PUBLIC DISCLOSURE

Swarm Technologies Inc.
Exhibit A to FCC Form 442 (File No. 0976-ES-ST-2018)
(1U system) June 7, 2018

Exhibit A - Narrative Statement

Introduction:

Swarm Technologies Inc ("Swarm") is a California based corporation seeking to deploy 1U CubeSat-sized two-way communications satellites [redacted] The initial experimental space deployment is comprised of three satellites, each with a 1U form factor. The three satellites will be weighted slightly differently so that they naturally spread out in orbit over time due to differing ballistic coefficients.

Each satellite will use VHF band frequencies for communications. There will also be an experimental deployment of two ground stations in the United States for communications with the 1U spacecraft. The VHF frequency proposed in this application, more specifically in the 137-138 MHz and 148-149.9 MHz bands, is allocated on a primary basis for space to ground Mobile Satellite Service (MSS) communications for non-Federal, non-voice, non-geostationary orbit (NGSO) systems and capable of [redacted]

Swarm requests experimental authority [redacted]

Experimental Program Description:

The proposed architecture is comprised of both space and ground units for [redacted]

[redacted]

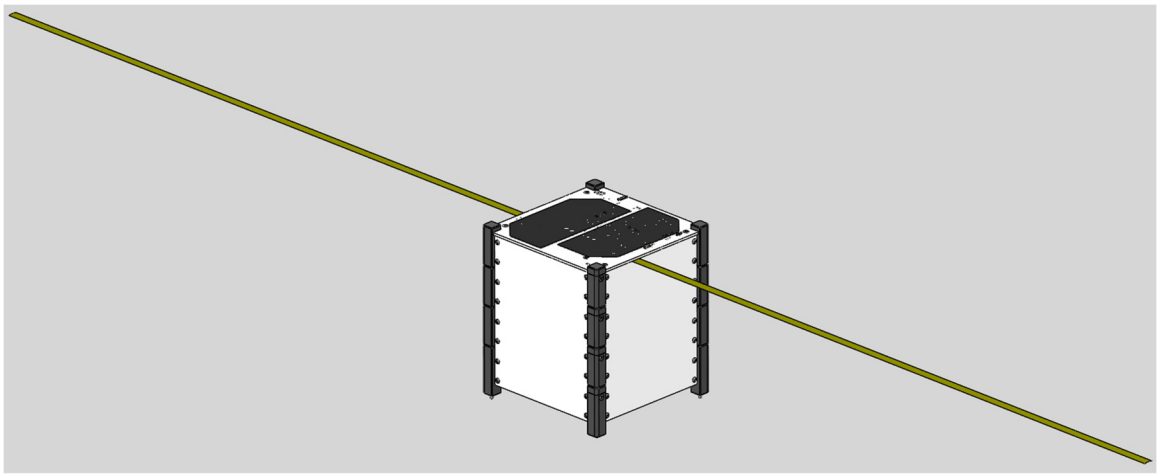

Figure 1: Image of a single satellite.

The satellites will orient themselves with the VHF antenna wires in the zenith and nadir directions for maximizing the antenna gain along the horizon.

The satellites contain a battery with [redacted]

Communication between space and ground elements uses VHF frequencies. The two quarter-wavelength (split dipole, linear polarization) deployed antenna wires provide a donut-shaped antenna gain pattern that maximizes gain along the horizon, which is ideal for long distance communications with ground stations.

The experimental program is designed to meet the following objectives and validations:

[redacted]

General Description of the Overall System and Operations:

The Swarm satellite network consists of three data relay satellites and two ground stations [redacted]

The system architecture consists of ground stations that [redacted]

The satellites and ground stations will transmit only upon command from the ground and persist only during active data transmissions. Any transmission can be immediately terminated by ground command if interference is detected or reported. [redacted]

Public Interest Consideration:

The Commission's grant of this application will serve the public interest by allowing Swarm to demonstrate the above described [redacted]

[redacted]

[redacted]

Launch, Orbital Parameters, and Lifetime:

The experimental deployment space launch is planned for the SpaceX SSO-A launch vehicle scheduled September 1, 2018 into a Low Earth Orbit (LEO) at approximately 575 km altitude. Swarm satellites do not employ propulsion or other active orbit maintenance technology, but with their low mass, the orbit will naturally decay and the satellites will re-enter the atmosphere within approximately 5.3 years (nominal scenario, see ODAR in Exhibit B for more details) and completely burn up before reaching the ground. Table 1 details the anticipated orbit parameters.

Orbital Parameters	Values	Accuracy
Inclination Angle (deg.)	98	+/- 1
Apogee (km)	575	+/- 50
Perigee (km)	575	+/- 50
Semi-major Axis (km)	575	+/- 50

Table 1: Anticipated orbit for Swarm satellites

Orbital Debris and Assessment Report (ODAR) and Radar Tracking:

Exhibit B attached to this application describes fully the orbital debris and assessment report requirements pursuant to 47 C.F.R. § 5.64.

Non-Interference Criterion:

Pursuant to 47 C.F.R. § 5.84 and 5.85, it is understood that a grant of authority for this experimental program will be on a non-exclusive and non-interference basis to both Federal and non-Federal authorized users of the VHF spectrum proposed in this application. Operations under the experimental program will be conducted only at the two coordinated ground stations. Exhibit C attached to this application describes fully the electromagnetic compatibility of the Swarm system with other users and services in the VHF frequencies proposed in this application, more specifically in the 137-138 MHz and 148-149.9 MHz bands.

Power Flux Density Calculation at Earth's Surface:

In compliance with section 25.142 of the Commission's rules, in the 137-138 MHz band the power flux density (PFD) at the Earth's surface produced by the satellites will not exceed -153 dB(W/m²) in any 4 kHz band at any angle of arrival. Swarm ground stations transmit with a power spectral density (PSD) of -20 dBW/4kHz.

The out of band emissions are minimized by digital modulation techniques and filtering with at least 20 dB spectral roll off at 120% of signal bandwidth in any 4 kHz band, 40 dB at 200%

bandwidth, 55 dB at 300% bandwidth, and more than 60 dB beyond 4 times the bandwidth. A center frequency of 137.920 MHz is chosen to remain within the band allocated to NGSO MSS, minimizing potential for interference into adjacent services, including allowance for Doppler shift and frequency tolerance.

Radio System Technical Characteristics:

Both satellites and ground stations share similar antenna and radio frequency characteristics and link parameters which are further characterized in the link budget provided in Table 2.

	ground to satellite		satellite to ground		
Item	**Nominal**	**Worst-Case**	**Nominal**	**Worst-Case**	**Units**
Satellite Orbital Altitude	**575**	**575**	**575**	**575**	km
Earth Radius	6371	6371	6371	6371	km
Frequency	0.148	0.148	0.138	0.138	GHz
Elevation Angle to Satellite	30	1	30	1	deg
Satellite Angle from Nadir	52.59	66.50	52.59	66.50	deg
Theta Angle	7.41	22.50	7.41	22.50	deg
Transmitter Power	**0.20**	**0.20**	**0.20**	**0.20**	Watts
Transmitter Power	-6.99	-6.99	-6.99	-6.99	dBW
Transmitter Line Loss	-1.00	-1.00	-1.00	-1.00	dBW
Peak Transmit Antenna Gain	2.00	2.00	2.00	2.00	dBi
Transmit Antenna Pattern Loss	-1.25	0.00	-1.25	0.00	dB
Transmit Total Gain	-0.25	1.00	-0.25	1.00	dB
Eq. Isotropic Radiated Power	**-7.24**	**-5.99**	**-7.24**	**-5.99**	**dBW**
Propagation Path Length	1034	2658	1034	2658	km
Path Loss	-136.15	-144.35	-135.54	-143.74	dB
Polarization Loss	-0.04	-0.34	-0.04	-0.34	dB
Power @ Receiver Antenna	**-143.42**	**-150.68**	**-142.81**	**-150.07**	**dBW**
Peak Receive Antenna Gain	2.00	2.00	2.00	2.00	dBi
Receive Antenna Line Loss	-1.00	-1.00	-1.00	-1.00	dB
Receive Antenna Pattern Loss	-2.00	-0.75	-2.00	-0.75	dB
Rx Gain with pointing error	-1.00	0.25	-1.00	0.25	dB
Rx Power	**-144.42**	**-150.43**	**-143.81**	**-149.83**	**dBW**
Rx Antenna System Noise	728	728	728	728	K
Rx Antenna G/T	-29.62	-28.38	-29.62	-28.38	dB/K
Received C/No	55.55	49.54	56.16	50.15	dB-Hz
Bandwidth	125	125	125	125	kHz
BW Spreading Factor	7	7	7	7	
Received C/N	4.09	-1.92	4.70	-1.31	dB
Target Data rate	5.40	5.47	5.47	5.47	kbps
Target Rx Level	-155	-155	-155	-155	dBW
Implementation Margin	6	6	6	6	dB
C/No Objective	50.97	50.97	50.97	50.97	dB-Hz
C/N Objective	0.00	0.00	0.00	0.00	dB
Remaining Margin	**4.10**	**-1.92**	**4.70**	**-1.31**	**dB**

Table 2: Space and ground link budget.

The satellite antenna is a ¼ wave dipole with a donut shaped antenna pattern oriented with maximum gain toward the horizons and minimum gain in the nadir direction. The ground station is a vertically polarized dipole antenna. Figure 2 and Figure 3 show the space and ground antenna patterns and characteristics respectively, applicable for both transmit and receive.

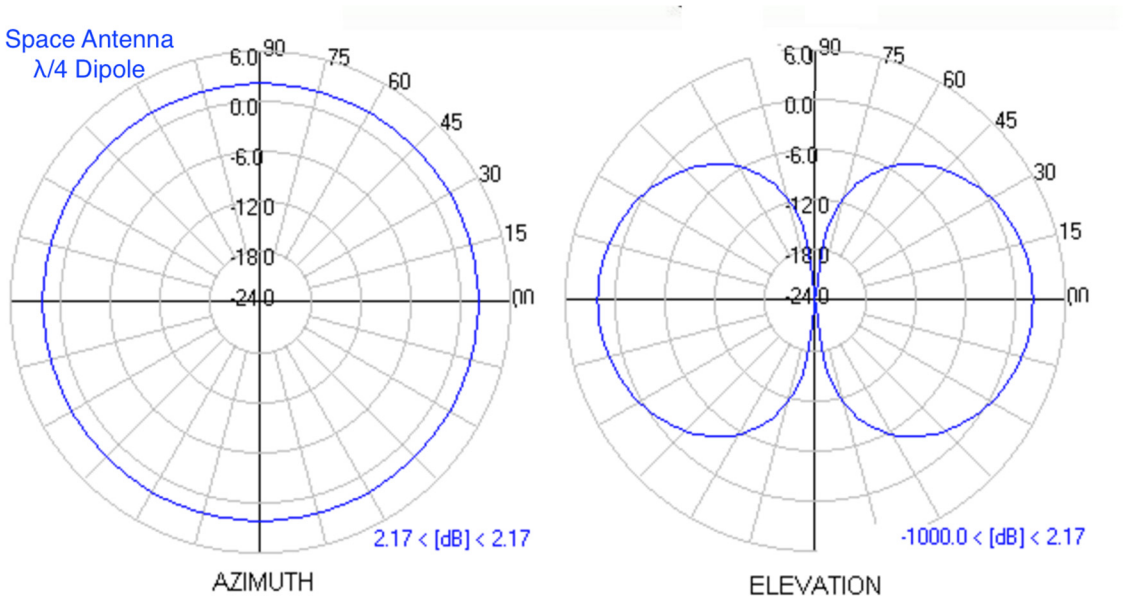

Figure 2: Satellite transmit and receive antenna pattern.

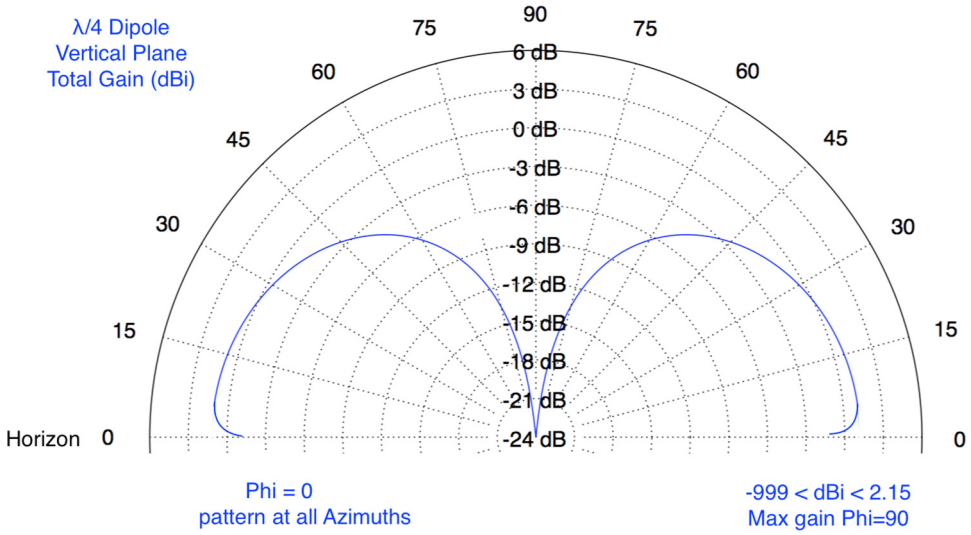

Figure 3: Ground station transmit and receive antenna pattern.

All satellite to ground station communications initiate upon command and self-terminate at the completion of the data transmission. If any deviation from the authorized technical requirements of the transmission is detected, the ground system will mute further transmissions until the deviation is understood and can be corrected.

Swarm requests a waiver of rule 47 C.F.R. § 5.115 related to station identification. More specifically, Swarm requests a waiver of the requirement for periodic station identification in the interest of minimizing transmission durations and activity. Grant of such waiver serves the public interest, as compliance with the station identification requirement unnecessarily adds additional data and modulation changes during transmissions. Grant of such waiver does not adversely affect the spectrum rights of any third party and is consistent with Commission's longstanding commitment to spectral efficiency.

Ground Station Locations:

Ground Station 1
321 Camino Al Lago
Menlo Park, CA 94027
lat/long (NAD83): 37.4363, -122.2123, 40m
Antenna height, 3 meters above ground level
Antenna type: VHF vertical dipole

Ground Station 2
4015 Biltmore Cove Way
Buford, GA 30519
lat/long (NAD83): 34.0847, -83.9476, 366m
Antenna height, 3 meters above ground level
Antenna type: VHF vertical dipole

ITU Advance Publication and Cost recovery:

Pursuant to 47 C.F.R. § 25.111 for space systems, it is understood that the commission will submit filings to the ITU on behalf of the applicant pursuant to international obligations for the coordination and registration of space network systems. Swarm will provide the commission the appropriate electronic files for submission to the ITU and hereby provides its commitment to the cost recovery of any such filings to the ITU.