Swarm Technologies Inc.
Exhibit A to FCC Form 442
April 26, 2017

Exhibit A - Narrative Statement

Introduction:

Swarm Technologies Inc ("Swarm") is a California based corporation seeking to deploy the world's smallest two-way communications satellites to serve as a cost-effective low-data rate Internet of Things (IoT) network connectivity solution for remote and mobile sensors. The initial experimental space deployment is comprised of four satellites, each with a 1/4U form factor employing radar signature enhancement technology (which enables them to be passively tracked, see Section 9 of Exhibit B ODAR) and using VHF band frequencies for communications. There will also be an experimental deployment of ground stations for communications with the space units.

Swarm requests experimental authority to demonstrate the capabilities of these microsatellites for serving low data rate communication relays for remote sensors and data collectors. Experimental operations is scheduled to begin upon launch, currently scheduled in September 2017, and for a period of at least 6 months and up to 2 years.

Experimental Program Description:

The proposed architecture is comprised of both space and ground units for the collection of ground based remote sensor data, radio relay to space units, and radio relay to Internet connected ground stations for data dissemination to the end user. The network of satellites is comprised of Basic Electronic Elements ("BEEs") which are 1/4U form factor satellites, made out of an aluminum frame, PCBs, a 12.5 Whr battery and solar panels for recharge. BEEs include radar return enhancement technology to ensure they are trackable. Ground stations include Wi-Fi for intercommunications with ground-based sensors and connection to the Internet. Figure 1 provides a pictorial description of the BEEs and their characteristics.

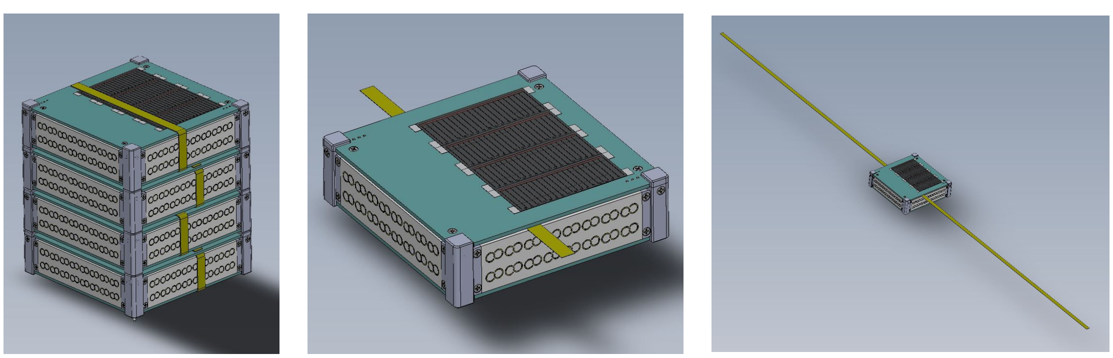

Figure 1: Images of the Basic Electronic Elements (BEEs), 4 stacked BEEs pre-deployment (left), single BEE (center), BEE with deployed antenna (right).

The BEEs use a novel attitude control scheme (patent pending) to achieve a stable orientation to 1) maximize solar power collection, and 2) orient the VHF antenna wires in the zenith and nadir directions for maximizing the antenna gain along the horizon. Aerodynamic drag on the BEE provides stabilization in 1-axis, and gravity gradient provides stabilization in the second and third axis. Combined, drag and gravity gradient coarsely stabilizes the satellite, without using power.

The BEE contains a battery with enough stored energy for several days of operation in normal duty cycle sensing/networking mode without any recharge. There are solar panels that provide recharge maintaining a positive orbit average net power and the BEE potentially remains operational for up to 10 years (longer than the expected orbital lifetime).

Communication between space and ground elements is using 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:

- Demonstrate the autonomous passive satellite launch deployment method (four 1/4U satellites deployed from a 1U CubeSat form factor) where upon ejection from the launch vehicle, the satellites individually separate from each other utilizing springs in their feet, and over time space out in the orbit plane to achieve more distributed global coverage.

- Demonstrate the passive attitude control methodology that combines drag stabilization and gravity gradient stabilization to maintain a desired static orientation in orbit to optimize the antenna pattern orientation for communication with the ground. This test requires 1+ year of operation to validate our orbital separation models.

- Demonstrate the effectiveness of the radar return signal enhancement technology to ensure reliable ground tracking of the small satellites regardless of their operational state.

- Demonstrate the use of low power and low data rate VHF communications between Earth and space for remote sensor data relay services, which include Earth to space uplink of data from remote sensors and space to Earth data relay to Internet-connected ground stations.

General Description of the Overall System and Operations:

The Swarm BEE network consists of 4 BEEs, ground stations connected to remote sensors, and Internet-connected ground stations for data relay back to the Internet.

The system architecture consists of ground stations that receive data from nearby or connected sensors and transmit this data to BEEs in space. BEEs receive and store messages onboard, and download these messages when they pass over ground stations in the future using a store-and-forward delay tolerant networking approach. All transmissions will be scheduled *a priori* and uploaded to all BEEs and downloaded to all ground stations in advance of the schedule execution. BEEs and ground stations will only transmit at designated time slots according to the schedule (they have on-board GPS to have accurate timing information), and will be listening during the times they are scheduled to receive messages. All uplink and downlink transmissions will be one-way.

Public Interest Consideration:

The commission's grant of this application will serve the public interest by allowing Swarm to demonstrate the above described very low-cost satellite technology which aims to serve the growing interest in collecting and disseminating remote sensor data from anywhere on the Earth at very low cost to the user, including Earth weather data for environmental monitoring. This technology expands the markets access to low cost remote sensor data networks.

In addition, this commercial program is relevant to NASA's strategic goals for small satellite technology development, science, and exploration. In a separate and future program, we will work together with NASA under the Cubesat Launch Initiative, Solicitation Reference number NNH15HEOD001L, as well as a separate and future joint NASA-Ames / Swarm networking demonstration mission.

Launch, Orbital Parameters, and Lifetime:

The experimental deployment space launch is planned for the PSLV launch vehicle scheduled September 15, 2017 into a near-polar Sun Synchronous Low Earth Orbit (LEO) at approximately 580 km altitude. Swarm BEEs do not employ propulsion or other active orbit maintenance technology and with its low mass, the orbit will naturally decay and re-enter the atmosphere within approximately 7.7 years or less (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.)	97.7	+/- 0.1
Apogee (km)	580	+/- 15
Perigee (km)	580	+/- 15
Semi-major Axis (km)	580	+/- 1.0
LTDN	9:30 am	+/- 15 min

Table 1. Anticipated Orbit for Swarm BEEs

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

Section 9 in Exhibit B attached to this application describes fully the orbital debris and assessment report requirements pursuant to 47 C.F.R. § 5.64. In addition this exhibit provides an engineering assessment of the ability to passively track the uniquely small satellites from ground radar.

Non-Interference Criterion and Frequency selection:

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 within the United States and line of site of a ground station.

The VHF frequency proposed in this application, more specifically in the 137-138 MHz band, 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 low data rate ground to space and space to ground communications with low power and antenna gain and ideally suitable for the proposed service of the Swarm BEEs. With this experimental application, we are requesting to use the same frequency for both space to ground and ground to space transmissions while avoiding as much as possible specific frequencies and ground station locations of other authorized users. Transmission durations are very short and infrequent, on average approximately 60 seconds every 20 minutes during experimental operations over a 2 hour period daily per ground station..

Authorized users for this band in the US include Orbcomm, NOAA, and others. Our frequency selection near the upper band edge will minimize potential interference since the frequency does not or minimally overlaps with most of the authorized users and operate at much lower PFD (~25 dB lower than Orbcomm satellites). If unexpected interference occurs at an authorized user's space or ground station, Swarm will relocate experimental ground stations or coordinate transmission times to mitigate any RFI.

The BEEs and ground stations will transmit only upon command from the schedule generated on the ground and uploaded to the BEEs and persist only during active data transmissions. There are no autonomous data beacon services on the satellite and are not required for tracking purposes. Any transmission can be immediately terminated by ground command if interference is detected or reported.

Power Flux Density Calculation at Earth's Surface:

Pursuant to Commission rules 25.142, in the 137-138 MHz band the power flux density (PFD) at the Earth's surface produced by the Space BEEs will not exceed -152.5 dB(W/m^2) in any 4 kHz band at any angle of arrival. The ground stations transmit with a power spectral density (PSD) of -7.4 dBW/4kHz.

The out of band emissions are minimized by digital modulation techniques and filtering with at least 20 dB spectral rolloff 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 137.950 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 BEEs and ground stations share similar antenna and radio frequency characteristics (except transmit power) and link parameters which are further characterized in the link budget provided in Table 2.

			Ground station to BEE (Uplink)		BEE to ground station (Downlink)	
Item	**Symbol**	**Units**	**Nominal**	**Worst-Case**	**Nominal**	**Worst-Case**
Satellite Orbital Altitude		km	580	580	580	580
Frequency	f	GHz	0.137	0.137	0.137	0.137
Elevation Angle to Satellite		deg	30	10	30	10
Transmitter Power	P	Watts	1.00	1.00	0.10	0.10
Transmitter Power	P	dBW	0.00	0.00	-10.00	-10.00
Transmitter Line Loss	Ll	dBW	-1.00	-1.00	-0.70	-0.70
Peak Transmit Antenna Gain	Gpt	dBi	4.50	4.50	2.15	2.15
Tx Antenna Pattern Loss		dB	-1.25	-0.13	-1.25	-0.13
Transmit Total Gain	Gt	dB	2.25	3.37	0.20	1.32
Eq. Isotropic Radiated Pwr	**EIRP**	**dBW**	**2.25**	**3.37**	**-9.80**	**-8.68**
Propagation Path Length	S	km	1042.29	1885.46	1042.29	1885.46
Space Loss	Ls	dB	-135.54	-140.69	-135.54	-140.69
Polarization Loss	La	dB	-0.04	-0.16	-0.04	-0.16
Power @ Receiver Antenna		**dBW**	**-133.33**	**-137.49**	**-145.38**	**-149.54**
Peak Receive Antenna Gain	Grp	dBi	2.15	2.15	4.50	4.50
Receive Antenna Line Loss	Lr	dB	-0.70	-0.70	-1.00	-1.00
Rx Antenna Pattern Loss		dB	-2.01	-0.89	-2.01	-0.89
Received Power		**dBW**	**-133.89**	**-136.93**	**-143.89**	**-146.93**
Implementation Margin		dB	6.00	6.00	6.00	6.00
Target Data Rate	R	dB	10.00	10.00	1.00	1.00
Target Rx Level		dBW	-147.56	-147.56	-160.39	-160.39
Remaining Margin		**dB**	**7.67**	**4.63**	**10.50**	**7.46**

Table 2, space and ground BEE link budget.

The space BEE 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.

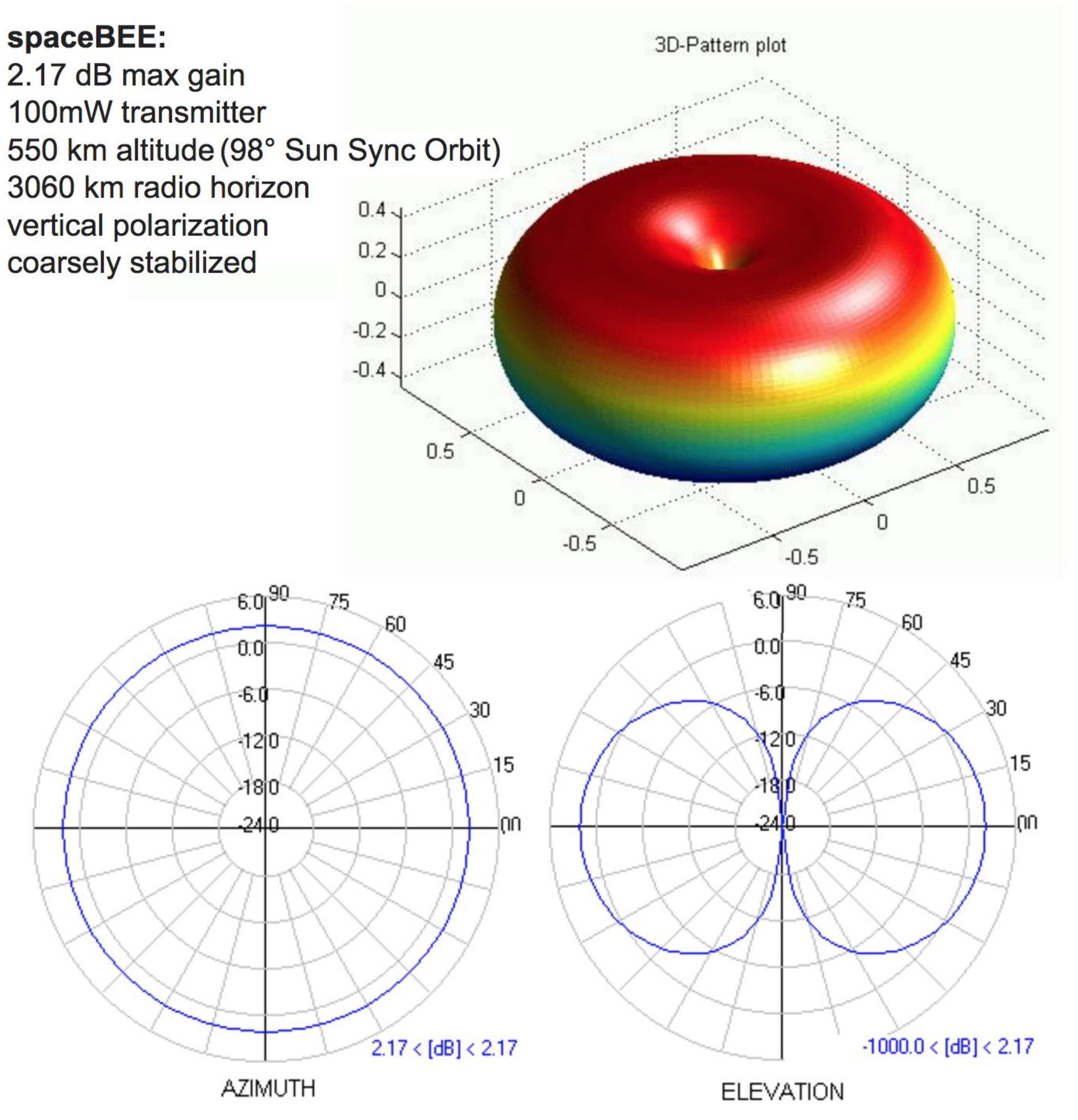

Figure 2: Space BEE Antenna pattern and characteristics.

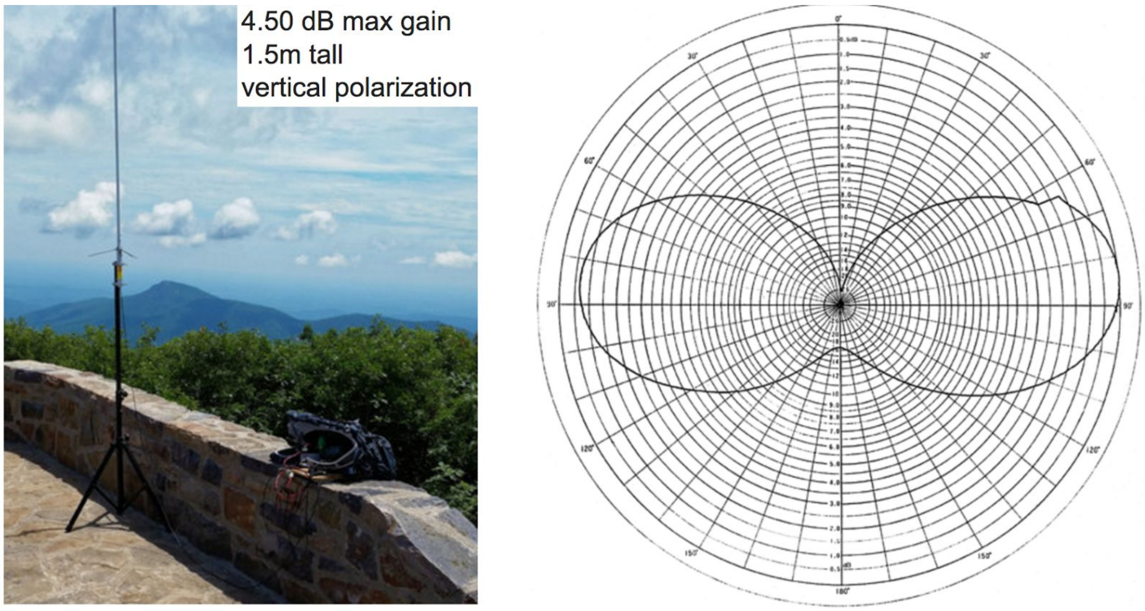

Figure 3: Ground Station Antenna pattern and characteristics.

All BEE 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 not initiate 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 as already waived under rule 47 C.F.R. §§ 25.206 for space stations not under the requirements of rule 25.281 (video transmissions). More specifically Swarm requests a waiver to the requirement for periodic station identification in the interest of minimizing transmission durations and activity, as it unnecessarily adds additional data and modulation changes during the transmissions to comply.

Ground Station Locations:

Ground Station 1
688 Coral Ct
Los Altos, CA 94024
lat/long (NAD83): 37.3816, -122.0972
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
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.