

## Application for Gateway Earth Station Authorization

### Overview

Swarm Technologies, Inc. (“Swarm”) is a U.S. corporation that has applied to launch and operate an innovative constellation of 150 small two-way communications satellites in the non-voice, non-geostationary (“NVNG”) Mobile-Satellite Service (“MSS”).<sup>1</sup> Swarm’s proposed satellite constellation will provide global data services to industry, government, nonprofit, and research and development users. By leveraging advances in small satellite technology and the increased availability of launch opportunities, the Swarm constellation will be deployed rapidly and will provide connectivity at far lower costs than have been previously possible.

In this application, Swarm seeks authorization for operation of a gateway earth station located in California that Swarm will use to transfer data between the Swarm satellite constellation and the terrestrial Internet and to conduct telemetry, tracking, and command (“TT&C”) operations. The gateway earth station will operate on frequencies in the 148-149.95 MHz (uplink) and 137-138 MHz (downlink) bands, consistent with Swarm’s space station application.<sup>2</sup>

In the following narrative and in the accompanying Form 312, Swarm demonstrates that the proposed earth station complies with all technical and operational requirements and that grant of this application would serve the public interest. Swarm intends to deploy its constellation rapidly upon approval of its pending space station application, and is prepared to begin offering commercial services even prior to full deployment of its constellation. The gateway earth station

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<sup>1</sup> 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”).

<sup>2</sup> *Id.*, Narrative Exhibit at 9.

for which authorization is requested is a key component of Swarm’s network infrastructure and is vital to delivering services to customers. Swarm therefore requests that the Commission grant the requested authorization as expeditiously as possible.

**Frequencies and Emissions**

To supplement the information provided in the Form 312, Main Form and Schedule B, additional information regarding the operating frequencies and emission characteristics of Swarm’s proposed earth station is provided below.

*Frequencies*

A complete listing of the requested frequencies on which Swarm’s earth station will transmit and receive is provided in Table 1. These frequencies are identical to those requested in Swarm’s Part 25 application for the corresponding 150-satellite system.<sup>3</sup>

**Table 1.** Frequencies on which Swarm’s earth station will transmit and receive.

<b>Lower Frequency (MHz)</b>	<b>Upper Frequency (MHz)</b>	<b>Transmit or Receive Mode</b>	<b>Nature of Service</b>
137.0250	137.1750	Receive	NVNG MSS
137.3275	137.3750	Receive	NVNG MSS
137.4725	137.5350	Receive	NVNG MSS
137.5850	137.6500	Receive	NVNG MSS
137.8125	138.0000	Receive	NVNG MSS
148.2500	148.5850	Transmit	NVNG MSS
148.6350	148.7500	Transmit	NVNG MSS
149.9000	149.9500	Transmit	NVNG MSS

As described in Swarm’s space station application, Swarm does not propose to designate exclusive feeder uplink and downlink channels within its requested frequency assignment.<sup>4</sup>

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<sup>3</sup> *Id.*

<sup>4</sup> *Id. at 8.*

Instead, customer data will be transferred between Swarm’s earth station and satellites on the uplink and downlink frequencies shown in Table 1. Similarly, Swarm does not propose to designate channels exclusively for TT&C purposes.<sup>5</sup> TT&C operations will be conducted on channels within the uplink and downlink frequencies shown in Table 1.<sup>6</sup>

### *Emission Characteristics*

Swarm’s proposed earth station will operate on channels within the uplink and downlink frequencies provided in Table 1. The earth station will only transmit on a single channel at any given time. Both the Swarm satellites and earth station are capable of operating with a variety of emissions designators, and Swarm may vary, within the range specified in this application, the bandwidth of channels on which the earth station transmits and receives to best serve customer and network needs and maximize spectral efficiency. Consistent with 47 C.F.R. § 25.275, Swarm specifies in Schedule B only those carriers with the highest Effective Isotropic Radiated Power (“EIRP”) density, narrowest bandwidth, and largest bandwidth, and will transmit using emissions not specifically listed only if doing so would “not exceed the highest EIRP, EIRP density, and bandwidth prescribed for any listed emission.”<sup>7</sup> For completeness, information regarding the characteristics of additional emissions designators and their corresponding power, EIRP, and EIRP density levels is provided in Table 2 below. In each case, the assigned bandwidth includes an appropriate frequency allowance to account for Doppler shift and frequency tolerance.

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<sup>5</sup> *Id.*

<sup>6</sup> Pursuant to 47 C.F.R. §25.202(g)(1), 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.

<sup>7</sup> 47 C.F.R. § 25.275(c).

Emissions specified in Schedule B are highlighted in blue and define the maximum bandwidth, EIRP, and EIRP density with which the earth station will transmit.

**Table 2.** Potential bandwidths, power levels, and EIRP levels for earth station transmissions.<sup>8</sup>

<b>Emission Designator</b>	<b>Necessary Bandwidth (kHz)</b>	<b>Assigned Bandwidth (kHz)</b>	<b>Power Level (W)</b>	<b>Max EIRP (dBW)</b>	<b>Max EIRP Density (dBW/4kHz)</b>
7K80F1D	7.8	16.0	10.0	21.0	18.1
10K4F1D	10.4	20.0	10.0	21.0	16.9
15K6F1D	15.6	24.0	10.0	21.0	15.1
20K8F1D	20.8	30.0	10.0	21.0	13.8
31K3F1D	31.3	40.0	10.0	21.0	12.1
41K7F1D	41.7	50.0	10.0	21.0	10.8
62K5F1D	62.5	72.0	10.0	21.0	9.1
125KF1D	125.0	134.0	10.0	21.0	6.1
250KF1D	250.0	259.0	10.0	21.0	3.0

*Half-Power Beam Width (47 C.F.R. § 25.130(f))*

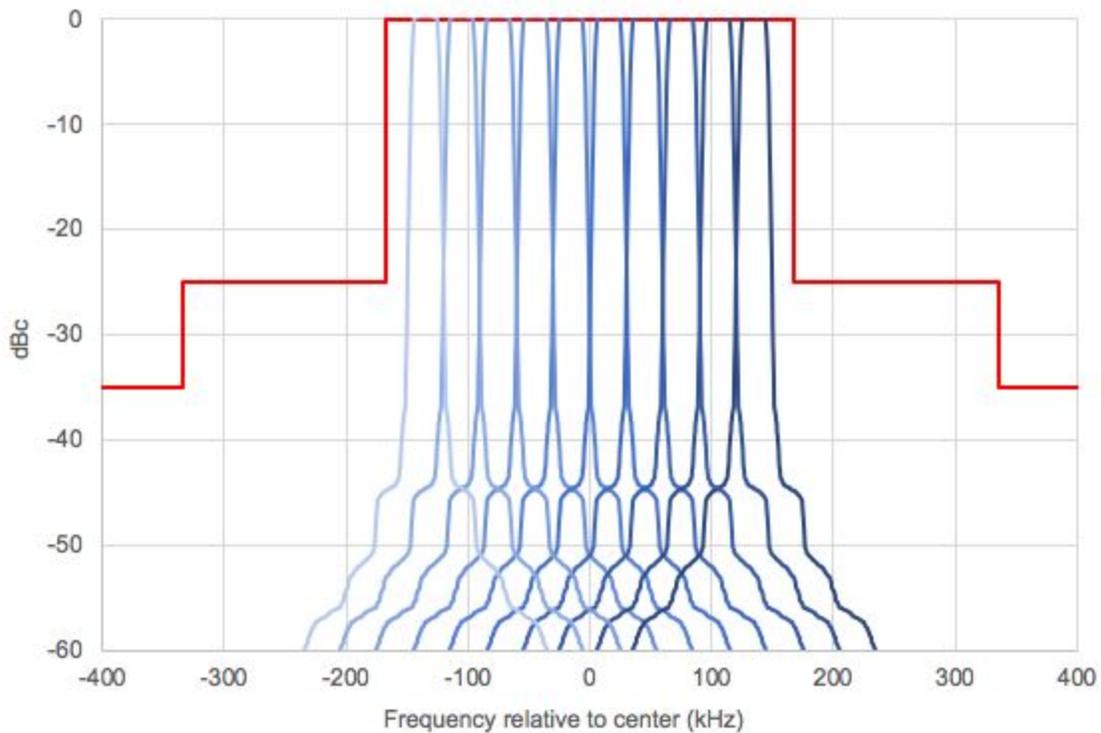
Swarm’s gateway earth station will transmit using one of the four antennas whose specifications are provided in the accompanying Form 312 Schedule B. The half-power beam widths for the antennas are as follows:

<b>Antenna ID</b>	<b>Model</b>	<b>Maximum Gain (dBi)</b>	<b>Half-Power Beam Width (°)</b>
W1/2	001	2.0	29.0
COLINEAR	002	5.5	32.0
QFH	003	0.0	104.0
YAGI	004	11.0	52.0

<sup>8</sup> To provide an upper bound on the maximum EIRP and EIRP density levels, the values provided in Table 2 were calculated using the maximum antenna gain of 11.0 dBi. As described in the accompanying Form 312 Schedule B, the proposed earth station will be transmit using one of four antennas with gain values of 2.0 dBi, 5.5 dBi, 0.0 dBi, and 11.0 dBi. Only one antenna will transmit at any given time.

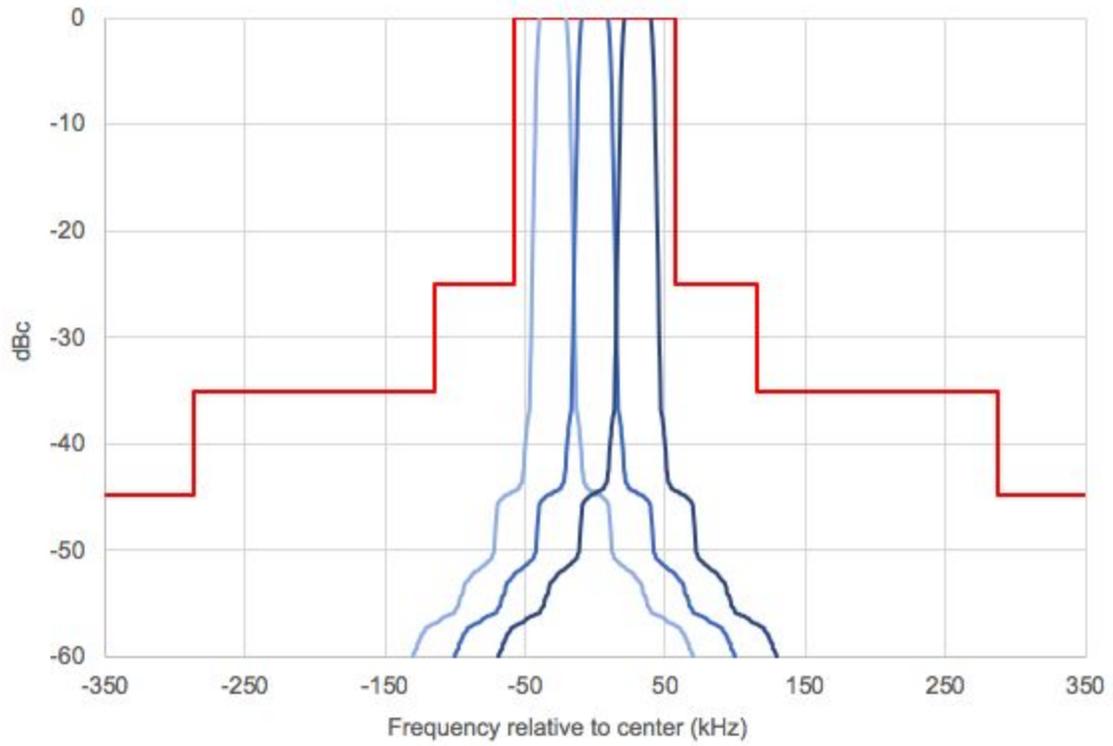
*Out-of-Band Emissions (47 C.F.R. § 25.202(f))*

Figures 1-3 below show the channels on which the proposed gateway earth station will transmit. As discussed previously, the earth station will only transmit on a single channel at any given time. As shown, the spectrum masks for Swarm earth station emissions comply with the limits set forth in Section 25.202(f) of the Commission’s rules.<sup>9</sup>

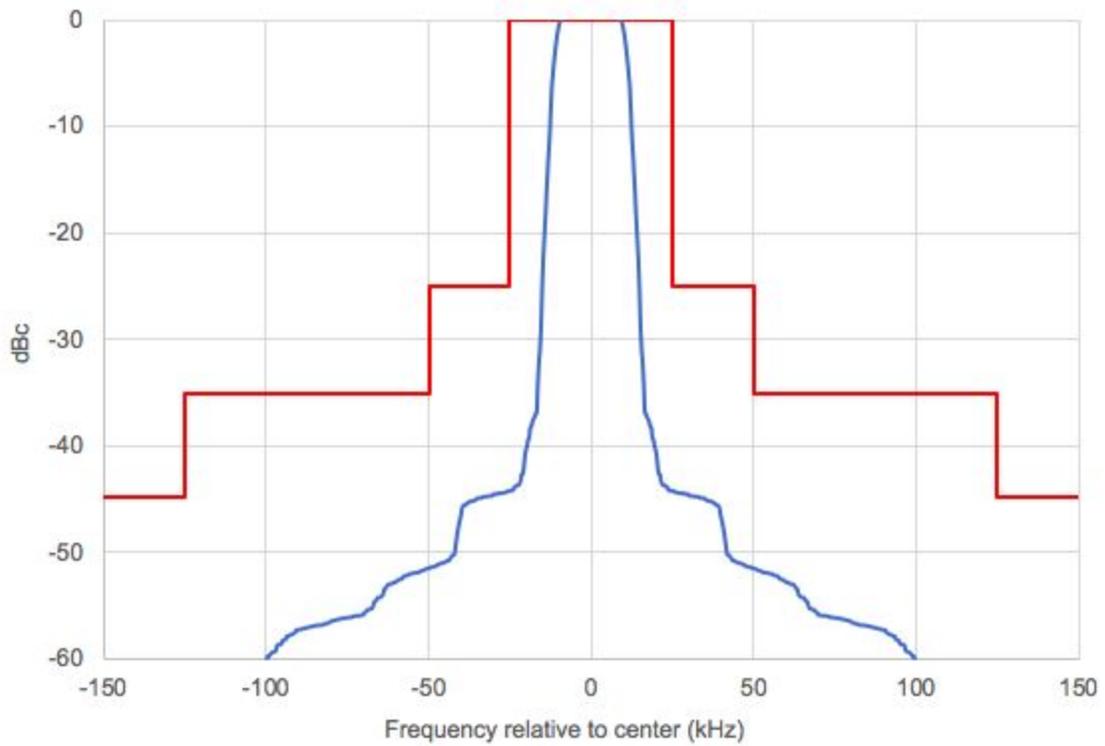


**Figure 1.** Emission mask for the 148.250-148.585 MHz band.

<sup>9</sup> Figures 1-3 reflect Swarm’s nominal initial plan for transmissions, 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. Transmissions using alternative emissions designators (see Table 2) will also comply with the emissions mask requirements shown for each frequency band.



**Figure 2.** Emission mask for the 148.635-148.750 MHz band.



**Figure 3.** Emission mask for the 149.000-149.950 MHz band.

*Frequency Tolerance (47 C.F.R. § 25.202(d))*

The carrier frequency of the earth station will be maintained within 0.001% of the reference frequency as required by Section 25.202(d) of the Commission's rules.

*Minimum Antenna Elevation Angle. (47 C.F.R. § 25.205(a))*

The Swarm earth station antennas will not transmit at elevation angles less than five degrees, measured from the horizontal plane to the direction of maximum radiation.

**Operating Conditions (47 C.F.R. §§ 25.142(b))**

*Service Limitation (47 C.F.R. § 25.142(b)(1))*

Pursuant to 47 C.F.R. § 25.142(b)(1), Swarm will not provide voice services.

*Coordination with Federal Government Users (47 C.F.R. § 25.142(b)(2))*

To ensure that Swarm does not cause unacceptable interference for federal users, Swarm will coordinate with federal government operations through the process established by NTIA and the Interdepartment Radio Advisory Committee, as specifically contemplated by 47 C.F.R. § 25.142(b)(2). Swarm will provide any additional information requested by the Commission required for coordination with federal users.<sup>10</sup>

*Coordination with Other NVNG MSS Systems (47 C.F.R. § 25.142(b)(3))*

Swarm does not request authority to operate in any spectrum assigned on a primary basis to the sole NVNG MSS incumbent, ORBCOMM. As a result, upon approval of Swarm's pending Part 25 satellite system authorization, Swarm will be the only authorized commercial satellite operator in the frequency bands shown in Table 1.<sup>11</sup> In addition, as explained above,

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<sup>10</sup> See 47 C.F.R. §25.142(b)(2)(iii).

<sup>11</sup> See Consolidated Opposition and Response of Swarm Technologies, Inc. at 2-10, IBFS File No. SAT-LOA-20181221-00094 (filed Apr. 15, 2019) ("Consolidated Opposition and Response") (explaining that ORBCOMM must terminate any use of the spectrum requested by Swarm once Swarm commences operations

Swarm's gateway earth station will comply with the applicable out-of-band emissions requirements in 47 C.F.R. § 25.202(f), thereby protecting operations in neighboring bands. Pursuant to §25.142(b)(3), Swarm is willing to coordinate its proposed frequency usage with ORBCOMM, which should be a very straightforward process given the absence of any frequency overlap and Swarm's compliance with 47 C.F.R. § 25.202(f). Swarm also will work to coordinate in good faith with future NVNG MSS operators to ensure efficient use of radio spectrum.

### **Grant of this Application Would Serve the Public Interest**

The grant of this application would serve the public interest by enabling access to a new generation of innovative and affordable NVNG MSS services that will be provided by Swarm's proposed satellite network.

As described in Swarm's space station application and the record filed in support, considerable demand across a diverse set of industry verticals exists for the low-cost global communications services that Swarm proposes to provide, and Swarm's network will address customer needs that are unmet by existing satellite services.<sup>12</sup> Twenty potential users of Swarm's satellite services from the automotive, agriculture, maritime, telecommunications, global development, and technology sectors filed comments in support of Swarm's application,<sup>13</sup> many

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because none of Swarm's requested frequencies overlap with ORBCOMM's primary assignments); see also Applications by ORBCOMM License Corp., Order and Authorization, 23 FCC Rcd. 4804 ¶¶ 11, 22, 23 (Int'l Bur. and Office of Eng'g & Tech. Mar. 21, 2008) (conditioning any use of spectrum by ORBCOMM outside of its primary assignments on ORBCOMM's "operating using only frequency bands assigned to it on a primary basis . . . upon commencement of operations by another U.S.-licensed non-voice, non-geostationary mobile satellite system").

<sup>12</sup> See Space Station Application, Narrative at 28-32; Consolidated Opposition and Response at 22-24.

<sup>13</sup> See Comments of Ford Smart Mobility, LLC, Application No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) ("Ford Comments"); Comments of Vodafone Group, Application No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019); Comments of Aclima, Application No. SAT-LOA-20181221-00094 (filed Mar. 30, 2019) ; Comments of Arable Labs Inc., Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019); Comments of Arch Systems, Application NO. SAT-LOA-20181221-00094 (filed Mar. 29, 2019); Comments of Autonomic, LLC, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) ("Autonomic Comments"); Comments of Bluetown,

of whom emphasized that Swarm’s network promises to “open new markets that current satellite technology cannot satisfy.”<sup>14</sup>

Swarm has also filed for authorization of 1,000,000 customer mobile earth station (“CMES”) devices that end users will employ to communicate with the Swarm constellation.<sup>15</sup> Swarm has designed its CMES devices to be inexpensive, energy-efficient, and easy to deploy, making them ideally suited for remote Machine-to-Machine (“M2M”) and Internet of Things (“IoT”) applications beyond the reach of existing cellular networks.

This application seeks authorization for a key component of Swarm’s ground-based network infrastructure: an earth station that Swarm will use to connect its satellite constellation to the terrestrial Internet and to perform TT&C operations. Swarm is prepared to deploy its satellite constellation upon approval of its pending space station authorization, and to begin offering services to commercial users shortly thereafter. Authorization of the gateway earth station component of Swarm’s network will enable significant numbers of new satellite users to

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Application No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) (“Bluetown Comments”); Comments of DroneSeed, Application No. SAT-LOA-20181221-00094 (filed Mar. 31, 2019) (“DroneSeed Comments”); Comments of Foss Maritime Company, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019); Comments of The Freshwater Trust, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019); Comments of Greenridge Sciences, Application No. SAT-LOA-20181221-00094 (filed Apr. 3, 2019) ; Comments of Heather Mariash, Application No. SAT-LOA-20181221-00094 (filed Apr. 5, 2019); Comments of Hivemind, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019); Comments of Hopkins Marine Station of Stanford University, Application No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019) (“Stanford Univ. Comments”); Comments of Lower Yukon School District, Application No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019); Comments of Social Capital, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019) (“Social Capital Comments”); Comments of Sofar Ocean Technologies, Application No. SAT-LOA-20181221-00094 (filed Apr. 1, 2019); Comments of SweetSense, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019); Comments of Tule Technologies Inc., Application No. SAT-LOA-20181221-00094 (filed Apr. 2, 2019); Comments of the University of Houston, Application No. SAT-LOA-20181221-00094 (filed Mar. 29, 2019).

<sup>14</sup> Ford Comments at 2; see also Social Capital Comments at 1 (describing Swarm’s network as a “fundamentally enabling technology” capable of addressing “applications from water accessibility and food safety, to environmental monitoring and intelligent energy systems”); Autonomic Comments at 2; DroneSeed Comments at 1; Stanford Univ. Comments at 1; Bluetown Comments at 1.

<sup>15</sup> Swarm Technologies, Inc., Application for Blanket Earth Station Authorization, IBFS File No. SES-LIC-20190612-00769 (filed June 12, 2019).

benefit from Swarm's low-cost satellite technology and bring IoT connectivity to new verticals and rural communities. For these reasons, expeditious grant of this application would serve the public interest and ensure that services can be provided to end users without delay.

Respectfully submitted,

**Swarm Technologies, Inc.**

By:     /s/ Sophie Arlow    

Dr. Sophie Arlow

Lead Program Manager

Dr. Sara Spangelo

Chief Executive Officer

Kalpak Gude

General Counsel

Swarm Technologies Inc.

845 Madonna Way

Los Altos, CA 94024