

## Application for Blanket 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 a blanket authorization pursuant to 47 C.F.R. § 25.115(d) for operation of up to 1,000,000 Customer Mobile Earth Station (“CMES”) devices that end users will employ to communicate with Swarm’s satellite constellation. The devices 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> Swarm seeks authorization for CMES devices to be deployed and operated throughout the continental United States, Alaska, Hawaii, Puerto Rico, Guam, the U.S. Virgin Islands, all U.S. territories and possessions, and all U.S. territorial waters. CMES devices may use one of several antennas, depending on the application. The characteristics of each proposed terminal are provided in the accompanying Schedule B, as is the quantity to be licensed for each terminal type.

In the following narrative and in the accompanying Form 312, Swarm demonstrates that the proposed devices comply with all technical and operational requirements and that grant of this

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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> Space Station Application Narrative Exhibit at 9.

application would serve the public interest. Swarm will deploy its constellation rapidly upon approval of its pending space station application, and will be prepared to offer commercial services even prior to full deployment of its constellation. Swarm therefore requests that the Commission grant the requested authorization of the ground segment of Swarm’s network 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 CMES devices is provided below.

*Frequencies*

A complete listing of the requested frequencies on which Swarm’s CMES devices 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 CMES devices 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

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<sup>3</sup> See *id.*

### *Emission Characteristics*

Swarm proposes to operate CMES devices on multiple channels within the uplink and downlink frequencies provided in Table 1. Both the Swarm satellites and CMES devices are capable of operating with a variety of emissions designators to meet the diverse needs of customers, and Swarm may vary, within the range specified in this application, the bandwidth of channels on which CMES devices transmit and receive to best serve customer 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>4</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. Emissions specified in Schedule B are highlighted in blue and define the maximum bandwidth, EIRP, and EIRP density with which CMES terminals will transmit. Swarm notes that the maximum power level requested for CMES terminals differs from the power level assumed in the reverse link budget that Swarm provided for illustrative purposes in the narrative to its space station application.<sup>5</sup> There have been no changes to the link budget for the space to ground link at issue in that application.

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<sup>4</sup> 47 C.F.R. § 25.275(c).

<sup>5</sup> Space Station Application, Narrative at 27-28.

**Table 2.** Potential bandwidths, power levels, and EIRP levels for Swarm CMES transmissions.<sup>6</sup>

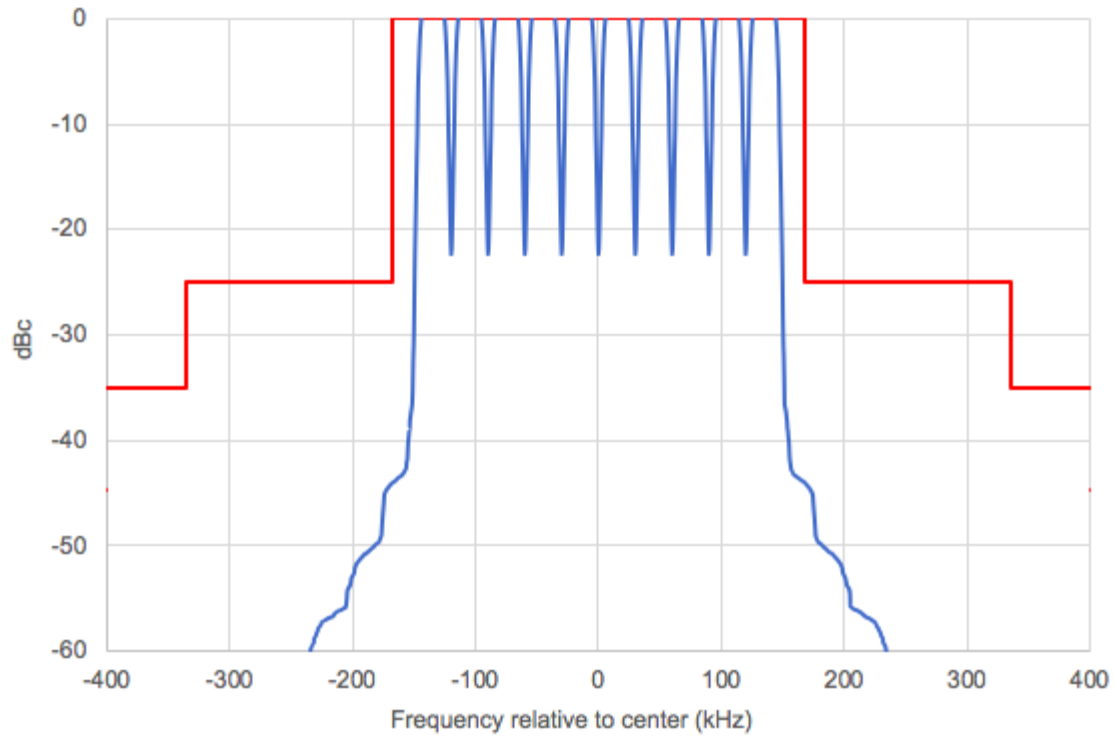
<b>Emission Designator</b>	<b>Necessary Bandwidth (kHz)</b>	<b>Assigned Bandwidth (kHz)</b>	<b>Power Level (W)</b>	<b>Max EIRP (dBW)</b>	<b>Max EIRP Density (dBW/4kHz)</b>
7K8F1D	7.8	16.0	5.0	12.5	9.6
10K4F1D	10.4	20.0	5.0	12.5	8.3
15K6F1D	15.6	24.0	5.0	12.5	6.6
20K8F1D	20.8	30.0	5.0	12.5	5.3
31K3F1D	31.3	40.0	5.0	12.5	3.6
41K7F1D	41.7	50.0	5.0	12.5	2.3
62K5F1D	62.5	72.0	5.0	12.5	0.6
125K0F1D	125.0	134.0	5.0	12.5	-2.5
250K0F1D	250.0	259.0	5.0	12.5	-5.5

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

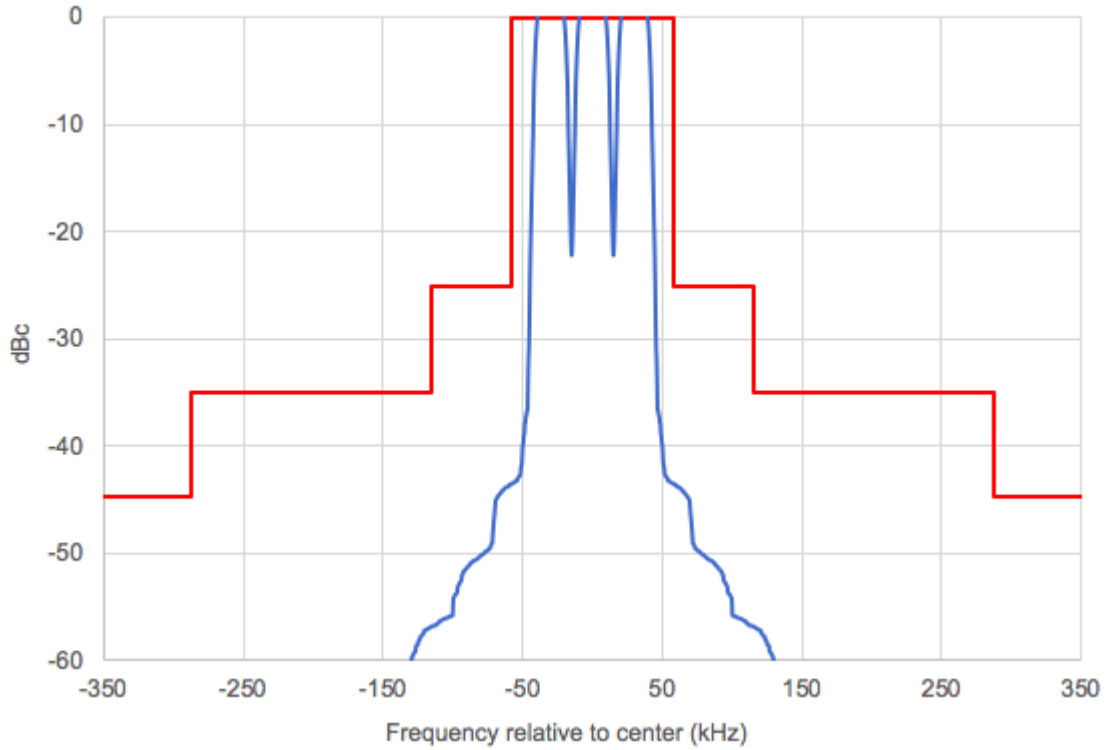
As demonstrated below, the spectrum masks for Swarm CMES emissions comply with the limits set forth in Section 25.202(f) of the Commission's rules.<sup>7</sup>

<sup>6</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 5.5 dBi. As described in the accompanying Form 312, CMES devices will use antennas with gain ranging from -10.0 dBi to 5.5 dBi.

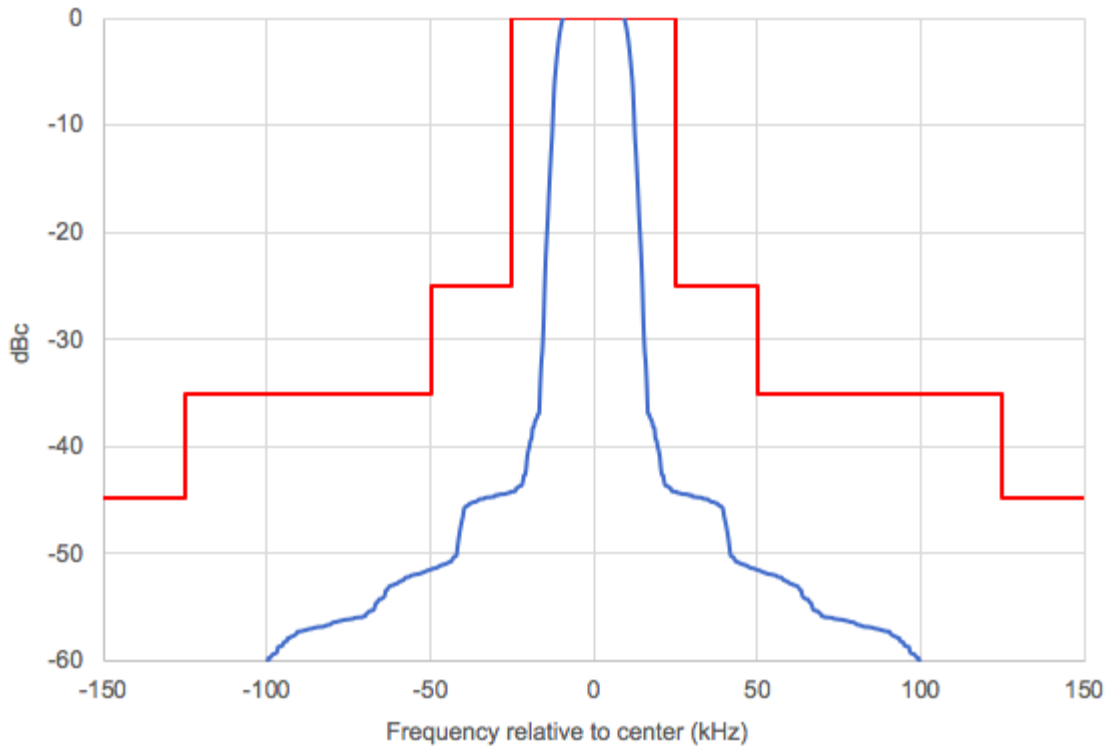
<sup>7</sup> Figures 1-3 reflect Swarm's nominal initial plan for communications links, which consists of channels with a necessary bandwidth of 20.8 kHz and an assigned bandwidth of 30.0 kHz to account for Doppler shift and frequency tolerance. Transmissions using alternative emissions designators (see Table 2) will also comply with the emissions mask requirements shown for each frequency band.



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

In addition, the carrier frequency of each CMES device will be maintained within 0.001% of the reference frequency as required by Section 25.202(d) of the Commission’s rules.

**Additional Technical Parameters, Operating Conditions, and Demonstration of Non-Interference (47 C.F.R. §§ 25.135)**

As required under 47 C.F.R § 25.135, Swarm provides the following information to demonstrate that its blanket-licensed CMES devices comply with the operating conditions set forth in 47 C.F.R. § 25.142(b) and will not cause unacceptable interference to other authorized users of the spectrum.

*Technical Parameters*

Information regarding the power levels at which CMES devices will transmit is provided in the accompanying Form 312 and in Table 2 above.

Additionally, in the 148-149.9 MHz band, the CMES devices that are the subject of this application will operate using the following technical parameters: (1) 1% duty cycle within any 15-minute period, (2) a maximum duration of 450 ms per transmission, and (3) a minimum of 15 seconds of separation between consecutive transmissions on the same frequency.<sup>8</sup>

CMES devices will employ techniques to avoid transmitting on frequencies in active use by terrestrial fixed and mobile stations. As a result, the -16 dBW/4 kHz power density limit and 0.25% duty cycle limitations provided in footnote US323 will not apply. Specifically, Swarm CMES devices use a Carrier-Sense Multiple Access (CSMA) media access control (MAC) protocol with Collision Avoidance (CSMA/CA). This “listen-before-talk” protocol verifies the absence of other traffic before a transmission is initiated on a given channel. If the carrier-sensing mechanism of a Swarm CMES device determines that another transmission is in progress, the transmitter waits for the transmission in progress to end before initiating its own transmission.

Using this CSMA protocol, multiple carriers on the ground, including both Swarm CMES devices and non-Swarm devices, can operate on the same frequencies with a minimal probability of interference to either system. There is also an inherently low probability of signal collision because of the low duty cycle and distributed geography of the anticipated customer deployments.

*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))*

As explained above, Swarm CMES devices will comply with technical parameters intended to protect federal users from NVNG MSS ground to space operations. In addition, to ensure that Swarm does not cause unacceptable interference for federal users, Swarm will

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<sup>8</sup> See 47 C.F.R § 2.106 at footnote US323.

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>9</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>10</sup> In addition, as explained above, Swarm’s devices will comply with the applicable out-of-band emissions requirements in Section 25.202(f), thereby protecting operations in neighboring bands. Pursuant to Section 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 Section 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 permitting end users to access a new generation of NVNG MSS services that will be provided by Swarm’s proposed

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<sup>9</sup> See 47 C.F.R. §25.142(b)(2)(ii).

<sup>10</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 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, 4808, 4812-13 ¶¶ 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”).



satellite constellation. 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. Moreover, 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, and Swarm’s network will address customer needs that are unmet by existing satellite services.<sup>11</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>12</sup> many of whom emphasized that Swarm’s network promises to “open new markets that current satellite technology cannot satisfy.”<sup>13</sup>

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<sup>11</sup> See Space Station Application, Narrative at 28-32; Consolidated Opposition and Response at 22-24.

<sup>12</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, 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>13</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.

Authorization of Swarm's network also will help to ensure that U.S. companies lead the way in a new era of innovation enabled by small satellite technology. 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. Approval of the blanket earth station application will enable significant numbers of new satellite users to 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,

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