HWG | HARRIS, WILTSHIRE & GRANNIS LLP

8 July 2020

Ex Parte

Mr. Jose P. Albuquerque
Chief, Satellite Division, International Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Swarm Technologies, Inc.; IBFS File Nos. SAT-MOD-20200501-00040 and SAT-AMD-20200504-00041; Call Sign: S3041

Dear Mr. Albuquerque:

Swarm Technologies, Inc. ("Swarm") hereby responds to your June 25, 2020 letter[1] requesting information about its pending application to modify the authorization for its non-voice, non-geostationary-orbit mobile-satellite service system in the 137–138 MHz and 148–150.05 MHz frequency bands[2] and the amendment filed thereto.[3]

Question 1. On page 2 of Swarm's orbital debris assessment report filed in both SAT-MOD-20200501-00040 and SAT-AMD-20200504-00041, tables providing the allocation of altitudes and orbital inclinations for the satellite constellation are included. The information provided regarding the number of satellites per plane is not consistent with the accompanying Schedule S reports. Please clarify applicable altitudes and orbital inclinations for the Swarm satellites.

Response: Swarm acknowledges the discrepancy in aggregate satellite counts per inclination band between the Orbital Debris Assessment Reports ("ODARs") and Schedule S reports submitted with the above-referenced applications. The allocations described and analyzed in the ODARs reflect Swarm's intended orbit distribution. The aggregate probability of

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1 *See* Letter from Jose P. Albuquerque, Chief, Satellite Division, International Bureau, FCC, to Shiva Goel, Harris, Wiltshire & Grannis, LLP, Counsel to Swarm Technologies, Inc., IBFS File Nos. SAT-MOD-20200501-00040 & SAT-AMD-20200504-00041, Call Sign S3041 (Jun. 25, 2020).

2 Swarm Technologies, Inc., *Application to Modify the Authorization for the Swarm NGSO Satellite System,* IBFS File No. SAT-MOD-20200501-00040 (filed May 1, 2020) ("Modification Application"); *see also Application of Swarm Technologies, Inc.*, Memorandum Opinion, Order and Authorization, 34 FCC Rcd. 9469 (Int'l Bur. Oct. 17, 2019).

3 *See* Swarm Technologies, Inc., *Amendment to Application to Modify the Authorization for the Swarm NGSO Satellite System,* IBFS File No. SAT-AMD-20200504-00041 (filed May 4, 2020) ("Amendment").

collision values reported in both applications thus remain unchanged, since Swarm computed them based on the satellite distributions in the ODARs. Likewise, the orbital parameters listed in Table 3 of the Amendment narrative are accurate.[4] Swarm hereby attaches corrected Schedule S reports that convey its planned satellite distributions should the Commission deem them necessary. Exhibit A corrects the Schedule S associated with the Modification Application, SAT-MOD-20200501-00040. Exhibit B corrects the Schedule S associated with the Amendment, SAT-AMD-20200504-00041.

Question 2. Pursuant to 47 C.F.R. § 25.114(d)(14)(3) of the Commission's rules, please provide information regarding the station-keeping tolerances for the Swarm satellites.

Response: With the authority sought in the Modification Application, Swarm's satellites will be able to maneuver using either built-in magnetorquers or both built-in magnetorquers and an on-board propulsion system.[5] Using these capabilities, Swarm plans to command orbital maneuvers to avoid collisions in response to conjunction alerts, to minimize dwell time at the altitude of the International Space Station, and for deorbiting.[6] While Swarm may use orbital maneuvers for station keeping, it does not intend to maintain specific tolerances for apogee and perigee altitudes, inclination, right ascension of the ascending node (RAAN), or the local time at the descending node (LTDN). Instead, Swarm intends to allow its satellites to decay naturally in altitude over time from their deployment at altitudes up to 585 km down to 300 km, where they will cease operations and burn up upon atmospheric re-entry.[7] Swarm satellites will demise fully in the atmosphere upon re-entry.

Swarm reiterates that all of its orbital debris risk calculations were computed assuming only passive drift down from deployment altitude until deorbit.[8] Based on those calculations, the summed, aggregate probability of collision between the entire 300-satellite constellation proposed in the Amendment and any trackable object over the duration of the 15-year license term would be 0.00034, which is significantly less than the 0.001 value established in NASA

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4 Amendment, Narrative Exhibit at 8.

5 As explained in its Modification Application, Swarm seeks the flexibility to implement on-board propulsion on its satellites at its discretion, but would ensure that all satellites launched after the effective date of any rule mandating propulsion comply with such a requirement. *See* Modification Application, Narrative Exhibit at 2.

6 *See id.* at 5, 9-10; *see also* Amendment, Narrative Exhibit at 22.

7 *See, e.g.*, Modification Application, Exhibit A at 2-3, 5; Amendment, Narrative Exhibit at 21. *See also Swarm Grant*, 34 FCC Rcd. 9469 ¶¶2, 18(e); 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, Narrative Exhibit at 3 (filed Dec. 21, 2018, granted Oct. 17, 2019); *id.*, Exhibit A at 2-3.

8 *See* Modification Application, Exhibit A at 7; Amendment, Exhibit A at 7.

Requirement 4.5-1.[9] The aggregate probability would be even lower for Swarm's currently authorized 150-satellite constellation with the expanded altitude flexibility proposed in the Modification Application.[10] Swarm's maneuvering capabilities, including the on-board propulsion system for which it now seeks authority, stand to further decrease these already low aggregate probabilities.

Please do not hesitate to contact me if you have any additional questions.

Sincerely,

Shiva Goel
Counsel to Swarm Technologies

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9 Amendment, Narrative Exhibit at 20; *id.*, Exhibit A at 7. *See also Mitigation of Orbital Debris in the New Space Age*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd. 4156 ¶ 34 (2020) (adopting a non-aggregate .001 standard for collision risk disclosures in 47 C.F.R. § 25.114(d)(14)(iv)(A)(1)).

10 *See* Modification Application, Narrative Exhibit at 9; *id.*, Exhibit A at 6.

EXHIBIT A

Approved by OMB 3060-0678
Estimated Burden: up to 80 hours
April 2016

Federal Communications Commission

(DRAFT COPY - Not for submission) Schedule S

312 File Number:

Filing Description

Question	Response
Description	(UPDATED July 2020) Application to Modify the Authorization for the Swarm NGSO Satellite System in VHF MSS band

Satellite Information

Question	Response
Select Orbit Type	NGSO
Space Station or Satellite Network Name	Swarm 1
Estimated Lifetime of Satellite(s) From Date of Launch	5 Years
Will the space station(s) operate on a Common Carrier basis?	No

Operating Frequency Bands (2)

Nature of service	Description	Frequency Band(s)	Mode Type
Mobile-Satellite Service		137.0 MHz -138.0 MHz	Transmit
Mobile-Satellite Service		148.0 MHz -150.0 MHz	Receive

Orbital Information For Non-Geostationary Satellites

Question	Response
Total Number of Satellites in the active constellation	150
Orbit Epoch Date	07/01/2020
Celestrial Reference Body	Earth

Orbital Plane 1:

Question	Response
Number of Satellites in Plane	24
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	234.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	0.0
2	15.0
3	30.0
4	45.0
5	75.0
6	90.0
7	105.0
8	120.0
9	135.0
10	150.0
11	165.0
12	180.0
13	195.0

14	210.0
15	225.0
16	240.0
17	255.0
18	270.0
19	285.0
20	300.0
21	315.0
22	330.0
23	345.0
24	60.0

Orbital Plane 2:

Question	Response
Number of Satellites in Plane	24
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	168.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	0.0

2	15.0
3	30.0
4	45.0
5	345.0
6	330.0
7	315.0
8	300.0
9	285.0
10	270.0
11	255.0
12	240.0
13	225.0
14	210.0
15	195.0
16	180.0
17	165.0
18	150.0
19	135.0
20	120.0
21	105.0
22	90.0
23	75.0
24	60.0

Orbital Plane 3:

Question	Response
Number of Satellites in Plane	12

Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	54.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	90.0
2	120.0
3	0.0
4	300.0
5	270.0
6	180.0
7	150.0
8	240.0
9	330.0
10	60.0
11	30.0
12	210.0

Orbital Plane 4:

Question	Response
Number of Satellites in Plane	18

Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	332.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	40.0
2	60.0
3	80.0
4	100.0
5	120.0
6	140.0
7	160.0
8	180.0
9	200.0
10	220.0
11	240.0
12	260.0
13	280.0
14	300.0
15	320.0
16	340.0

17	20.0
18	0.0

Orbital Plane 5:

Question	Response
Number of Satellites in Plane	12
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	288.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	330.0
2	300.0
3	0.0
4	30.0
5	60.0
6	90.0
7	120.0
8	150.0
9	180.0
10	210.0

11	240.0
12	270.0

Orbital Plane 6:

Question	Response
Number of Satellites in Plane	24
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	127.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	345.0
2	330.0
3	315.0
4	300.0
5	285.0
6	90.0
7	105.0
8	120.0
9	135.0
10	150.0

11	165.0
12	180.0
13	195.0
14	210.0
15	225.0
16	240.0
17	255.0
18	270.0
19	75.0
20	60.0
21	45.0
22	30.0
23	15.0
24	0.0

Orbital Plane 7:

Question	Response
Number of Satellites in Plane	12
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	105.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	0.0
2	120.0
3	90.0
4	60.0
5	30.0
6	330.0
7	300.0
8	270.0
9	240.0
10	210.0
11	180.0
12	150.0

Orbital Plane 8:

Question	Response
Number of Satellites in Plane	12
Inclination Angle	10.0 degrees
Right Ascension of Ascending Node	0.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-10.0 degrees
Active Service Arc End Angle with respect to Ascending Node	10.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	210.0
2	180.0
3	150.0
4	0.0
5	30.0
6	60.0
7	90.0
8	120.0
9	330.0
10	300.0
11	270.0
12	240.0

Orbital Plane 9:

Question	Response
Number of Satellites in Plane	12
Inclination Angle	45.0 degrees
Right Ascension of Ascending Node	0.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-45.0 degrees
Active Service Arc End Angle with respect to Ascending Node	45.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	240.0
2	270.0
3	300.0
4	330.0
5	30.0
6	60.0
7	0.0
8	210.0
9	180.0
10	150.0
11	120.0
12	90.0

Receiving Beams 1:

Question	Response
Beam ID	RB01
Receive Beam Frequency	148.25 MHz -148.585 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
G/T at Max. Gain Point	-24.8 dB/K
Min. Saturation Flux Density	-154.2 dBW/m2
Max. Saturation Flux Density	-125.2 dBW/m2
Co- or Cross Polar Mode	C
Service Area Description	Global

Receiving Beams 2:

Question	Response
Beam ID	RB03
Receive Beam Frequency	149.9 MHz -149.95 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees

Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
G/T at Max. Gain Point	-24.8 dB/K
Min. Saturation Flux Density	-154.2 dBW/m2
Max. Saturation Flux Density	-125.2 dBW/m2
Co- or Cross Polar Mode	C
Service Area Description	Global

Receiving Beams 3:

Question	Response
Beam ID	RB02
Receive Beam Frequency	148.635 MHz -148.75 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
G/T at Max. Gain Point	-24.8 dB/K
Min. Saturation Flux Density	-154.2 dBW/m2
Max. Saturation Flux Density	-125.2 dBW/m2
Co- or Cross Polar Mode	C
Service Area Description	Global

Receiving Channels (14)

Channel ID	Channel Bandwidth (MHz)	Center Frequency s (MHz)	Feeder Link, Service Link or TT&C
R009	0.03	148.5225	Service Link
R010	0.03	148.5525	Service Link
R011	0.03	148.6625	Service Link
R012	0.03	148.6925	Service Link
R013	0.03	148.7225	Service Link
R008	0.03	148.4925	Service Link
R004	0.03	148.3725	Service Link
R007	0.03	148.4625	Service Link
R006	0.03	148.4325	Service Link
R005	0.03	148.4025	Service Link
R003	0.03	148.3425	Service Link
R002	0.03	148.3125	Service Link
R001	0.03	148.2825	Service Link
R014	0.03	149.925	Service Link

Transmitting Beams 1:

Question	Response
Beam ID	TB01
Transmit Beam Frequency	137.025 MHz -137.175 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-41.4 dBW/Hz
Max. Transmit EIRP	1.76 dBW
Co- or Cross Polar Mode	C
Service Area Description	Global

Max. Power Flux Density

* BW:	* 0° - 5° (dbW/m^2 /BW):	* 5° - 10° (dbW/m^2 /BW):	* 10° - 15° (dbW/m^2 /BW):	* 15° - 20° (dbW/m^2 /BW):	* 20° - 25° (dbW/m^2 /BW):	* 25° - 90° (dbW/m^2 /BW):
4.0 kHz	-129.4	-129.3	-129.2	-129.0	-128.8	-125.9

Transmitting Beams 2:

Question	Response
Beam ID	TB02
Transmit Beam Frequency	137.328 MHz -137.375 MHz

Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-41.4 dBW/Hz
Max. Transmit EIRP	1.76 dBW
Co- or Cross Polar Mode	C
Service Area Description	Global

Max. Power Flux Density

* BW:	* 0° - 5° (dbW/m^2 /BW):	* 5° - 10° (dbW/m^2 /BW):	* 10° - 15° (dbW/m^2 /BW):	* 15° - 20° (dbW/m^2 /BW):	* 20° - 25° (dbW/m^2 /BW):	* 25° - 90° (dbW/m^2 /BW):
4.0 kHz	-129.4	-129.3	-129.2	-129.0	-128.8	-125.9

Transmitting Beams 3:

Question	Response
Beam ID	TB03
Transmit Beam Frequency	137.473 MHz -137.535 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees

Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-41.4 dBW/Hz
Max. Transmit EIRP	1.76 dBW
Co- or Cross Polar Mode	C
Service Area Description	Global

Max. Power Flux Density

* BW:	* 0° - 5° (dbW/m^2 /BW):	* 5° - 10° (dbW/m^2 /BW):	* 10° - 15° (dbW/m^2 /BW):	* 15° - 20° (dbW/m^2 /BW):	* 20° - 25° (dbW/m^2 /BW):	* 25° - 90° (dbW/m^2 /BW):
4.0 kHz	-129.4	-129.3	-129.2	-129.0	-128.8	-125.9

Transmitting Beams 4:

Question	Response
Beam ID	TB04
Transmit Beam Frequency	137.585 MHz -137.65 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-41.4 dBW/Hz

Max. Transmit EIRP	1.76 dBW
Co- or Cross Polar Mode	C
Service Area Description	Global

Max. Power Flux Density

* BW:	* 0° - 5° (dbW/m^2 /BW):	* 5° - 10° (dbW/m^2 /BW):	* 10° - 15° (dbW/m^2 /BW):	* 15° - 20° (dbW/m^2 /BW):	* 20° - 25° (dbW/m^2 /BW):	* 25° - 90° (dbW/m^2 /BW):
4.0 kHz	-129.4	-129.3	-129.2	-129.0	-128.8	-125.9

Transmitting Beams 5:

Question	Response
Beam ID	TB05
Transmit Beam Frequency	137.813 MHz -138.0 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-41.4 dBW/Hz
Max. Transmit EIRP	1.76 dBW
Co- or Cross Polar Mode	C
Service Area Description	Global

Max. Power Flux Density

* BW:	* 0° - 5° (dbW/m^2 /BW):	* 5° - 10° (dbW/m^2 /BW):	* 10° - 15° (dbW/m^2 /BW):	* 15° - 20° (dbW/m^2 /BW):	* 20° - 25° (dbW/m^2 /BW):	* 25° - 90° (dbW/m^2 /BW):
4.0 kHz	-129.4	-129.3	-129.2	-129.0	-128.8	-125.9

Transmitting Channels (12)

Channel ID	Channel Bandwidth (MHz)	Center Frequency s (MHz)	Feeder Link, Service Link or TT&C
T011	0.03	137.9363	Service Link
T008	0.03	137.8463	Service Link
T007	0.03	137.6175	Service Link
T006	0.03	137.5038	Service Link
T005	0.03	137.3513	Service Link
T004	0.03	137.145	Service Link
T003	0.03	137.115	Service Link
T002	0.03	137.085	Service Link
T001	0.03	137.055	Service Link
T012	0.03	137.9663	Service Link
T009	0.03	137.8763	Service Link
T010	0.03	137.9063	Service Link

Certification Questions

Question	Response
Are the applicable service area coverage requirements of 25.143(b)(2)(ii) and (iii), or 25.144(a)(3)(i), or 25.145(c)(1) and (2), or 25.146(i)(1) and (2), or 25.148(c), or 25.225 met?	N/A
Are the applicable frequency tolerances of 25.202(e) and out-of-band emission limits of 25.202(f)(1),(2), and (3) met?	Yes
Are the cessation of emissions requirements of 25.207 met?	Yes
Are the applicable power-flux-density limits of 25.208 met, and is the appropriate technical showing provided within the application?	
For NGSO applications, are the applicable equivalent-power-flux-density limits of 25.208 met, and is the appropriate technical showing provided within the application?	N/A
Are the applicable full-frequency-reuse requirements of 25.210 met?	
If the application is for a 17/24 GHz BSS space station, will it be operated at an offset location with full power and interference protection in accordance with 25.262(b)?	

Attachments

File Name	Beam	Field	Attachment Type	Description
Receive Antenna Pattern.pdf	RB01	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite receive beam
Transmit Antenna Pattern.pdf	TB01	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite transmit beam
Receive Antenna Pattern.pdf	RB02	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite receive beam
Transmit Antenna Pattern.pdf	TB02	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite transmit beam
Transmit Antenna Pattern.pdf	TB05	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite transmit beam
Transmit Antenna Pattern.pdf	TB04	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite transmit beam
Transmit Antenna Pattern.pdf	TB03	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite transmit beam
Receive Antenna Pattern.pdf	RB03	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite receive beam

EXHIBIT B

Approved by OMB 3060-0678
Estimated Burden: up to 80 hours
April 2016

Federal Communications Commission

(DRAFT COPY - Not for submission) Schedule S

312 File Number:

Filing Description

Question	Response
Description	(UPDATED July 2020) Amendment to "Application to Modify the Authorization for the Swarm NGSO Satellite System" in VHF MSS band (137-138 MHz and 148-150.05 MHz)

Satellite Information

Question	Response
Select Orbit Type	NGSO
Space Station or Satellite Network Name	Swarm 1
Estimated Lifetime of Satellite(s) From Date of Launch	5 Years
Will the space station(s) operate on a Common Carrier basis?	No

Operating Frequency Bands (2)

Nature of service	Description	Frequency Band(s)	Mode Type
Mobile-Satellite Service		137.0 MHz -138.0 MHz	Transmit
Mobile-Satellite Service		148.0 MHz -150.05 MHz	Receive

Orbital Information For Non-Geostationary Satellites

Question	Response
Total Number of Satellites in the active constellation	300
Orbit Epoch Date	07/01/2020
Celestrial Reference Body	Earth

Orbital Plane 1:

Question	Response
Number of Satellites in Plane	36
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	234.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	210.0
2	220.0
3	230.0
4	240.0
5	250.0
6	260.0
7	270.0
8	280.0
9	290.0
10	300.0
11	310.0
12	320.0
13	330.0

14	340.0
15	350.0
16	70.0
17	80.0
18	90.0
19	100.0
20	110.0
21	120.0
22	130.0
23	140.0
24	150.0
25	160.0
26	170.0
27	60.0
28	30.0
29	20.0
30	10.0
31	0.0
32	50.0
33	40.0
34	200.0
35	190.0
36	180.0

Orbital Plane 2:

Question	Response
Number of Satellites in Plane	36

Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	168.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	170.0
2	160.0
3	50.0
4	150.0
5	140.0
6	130.0
7	120.0
8	110.0
9	100.0
10	90.0
11	80.0
12	70.0
13	60.0
14	40.0
15	30.0
16	20.0

17	10.0
18	0.0
19	350.0
20	340.0
21	330.0
22	320.0
23	310.0
24	300.0
25	290.0
26	280.0
27	270.0
28	260.0
29	250.0
30	240.0
31	230.0
32	220.0
33	210.0
34	200.0
35	190.0
36	180.0

Orbital Plane 3:

Question	Response
Number of Satellites in Plane	36
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	54.0 degrees
Argument of Perigee	0.0 degrees

Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	80.0
2	90.0
3	100.0
4	110.0
5	70.0
6	60.0
7	50.0
8	40.0
9	30.0
10	20.0
11	10.0
12	0.0
13	350.0
14	340.0
15	330.0
16	320.0
17	310.0
18	300.0
19	290.0

20	280.0
21	270.0
22	260.0
23	250.0
24	240.0
25	130.0
26	140.0
27	150.0
28	160.0
29	170.0
30	180.0
31	190.0
32	230.0
33	220.0
34	210.0
35	200.0
36	120.0

Orbital Plane 4:

Question	Response
Number of Satellites in Plane	48
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	332.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km

Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	0.0
2	7.5
3	15.0
4	22.5
5	30.0
6	37.5
7	45.0
8	52.5
9	292.5
10	210.0
11	217.5
12	225.0
13	232.5
14	240.0
15	247.5
16	255.0
17	262.5
18	270.0
19	277.5
20	285.0
21	300.0

22	307.5
23	315.0
24	322.5
25	330.0
26	337.5
27	345.0
28	352.5
29	202.5
30	195.0
31	187.5
32	180.0
33	172.5
34	165.0
35	157.5
36	150.0
37	142.5
38	135.0
39	127.5
40	120.0
41	112.5
42	105.0
43	97.5
44	90.0
45	82.5
46	75.0
47	67.5

48	60.0

Orbital Plane 5:

Question	Response
Number of Satellites in Plane	36
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	288.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	230.0
2	220.0
3	210.0
4	200.0
5	190.0
6	180.0
7	170.0
8	160.0
9	150.0
10	140.0
11	130.0

12	90.0
13	270.0
14	280.0
15	240.0
16	340.0
17	330.0
18	300.0
19	290.0
20	320.0
21	350.0
22	260.0
23	250.0
24	310.0
25	120.0
26	110.0
27	100.0
28	80.0
29	70.0
30	60.0
31	50.0
32	40.0
33	30.0
34	20.0
35	10.0
36	0.0

Orbital Plane 6:

Question	Response
Number of Satellites in Plane	36
Inclination Angle	97.7 degrees
Right Ascension of Ascending Node	127.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	350.0
2	340.0
3	330.0
4	320.0
5	310.0
6	300.0
7	290.0
8	280.0
9	270.0
10	260.0
11	250.0
12	240.0
13	230.0
14	220.0

15	170.0
16	160.0
17	0.0
18	10.0
19	20.0
20	30.0
21	40.0
22	50.0
23	60.0
24	70.0
25	80.0
26	90.0
27	100.0
28	110.0
29	120.0
30	130.0
31	140.0
32	150.0
33	210.0
34	200.0
35	190.0
36	180.0

Orbital Plane 7:

Question	Response
Number of Satellites in Plane	36
Inclination Angle	97.7 degrees

Right Ascension of Ascending Node	105.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-90.0 degrees
Active Service Arc End Angle with respect to Ascending Node	90.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	80.0
2	70.0
3	60.0
4	50.0
5	40.0
6	30.0
7	20.0
8	10.0
9	0.0
10	350.0
11	340.0
12	330.0
13	320.0
14	310.0
15	300.0
16	290.0
17	280.0

18	270.0
19	260.0
20	250.0
21	240.0
22	230.0
23	220.0
24	210.0
25	200.0
26	190.0
27	180.0
28	170.0
29	160.0
30	150.0
31	140.0
32	130.0
33	120.0
34	110.0
35	100.0
36	90.0

Orbital Plane 8:

Question	Response
Number of Satellites in Plane	24
Inclination Angle	10.0 degrees
Right Ascension of Ascending Node	0.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds

Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-10.0 degrees
Active Service Arc End Angle with respect to Ascending Node	10.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	285.0
2	315.0
3	345.0
4	90.0
5	105.0
6	120.0
7	135.0
8	330.0
9	300.0
10	270.0
11	210.0
12	195.0
13	180.0
14	165.0
15	225.0
16	150.0
17	75.0
18	60.0
19	45.0
20	30.0

21	15.0
22	0.0
23	240.0
24	255.0

Orbital Plane 9:

Question	Response
Number of Satellites in Plane	12
Inclination Angle	45.0 degrees
Right Ascension of Ascending Node	0.0 degrees
Argument of Perigee	0.0 degrees
Orbital Period	5790.0 seconds
Apogee	585.0 km
Perigee	585.0 km
Active Service Arc Begin Angle with respect to Ascending Node	-45.0 degrees
Active Service Arc End Angle with respect to Ascending Node	45.0 degrees

Mean Anomaly For Each Satellite

Satellite Number	Mean Anomaly (degrees) at the Orbit Epoch Date
1	150.0
2	180.0
3	210.0
4	240.0
5	0.0
6	30.0
7	60.0
8	300.0

9	270.0
10	330.0
11	90.0
12	120.0

Receiving Beams 1:

Question	Response
Beam ID	RB01
Receive Beam Frequency	148.0 MHz -150.05 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
G/T at Max. Gain Point	-24.8 dB/K
Min. Saturation Flux Density	-154.2 dBW/m2
Max. Saturation Flux Density	-125.2 dBW/m2
Co- or Cross Polar Mode	C
Service Area Description	Global

Receiving Channels (41)

Channel ID	Channel Bandwidth (MHz)	Center Frequency s (MHz)	Feeder Link, Service Link or TT&C
R022	0.05	149.075	Service Link
R041	0.05	150.025	Service Link
R040	0.05	149.975	Service Link
R039	0.05	149.925	Service Link
R038	0.05	149.875	Service Link
R037	0.05	149.825	Service Link
R036	0.05	149.775	Service Link
R035	0.05	149.725	Service Link
R034	0.05	149.675	Service Link
R032	0.05	149.575	Service Link
R031	0.05	149.525	Service Link
R030	0.05	149.475	Service Link
R029	0.05	149.425	Service Link
R027	0.05	149.325	Service Link
R026	0.05	149.275	Service Link
R025	0.05	149.225	Service Link
R024	0.05	149.175	Service Link
R023	0.05	149.125	Service Link
R021	0.05	149.025	Service Link
R020	0.05	148.975	Service Link
R019	0.05	148.925	Service Link
R018	0.05	148.875	Service Link
R017	0.05	148.825	Service Link
R016	0.05	148.775	Service Link

R015	0.05	148.725	Service Link
R014	0.05	148.675	Service Link
R013	0.05	148.625	Service Link
R012	0.05	148.575	Service Link
R011	0.05	148.525	Service Link
R010	0.05	148.475	Service Link
R009	0.05	148.425	Service Link
R008	0.05	148.375	Service Link
R007	0.05	148.325	Service Link
R006	0.05	148.275	Service Link
R005	0.05	148.225	Service Link
R004	0.05	148.175	Service Link
R003	0.05	148.125	Service Link
R002	0.05	148.075	Service Link
R001	0.05	148.025	Service Link
R033	0.05	149.625	Service Link
R028	0.05	149.375	Service Link

Transmitting Beams 1:

Question	Response
Beam ID	TB01
Transmit Beam Frequency	137.0 MHz -138.0 MHz
Beam Type	Fixed
Polarization	RHCP
Peak Gain	0.0 dBi
Antenna Pointing Error	2.0 degrees
Antenna Rotational Error	2.0 degrees
Polarization Switchable	
Polarization Alignment Relative to the Equatorial Plane	45.0 degrees
Max. Transmit EIRP Density	-41.4 dBW/Hz
Max. Transmit EIRP	1.76 dBW
Co- or Cross Polar Mode	C
Service Area Description	Global

Max. Power Flux Density

* BW:	* 0° - 5° (dbW/m^2 /BW):	* 5° - 10° (dbW/m^2 /BW):	* 10° - 15° (dbW/m^2 /BW):	* 15° - 20° (dbW/m^2 /BW):	* 20° - 25° (dbW/m^2 /BW):	* 25° - 90° (dbW/m^2 /BW):
4.0 kHz	-129.4	-129.3	-129.2	-129.0	-128.8	-125.9

Transmitting Channels (20)

Channel ID	Channel Bandwidth (MHz)	Center Frequency s (MHz)	Feeder Link, Service Link or TT&C
T008	0.05	137.375	Service Link
T007	0.05	137.325	Service Link
T006	0.05	137.275	Service Link
T001	0.05	137.025	Service Link
T011	0.05	137.525	Service Link
T002	0.05	137.075	Service Link
T003	0.05	137.125	Service Link
T004	0.05	137.175	Service Link
T005	0.05	137.225	Service Link
T009	0.05	137.425	Service Link
T010	0.05	137.475	Service Link
T012	0.05	137.575	Service Link
T013	0.05	137.625	Service Link
T014	0.05	137.675	Service Link
T015	0.05	137.725	Service Link
T016	0.05	137.775	Service Link
T017	0.05	137.825	Service Link
T018	0.05	137.875	Service Link
T019	0.05	137.925	Service Link
T020	0.05	137.975	Service Link

Certification Questions

Question	Response
Are the applicable service area coverage requirements of 25.143(b)(2)(ii) and (iii), or 25.144(a)(3)(i), or 25.145(c)(1) and (2), or 25.146(i)(1) and (2), or 25.148(c), or 25.225 met?	N/A
Are the applicable frequency tolerances of 25.202(e) and out-of-band emission limits of 25.202(f)(1),(2), and (3) met?	Yes
Are the cessation of emissions requirements of 25.207 met?	Yes
Are the applicable power-flux-density limits of 25.208 met, and is the appropriate technical showing provided within the application?	
For NGSO applications, are the applicable equivalent-power-flux-density limits of 25.208 met, and is the appropriate technical showing provided within the application?	N/A
Are the applicable full-frequency-reuse requirements of 25.210 met?	
If the application is for a 17/24 GHz BSS space station, will it be operated at an offset location with full power and interference protection in accordance with 25.262(b)?	

Attachments

File Name	Beam	Field	Attachment Type	Description
Receive Antenna Pattern.pdf	RB01	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite receive beam
Transmit Antenna Pattern.pdf	TB01	NGSO Antenna Gain Data	PDF file (*.pdf)	Antenna pattern for satellite transmit beam