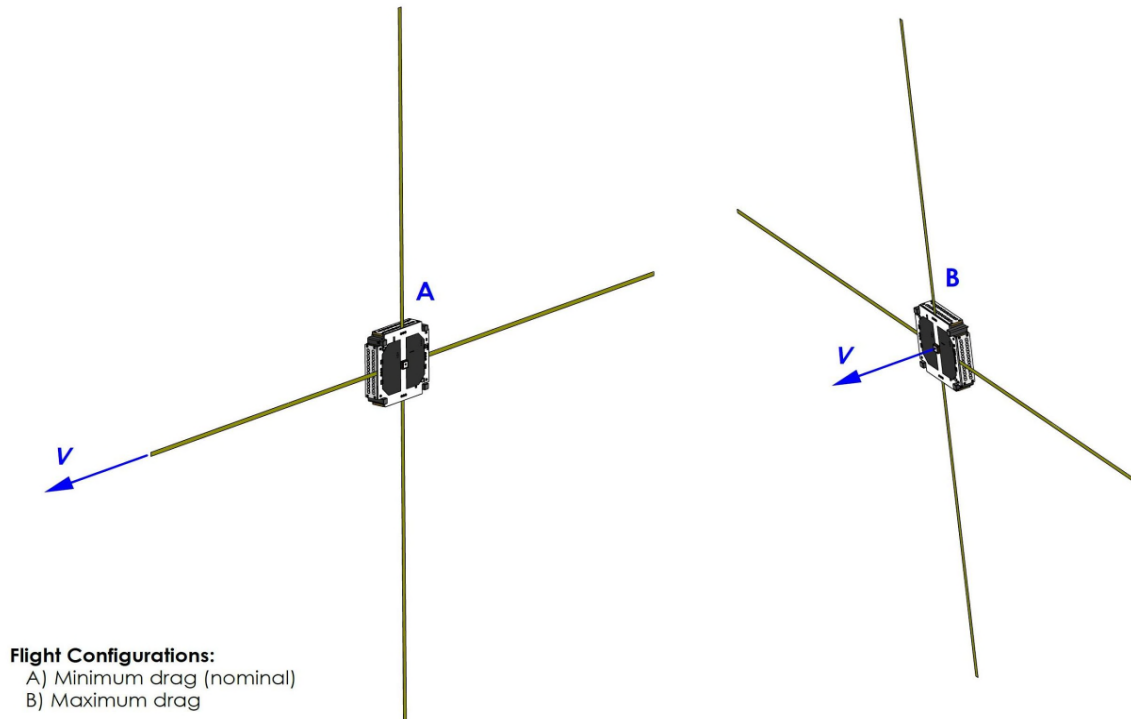


Figure 5. Flight configurations for a Swarm satellite, where “v” represents the velocity vector. (A) A Swarm satellite in the low-drag flight configuration. (B) A Swarm satellite in high-drag flight configuration to de-orbit more rapidly.

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 only source of stored energy on the satellite, 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 137-138 MHz band will not exceed -125 dBW/m²/4kHz, and emissions into the 150.05-153 MHz radio astronomy service band will not exceed -259 dBW/m²/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 137-138 MHz 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 400-550 km. Natural orbital altitude degradation will occur over time, resulting in Swarm satellites operating at altitudes below 400 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 550 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 6.²⁷ The power flux density values shown in Table 4 were calculated using the following parameters:

- Necessary bandwidth: 20.8 kHz
- Transmitter power: 1.5 W
- Maximum antenna gain: see Table 4
- Orbital altitude: 300, 400, 500, or 550 km
- Bandwidth of interest: 4 kHz

Table 4. Power flux density values as a function of elevation angle.²⁸

		Maximum PFD (dBW/m²/4kHz)			
Elevation angle	Max. Gain (dBi)	300 km orbit	400 km orbit	500 km orbit	550 km orbit
0-5°	-3.5	-129.4	-131.9	-133.9	-134.7
5-10°	-3.4	-129.3	-131.8	-133.8	-134.6
10-15°	-3.3	-129.2	-131.7	-133.6	-134.5
15-20°	-3.1	-129.0	-131.5	-133.4	-134.3
20-25°	-2.8	-128.8	-131.3	-133.2	-134.0
25-90°	0.0	-125.9	-128.4	-130.4	-131.2

The ITU specifies that space stations transmitting in the 137-138 MHz band require coordination with terrestrial services only if the PFD produced by the space station exceeds -125 dBW/m²/4kHz at the Earth’s surface.²⁹ 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.

²⁷ 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.

²⁸ PFD values were calculated using the necessary bandwidth (20.8 kHz) to account for the worst-case (highest PFD) scenario.

²⁹ See 47 C.F.R. §2.106 at International Footnote 5.208 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 137-138 MHz band.

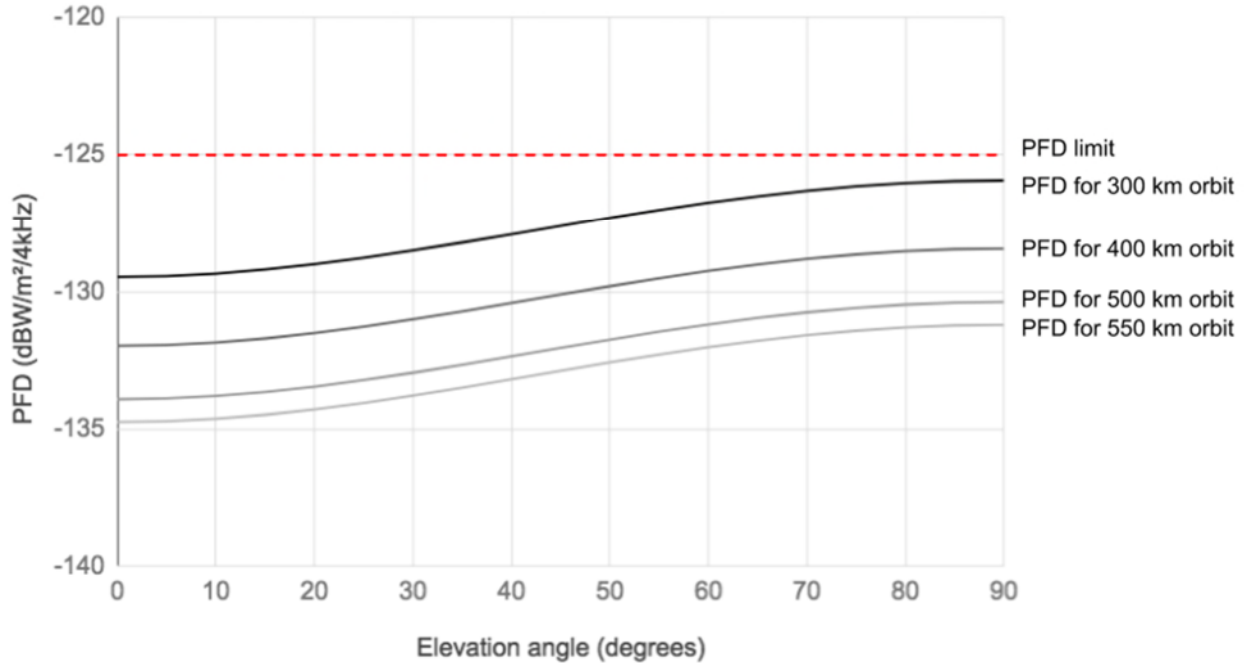


Figure 6. Power flux density at the Earth’s surface as a function of elevation angle.³⁰

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 150.05-153 MHz band. Swarm’s satellites transmit only in the 137-138 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 150.05-153 MHz band, resulting in a power flux density at Earth’s surface not exceeding $-261.9 \text{ dBW/m}^2/\text{Hz}$ for the worst case scenario of a 300 km orbital altitude, thereby

³⁰ PFD values were calculated using the necessary bandwidth (20.8 kHz) to account for the worst-case (highest PFD) scenario.

meeting the radio astronomy service protection criteria specified by the ITU of $-259 \text{ dBW/m}^2/\text{Hz}$ (see Table 5).³¹

Table 5. Calculation of out-of-band emissions from the Swarm system into the RAS band.

Out-of-Band Emissions into Radio Astronomy Services Band (150.05-153 MHz)	
Maximum EIRP (W)	1.50
Maximum EIRP (dBW)	1.76
Necessary Bandwidth (kHz)	20.8
Maximum PFD³² (dBW/m²/4kHz)	-125.9
Bandwidth Conversion	-36
Maximum PFD³³ (dBW/m²/Hz)	-161.9
Spectrum Roll-off Mask in RAS Band (dBc/m²/Hz)	-60
System Filtering in RAS Band (dBc/m²/Hz)	-40
Power Density in RAS Band (dBW/m²/Hz)	-261.9
RAS Protection Criteria (dBW/m²/Hz)	-259.0

4) *Emission Limitations*

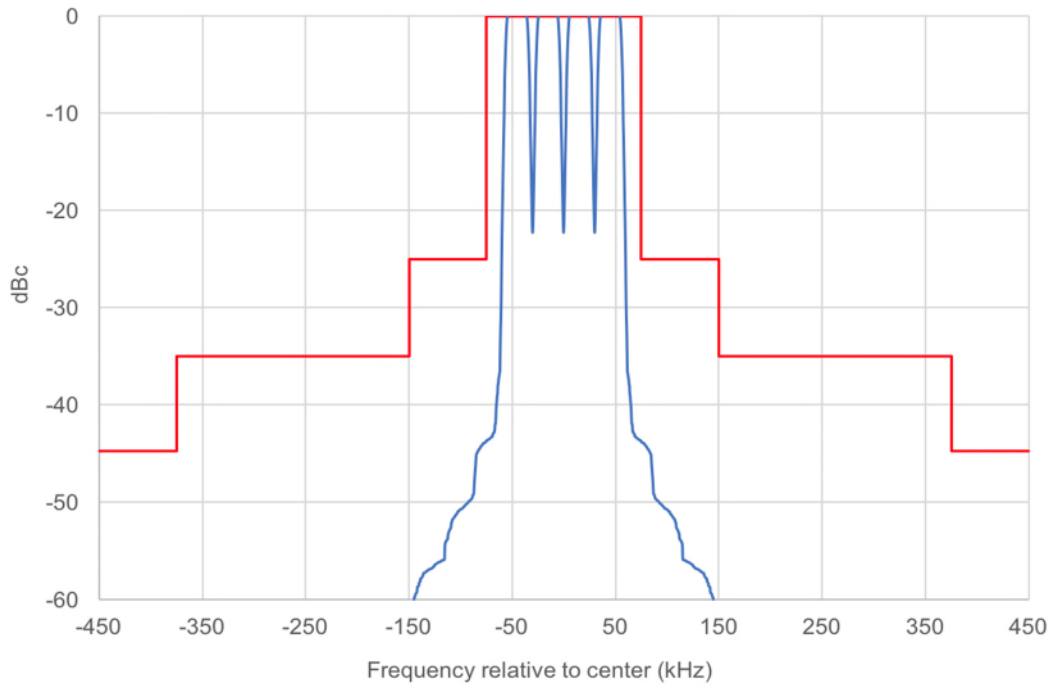
The spectrum masks for downlink transmissions from Swarm satellites in each downlink frequency band are shown below in Figures 7a-e. These spectrum masks demonstrate that Swarm's satellites comply with the out-of-band emission limitations specified in Section §25.202(f) of the Commission's rules.

³¹ 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 specified in ITU-R M.1583, the protection criteria is -238 dBW/m^2 in a 2.95 MHz reference bandwidth, and as recommended in ITU-R RA.769-2 Table 1, the threshold for harmful interference is $-259 \text{ dBW/m}^2/\text{Hz}$ at a center frequency of 151.525 MHz.

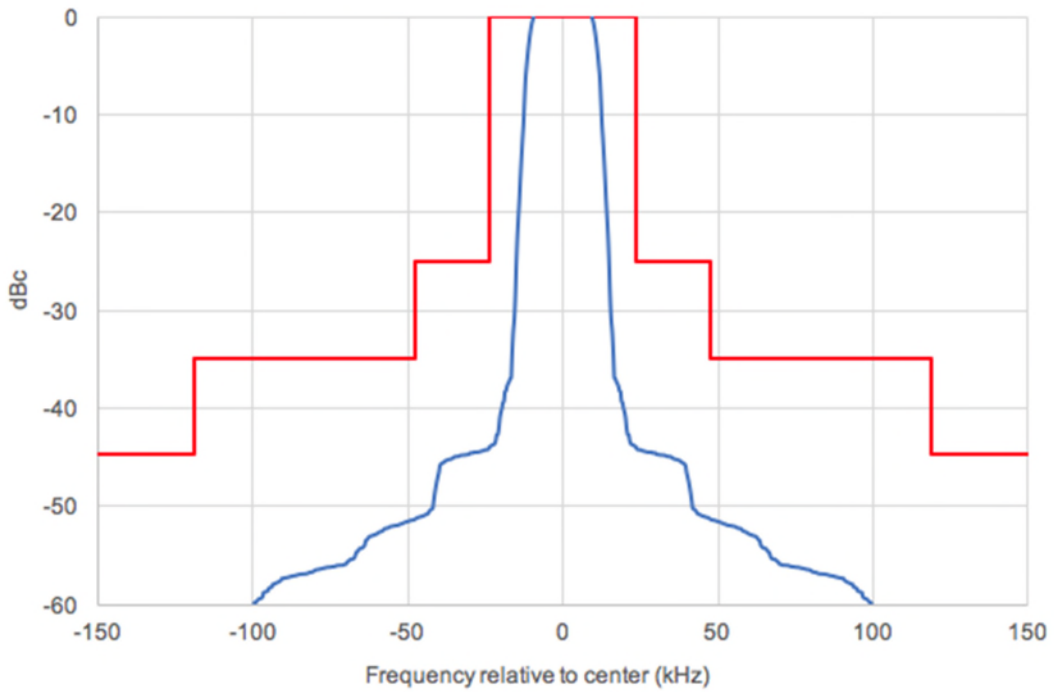
³² The maximum PFD at the Earth's surface corresponds to transmissions within the 137-138 MHz band at the minimum operational altitude of 300 km. PFD values were calculated using the necessary bandwidth (20.8 kHz) to account for the worst-case (highest PFD) scenario.

³³ *Id.*

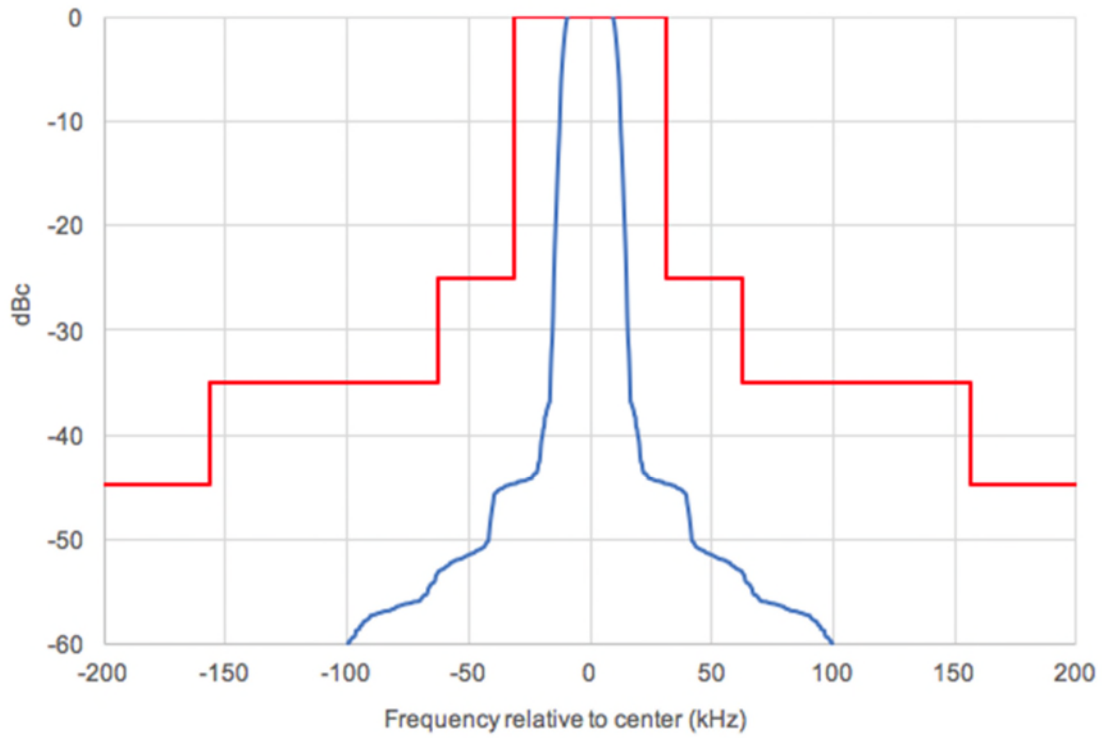
a) Emission mask for 137.0250-137.1750 MHz band



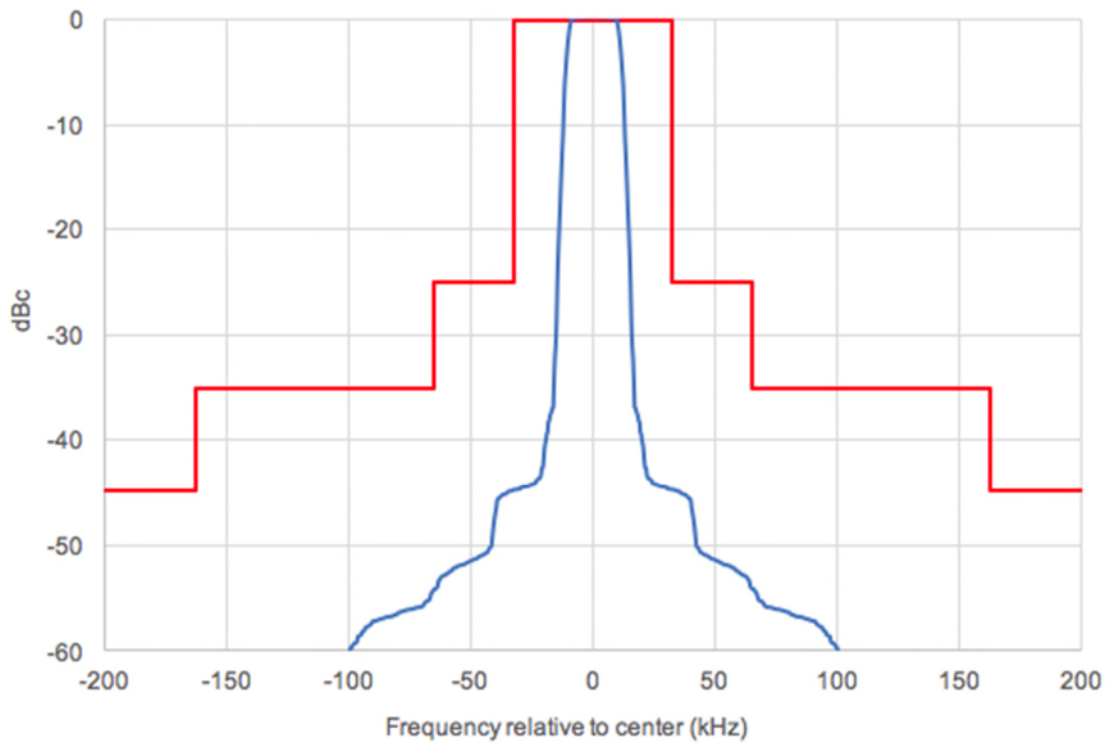
b) Emission mask for 137.3275-137.3750 MHz band



c) Emission masks for 137.4725-137.5350 MHz band



d) Emission mask for 137.5850-137.6500 MHz band



e) Emission mask for 137.8125-138.0000 MHz band

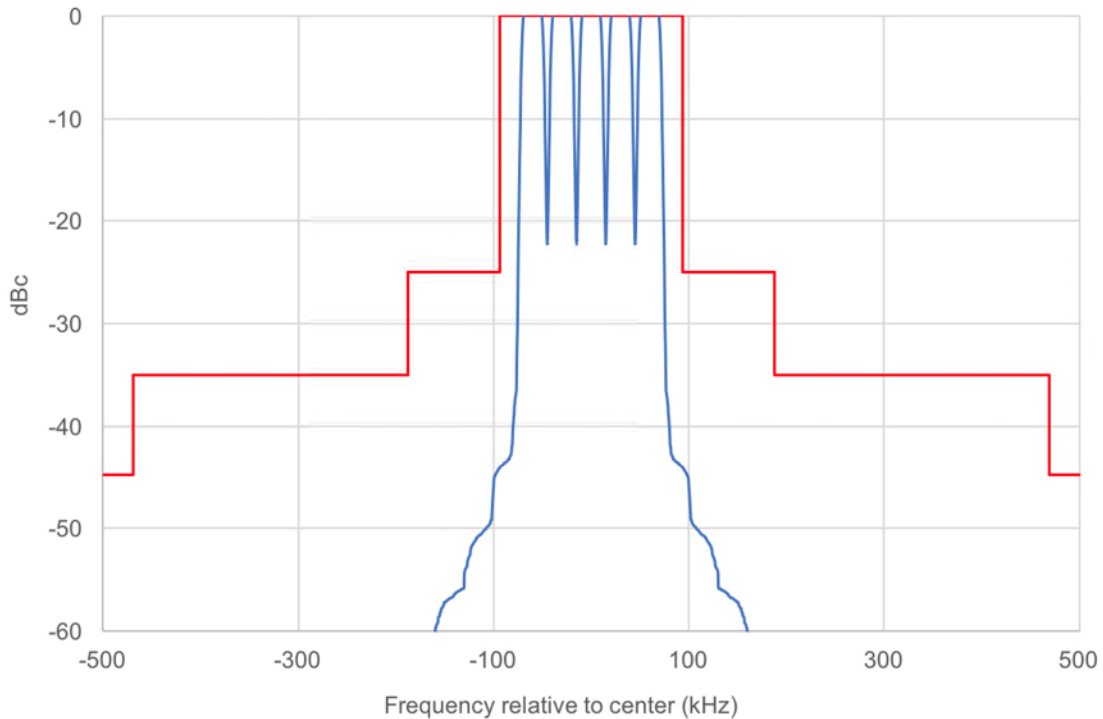


Figure 7. Spectrum masks for Swarm emissions in each downlink frequency band.

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

Section 25.259 of the Commission's rules requires non-voice, non-geostationary satellite systems in the 137-138 MHz band to time share with National Oceanic and Atmospheric Administration ("NOAA") meteorological satellite operations. Swarm is capable of complying with the regulations regarding restriction of transmissions into the "protection area" of the NOAA satellites described in Section 25.259(a). In addition, Swarm will provide a point of contact who will be available twenty-four hours per day, seven days per week to expeditiously address and resolve interference reports as required by Section 25.259(b). Each Swarm satellite is programmed to automatically turn off and cease transmission if no signal is received from a Swarm earth station after 48 hours, in compliance with Section 25.259(c). Swarm will provide any additional information requested by the Commission required for coordination of the satellite system with other Federal Government users.³⁴

3) Coordination with NVNG MSS Systems

Section 25.142(a)(1) of the Commission's rules requires Swarm to demonstrate that its satellite system will not cause unacceptable interference to currently authorized NVNG MSS systems in the frequency bands in which Swarm proposes to operate. Swarm has conducted a

³⁴ See 47 C.F.R. §25.142(b)(2)(ii).

comprehensive assessment of licensees in the band and in neighboring bands to evaluate the possibility of interference.³⁵ Only a single NVNG MSS operator, ORBCOMM, is licensed for commercial operations in Swarm’s proposed operating bands of 137-138 MHz and 148-149.95 MHz.

Swarm requests assignment of a subset of frequencies in the Little LEO³⁶ bands 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 1998,³⁷ and was granted primary assignment of additional “System 1” frequencies in 2008.³⁸ 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.³⁹ 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. 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.

³⁵ See *Exhibit D: Interference Study*.

³⁶ “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.

³⁷ 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).

³⁸ See *Applications by ORBCOMM License Corp., Order and Authorization, File No. SAT-MOD-20070531-0076*, 23 FCC Rcd 4804 (IB, OET 2008) (ORBCOMM 2008 Order).

³⁹ *Id.* at ¶ 11.

F. Construction Milestones: § 25.164

All of Swarm’s one 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 48-hour “dead-man’s switch”, which turns the satellite off every 48 hours. Each Swarm satellite must receive a “heartbeat” command from a Swarm earth station once every 48 hours to remain on and continue transmitting.

I. Link Budget

Link budgets for the Swarm service uplink and downlink are shown in Table 6, below. Values are provided for a scenario involving transmissions to and from a Swarm satellite with an orbital altitude of 500 km.

Table 6. Link budgets for Swarm service uplink and downlink.

Item	ground to satellite		satellite to ground		Units
	Nominal	Worst-Case	Nominal	Worst-Case	
Satellite Orbital Altitude	500	500	500	500	km
Earth Radius	6371	6371	6371	6371	km
Frequency	0.149	0.149	0.138	0.138	GHz
Elevation Angle to Satellite	50	0	50	0	deg

Satellite Angle from Nadir	36.58	68.01	36.58	68.01	deg
Theta Angle	3.42	21.99	3.42	21.99	deg
Transmitter Power	1.50	1.50	1.50	1.50	Watts
Transmitter Power	1.76	1.76	1.76	1.76	dBW
Transmitter Line Loss	-1.00	-1.00	-1.00	-1.00	dBW
Peak Transmit Antenna Gain	2.00	2.00	0.00	0.00	dB
Transmit Antenna Pattern Loss	-3.84	0.00	-1.18	-2.97	dB
Transmit Total Gain	-2.84	1.00	-2.18	-3.97	dB
Eq. Isotropic Radiated Power	-1.08	2.76	-0.42	-2.21	dBW
Propagation Path Length	637	2573	637	2573	km
Path Loss	-131.99	-144.12	-131.33	-143.46	dB
Polarization Loss	-3.00	-3.00	-3.00	-3.00	dB
Power at Receiver Antenna	-136.07	-144.36	-134.75	-148.67	dBW
Peak Receive Antenna Gain	0.00	0.00	2.00	2.00	dB
Receive Antenna Line Loss	-1.00	-1.00	-1.00	-1.00	dB
Receive Antenna Pattern Loss	-1.18	-2.97	-4.49	-0.66	dB
Rx Gain with pointing error	-2.18	-3.97	-3.49	0.34	dB
Rx Power	-138.25	-148.33	-138.24	-148.32	dBW
Necessary Bandwidth	20.8	20.8	20.8	20.8	kHz
Assigned Bandwidth per Channel	30.0	30.0	30.0	30.0	kHz
Target Rx Level	-162.80	-162.80	-162.80	-162.80	dBW
Implementation Margin	6	6	6	6	dB
Remaining Margin	18.54	8.47	18.55	8.48	dB

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.⁴⁰ Swarm's

⁴⁰ 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.

proposed constellation will leverage 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 communications⁴¹ has created an urgent need for a low-cost satellite-based transmission medium for end users operating in underserved or unserved rural areas 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.⁴² 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.⁴³ 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

⁴¹ 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.

⁴² 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*”).

⁴³ See *Telehealth NOI* at ¶¶ 9-10.

a competitive edge to U.S. farmers.⁴⁴ 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.

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,

⁴⁴ 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/>.

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 Improve Competition for Data Services Between Satellite Platforms

One of the most important public interest considerations for Swarm's proposed constellation is enhanced competition. 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.

IV. 47 U.S.C. § 304 WAIVER

Swarm Technologies, Inc. hereby waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise.

V. REQUESTED WAIVERS

A. Legal Standard

The Commission has a longstanding and well-established “obligation to seek out the ‘public interest’ in particular, individualized cases.”⁴⁵ Accordingly, the Commission may grant waivers of its rules “on its own motion or on petition if good cause therefor is shown.”⁴⁶ 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.⁴⁷ Waivers are appropriate where special circumstances “warrant a deviation from the general rule and such deviation will serve the public interest.”⁴⁸ 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.”⁴⁹ The Commission will also take into considerations “hardship, equity, or more effective implementation of overall policy” on an individual basis.⁵⁰

⁴⁵ *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).

⁴⁶ 47 C.F.R. § 1.3.

⁴⁷ *See WAIT Radio*.

⁴⁸ *Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

⁴⁹ *WAIT Radio*. at 1157.

⁵⁰ *Id.* at 1159.

B. Waiver of the § 25.157 Processing Round Requirement

Pursuant to 47 C.F.R. §25.157(c), applications for “NGSO-like” satellite systems are subject to a processing round procedure whereby other applications for NGSO-like operations are reviewed concurrently. This framework was established in order to reconcile the competing policy goals of maximizing competitive entry with accelerating the reassignment of spectrum to other satellite licensees for the timely provision of satellite services to customers.⁵¹

When assessing whether to forgo a processing round, the Commission looks at whether a licensee would “preclude additional entry.”⁵² The Commission has historically waived Section 25.175(c) on numerous occasions where it found that authorization of a satellite licensee would not prevent other licensees from operating in the band, nor cause harmful interference to existing licensees.⁵³ In doing so, the Commission has remained cognizant of the policy objectives behind the processing round procedure, noting that its purpose “is to prevent one applicant from unreasonably precluding additional entry by other operators in the requested frequency band.”⁵⁴

Grant of a waiver from the processing round procedure created under 47 C.F.R. §25.157(c) in the instant situation serves the public interest by allowing Swarm to expeditiously deploy a state-of-the-art, low-cost network that will deliver important lifeline communications⁵⁵ services to

⁵¹ *Amendment of the Commission’s Space Station Licensing Rules and Policies*, First Report and Order, 18 FCC Rcd 10760, 10788 (2003) (“First Space Station Licensing Order”).

⁵² *Northrop Grumman Space & Missions Systems Corporation*, 24 FCC Rcd 2330, 2342 (2009).

⁵³ *See, e.g., Space Imaging, LLC*, 20 FCC Rcd 11964 (2005); *Digitalglobe, Inc.*, 20 FCC Rcd. 15696 (2005).

⁵⁴ *Iridium Constellation for Modification of License to Authorize a Second-Generation NGSO MSS Constellation*, 31 FCC Rcd 8675 (2016) at para. 41.

⁵⁵ 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).

underserved or unserved communities both domestically and abroad, and at affordable rates that will be a fraction of those charged by incumbent providers. Moreover, grant of the waiver will not disadvantage any third party. The Little LEO bands⁵⁶ were always intended to support additional space communication networks and have remained underutilized for decades.⁵⁷ Swarm’s proposed network involves only approximately one quarter of the spectrum allocated for Little LEO NVNG services, leaving ample spectrum for a future entrant to join ORBCOMM and Swarm. It is also unnecessary to have a third processing round to allocate Little LEO spectrum when the Commission previously granted ORBCOMM additional spectrum on a “first-come, first-served” basis without such a procedure.⁵⁸ Finally, grant of the waiver will benefit the U.S. as a whole, by promoting both national security as well as continued United States leadership in small satellites and Internet-of-Things applications.

Grant of the instant waiver will serve the public interest by allowing Swarm to expeditiously deploy an innovative, cost-effective communications network. Swarm’s satellites are designed and manufactured in the United States, and the full constellation, providing global, continuous coverage, can be delivered, launched, and brought into service as early as 2019. As described in Section IV, Swarm intends to provide critical and affordable lifeline services to underserved areas of the United States 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

⁵⁶ The “Little LEO” bands include 137-138, 148-150.05, 399.9-400.05, and 400.15-401 MHz. *See* 47 CFR §25.202(a)(3).

⁵⁷ *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) (“Little LEO Order”).

⁵⁸ *See* ORBCOMM 2008 Order.

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 may have meaningful utility.⁵⁹ 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. economy at large.

Grant of the instant waiver will not disadvantage any third party. In fact, Swarm's network will put otherwise fallow spectrum underutilized or unused for several decades to its immediate and optimal use.⁶⁰ Specifically, Swarm seeks to deploy a satellite system consistent with the current Part 25 service rules for Little LEO NVNG systems. Moreover, Swarm's proposed

⁵⁹ 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.

⁶⁰ See Little LEO Order, *supra* n.57. To date, ORBCOMM is the only operator to have deployed satellites and utilized spectrum allocated to Little LEO systems.

network uses only one quarter of the spectrum allocated for Little LEO NVNG services, leaving ample spectrum for another entrant to join ORBCOMM and Swarm.⁶¹

Grant of the instant waiver is consistent with the Commission’s prior decision to encourage productive use of Little LEO spectrum on a first-come, first-serve basis. Specifically, in the early-1990s the Commission undertook two separate processing rounds to assign Little LEO spectrum to ten (10) NGSO applicants.⁶² Beginning in 2004, after both processing rounds yielded only one operational licensee, ORBCOMM, the Commission explained that Little LEO spectrum previously assigned to other systems was underutilized and therefore available on a “first-come, first-served” procedure.⁶³ In 2008, ORBCOMM asked the Commission for authority to utilize additional Little LEO spectrum for which it did not have prior authorization.⁶⁴ Subsequently, the Commission granted ORBCOMM’s requested authority without subjecting the company to a processing round in order to “put allocated Little LEO spectrum to productive use, rather than holding the spectrum sub-bands vacant in reserve for future applicants.”⁶⁵ In the interim decade the Little LEO bands have remained fallow, and acting promptly on Swarm’s instant application on a “first-come, first-served” basis remains consistent with the Commission’s long-standing goal of bringing spectrum

⁶¹ See 47 C.F.R. § 25.157(e). The Commission has adopted a rebuttable presumption that the “sufficient number of licensees in the frequency band” is three. See also First Space Station Licensing Order, 18 FCC Rcd at 10788-89.

⁶² See Public Notice, Report No. DS-1459, DA 94-1011 (1994) (establishing the cut-of date for the second Little LEO processing round); see also Public Notice, Report No. DS-1068, 6 FCC Rcd 2083 (1991) (establishing the cut-off date for the first Little LEO processing round).

⁶³ See Policy Branch Information, Spectrum Available, Public Notice, 19 FCC Rcd 4804 (2004); Policy Branch Information, Spectrum Available, Public Notice, 19 FCC Rcd 5368 (2004); Policy Branch Information, Public Notice, 20 FCC Rcd 20273 (2005).

⁶⁴ See ORBCOMM 2008 Order, supra n. 38. ORBCOMM requested modification of its authorization to operate in “System 1” Little LEO frequencies, as well as other available little LEO spectrum (System 2, System 3, and VITA) jointly with other licensees.

⁶⁵ *Id.* at 4808.

resources to use expeditiously. In point of fact, after 25 years of underutilization and two failed processing rounds, initiating a third processing round procedure after previously approving ORBCOMM's second Little LEO constellation on a first-come, first-served basis would materially disadvantage and discriminate against Swarm. Specifically, a third processing round would disadvantage Swarm against third parties coordinating through other jurisdictions by allowing such competitors to aggressively pursue landing rights in other regional jurisdictions while Swarm waits for the Commission to allocate resources that no other credible party has sought to utilize in decades.

Swarm has designed its proposed satellite system to provide global, low-cost connectivity to end users. The Swarm satellites incorporate custom, space-qualified hardware including an innovative scheme for attitude control, an efficient power distribution system, and a state-of-the-art transceiver system designed for effective wide area coverage. Because satellite launch costs are based on size and mass, the ¼U form factor of Swarm's satellites significantly reduces the cost of deploying the constellation and enables Swarm to deliver affordable services to its users. The small satellite form factor also allows Swarm to leverage rideshare opportunities with existing and emerging launch providers, enabling Swarm to rapidly deploy its constellation and begin offering commercial services. Swarm is prepared to begin deploying its constellation upon authorization from the Commission, and can begin offering commercial services prior to deployment of the full constellation. Swarm intends to deploy the full constellation within 12 months of authorization from the FCC, a previously unheard of timeframe for a global constellation, but one that Swarm's unique and innovative technology enables. Timely launch authorization and access to spectrum is critical for Swarm to remain competitive. Given this, Swarm urges the Commission to waive its

processing round procedure to expedite deployment of operations and provision of satellite services in its requested frequencies.

In the alternative, should the Commission not act favorably on the above waiver request and proceed to treat Swarm as the lead applicant in a processing round for Little LEO NVNG service, Swarm urges the prompt grant of its application without delay during the processing of any other timely filed applications. Acting promptly on Swarm's application will facilitate expedient and efficient use of Little LEO spectrum, and ensure that Swarm's time sensitive business plans are not unnecessarily hindered by waiting to act on all applications in the processing round concurrently in a "batch." The Commission recently followed the approach recommended by Swarm herein, and rejected requests to delay action on a processing round lead applicant during the pendency of other applications.⁶⁶ In doing so, the Commission explained that prompt action on the lead applicant would not disadvantage other processing round participants given that "[n]o spectrum preference is given based on the date of grant," and accordingly, there was "no need to delay grant" of the lead applicant.⁶⁷ If the Commission includes Swarm in a processing round, it should act similarly. Swarm requests no "spectrum preference" based on the date of grant, and acknowledges that the Commission may need to segment or split the Little LEO NVNG allocation to accommodate other timely filed and technically complete applications in the processing round. Thus, timely grant of Swarm's Application would not inhibit other users of the spectrum. Instead, it would only allow Swarm to quickly bring otherwise fallow spectrum into service more expeditiously.

⁶⁶ *In the Matter of WorldVu Satellites Limited Petition for Declaratory Ruling Granting Access to the U.S. Market for the OneWeb NGSO FSS System*, IBFS File No. SAT-LOI-20160428-0041, Order and Declaratory Ruling (rel. June 23, 2017) at para. 11.

⁶⁷ *Id.*

VI. 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/ Sophie Arlow

Sophie Arlow

Research and Operations Associate

Swarm Technologies, Inc.