From: Al Tsuda

To: Leann Nguyen
Date: March 27, 2014

Subject: FCC file# 0194-EX-PL-2014

Message:

To ensure proper review of your request for a test please provide the following additional information.

1. We will need a NOAA determination and approval for any operation of cameras aboard the cubesats.

We have discussed the operation of cameras aboard the cubesats with NOAA, and we are preparing application materials for them pursuant to their direction. A NOAA authorization will be secured prior to the launch of the satellites.

2. Please provide a tentative schedule of cubesat construction, launch integration dates and proposed launch dates and providers. Include the exact number of cubesats that you expect to launch.

The key remaining dates for cubesat construction, launch integration, and launch are provided in the following table:

Milestone:	Date;	Notes (ToL = Time of Launch)
Fabrication and RF closed loop testing:	Mar 2014-Jul 2015;	ToL - 19 months
Delivery for Launch Integration:	July 2015;	ToL - 3 months
Pre-launch testing of transmitting components:	Aug 2015;	ToL - 2 months
Launch:	Oct 2015;	ToL + 0
Release from launch adapter:	Oct 2015;	ToL + 0hr 30min
On-orbit check:	Oct 2015;	ToL + 24 hours
Start of experiments:	Oct 2015;	ToL + 4 weeks
Decommissioning:	July 2016;	ToL + 9 months
Re-entry:	2032;	ToL + 17 year

The baseline launch opportunity is aboard the Space-X Falcon 9 launch vehicle. Launch site is Vandenberg, CA in the Q3/2015 timeframe.

Two cubesats will be launched attached together. Following vehicle checkout, the cubesat will separate and operate within close proximity (< 25km) of each other for the rest of the mission.

3. Please provide any Spacecap analysis data files

We have not prepared Spacecap analysis data files for the cubesats. Given that the cubesat’s will operate on an experimental, non-conforming basis for a period of only about 9 months, we do not anticipate that the filing of a notification with the International Telecommunication Union would be needed.

4. We encourage you to concurrently contact the FCC International Bureau directly to discuss any current testing and future plans for non-experimental service operation.

We have reached out to the International Bureau to address this.

5. We also need the following information:

a- Is the satellite geostationary or non-geostationary?
The satellite is non-geostationary.

- If satellite is geostationary, please submit its latitude and longitude.
Not applicable.

- If satellite is non-geostationary, please submit inclination angle, apogee (km)/perigee (km), orbit period (hours), fractions of hours in decimal and number of satellites in the system.

Inclination angle	= 97.9 degrees
Apogee (km)/perigee (km)	= 620 km
Orbit period	= 1.6 hours
Number of satellites in the system	= 2 satellites

b - Description of the satellite and how it will operate.

The PONSFD satellites adhere to a design specification co-developed by Stanford University (“Stanford”) and California State University, San Luis Obispo (“Cal Poly”) referred to as the CubeSat Standard. Additional information regarding the CubeSat Standard can be found at the CubeSat Community website, http://www.CubeSat.org/.

The PONSFD satellites validate the technologies needed to support rendezvous, proximity operations, docking (“RPOD”), servicing, and formation flight by utilizing a pair of identical nanosatellites, and leveraging the inherent relative low costs of their vehicle manufacture and launch capabilities.

The PONSFD satellites weigh roughly 6 kg each and possesses the necessary hardware and software for a) power collection, storage, and distribution; b) attitude determination and control; c) command and data handling; d) thermal control; e) communications with the ground and the other vehicle; f) propulsion; and g) rendezvous, proximity operations, and docking.

The PONSFD satellites will be launch together from a 6U dispenser and will operate in close proximity with each other throughout the entire duration of the mission. Much of the experimental operations will be performed to test sensors, propulsion systems, fine attitude pointing control, and advanced guidance and navigation algorithms. Docking between the two vehicles will be attempted as part of the experimental operations. After the 6-12 months of mission lifetime, the vehicles will be passivated and allowed to re-enter using natural orbital decay within the 25 year guidelines for Low Earth Orbiting (LEO) satellites.

The PONSFD spacecraft will be fabricated, tested, launched, and operated by Tyvak using its Mission Operations Center (“MOC”) and affiliated Earth stations. TT&C for the satellites will be carried out by Tyvak via a two-way link in the UHF band between 399.9-400.05 MHz. The UHF link will also be used for communications between the two satellites at a significantly reduced power level. Additionally, there will be a payload communications capability that is separate from the TT&C communications system to report data gathered on experimental operations. The payload communications system will downlink data from the test instruments to NASA-operated Earth stations using spectrum in the S-band between 2,200-2,290 MHz. Finally, the satellites will conduct ranging determinations between the two satellites using low-power commercial-off-the-shelf (“COTS”) ISM transmitters in the 2.4 GHz range. The 2.4 GHz system may also be used for some inter-satellite communications, as an alternative to the primary UHF inter-satellite link.

- An analysis transmitting between satellites to satellite.

Inter-satellite link is on the 2.4Ghz ISM band, and uses a surface mount patch antenna transmitting at 1W

of RF both RHCP.
From: Vehicle A
To: Vehicle B
Transmit Power (Watts): 1
Frequency, GHz: 2.45
Transmit Antenna Gain, dBi: 3.0
Losses to Antenna, dB: -3.0
Transmitter EIRP, dBm: 30.0
Slant Range, km: 6.0
Path Loss, dB: -115.8
Polarization Loss, dB: -0.5
Transmit antenna pointing loss, dB: -1.0
Receive antenna pointing loss, dB: -1.0
Isotropic signal at Receive antenna, dBm: -88.3
Receive Antenna Gain, dBi: 3.0
Losses to Receiver, dB: -3.0
Received Power at LNA input, dBm: -88.3
Receive Noise Figure, dB: 2
Sky Temperature, K: 273
System Noise temperature: 442.6
Receiver G/T, dB/K: -23.46
Data Rate, bps: 256,000
Receiver Bandwidth, Hz: 22,000,000
Noise Power, dBm: -98.7
CNR, dB/Hz: 10.4
Required S/N, dB: 10
Coding Gain, dB : 2
System Link Margin, dB: 2.4

UHF Inter-satellite link at a reduced transmit power of 100mW for longer range, low data rate inter-satellite communications at power levels whose spectral density at the ground is low enough to not cause interference.
From: Vehicle A
To: Vehicle B
Transmit Power, Watts: 0.1
Frequency, GHz: 0.4
Transmit Antenna Gain, dBi; 1.0
Losses to Antenna, dB: -2.0
Transmitter EIRP, dBm: 19.0
Slant Range, km : 21.0
Path Loss, dB: -110.9
Polarization Loss, dB: -15.0
Transmit antenna pointing loss, dB: -6.0
Receive antenna pointing loss, dB: -6.0
Isotropic signal at Receive antenna, dBm: -118.9
Receive Antenna Gain, dBi: 1.0
Losses to Receiver, dB: -2.0
Received Power at LNA input, dBm: -119.9
Receive Noise Figure, dB: 1.3
Sky Temperature, K: 273
System Noise temperature: 374.2
Receiver G/T, dB/K: -24.73
Data Rate, bps: 9600
Receiver Bandwidth, Hz: 10,000
Noise Power, dBm: -132.9

CNR, dB/Hz: 12.9
Required S/N, dB: 10
Coding Gain, dB: 0
System Link Margin, dB: 2.9

- An analysis transmitting between satellites to ground stations.

S-Band Downlink to a 7.3m dish using a single patch antenna on the spacecraft with worst case pointing conditions (90 degrees off nadir, at 5 degrees above the horizon for the 620km orbit)
From: LEO
To: 7.3m dish
Transmit Power, Watts: 2
Frequency, GHz: 2.245
Satellite Line Loss to Antenna, dB: -2
Transmit Antenna Gain, dBic: 2
Satellite Antenna Pointing Loss: -8.0
Transmitter EIRP, dBm: 25.0
Slant Range, km: 1,978
Path Loss, dB: -165.4
Atmospheric Loss, dB: -0.3
Isotropic signal at Receive antenna, dBm: -140.7
Receive dish diameter, m: 7.3
Receive antenna efficiency: 0.7
Receive Antenna Gain, dBi: 43.1
Antenna Beamwidth, degrees: 2.561
Receive Antenna Pointing Loss, dB: -3.0
Polarization Loss, dB: -2
Diversity Combiner, dB: 0
Received Power at LNA input, dBm: -102.5
Receive Noise Figure, dB: 1
Sky Temperature, K: 100
System Noise temperature: 175.1
Receiver G/T, dB/K: 20.72
Data Rate, bps: 1,000,000
Receiver Bandwidth, Hz: 666,667
Noise Power, dBm: -117.9
CNR, dB/Hz: 15.4
Implementation Loss: -3.0
Required S/N, dB: 10
System Link Margin, dB: 2.4

UHF Downlink to a yagi array antenna on the spacecraft with worst case pointing conditions (90 degrees off nadir, at 5 degrees above the horizon for the 620km orbit) with a dipole antenna on the satellite.

From: LEO
To: NEN
Transmit Power, Watts: 2
Frequency, GHz: 0.4
Satellite Line Loss to Antenna, dB: -2
Transmit Antenna Gain, dBic: 0
Satellite Antenna Pointing Loss: -5.0
Transmitter EIRP, dBm: 26.0
Slant Range, km: 1,978
Path Loss, dB: -150.4
Atmospheric Loss, dB: -0.3

Isotropic signal at Receive antenna, dBm: -124.7
Receive dish diameter, m: --
Receive antenna efficiency: --
Receive Antenna Gain, dBi: 21.0
Antenna Beamwidth, degrees: --
Receive Antenna Pointing Loss, dB: -3.0
Polarization Loss, dB: -2
Diversity Combiner, dB: 0
Received Power at LNA input, dBm: -108.7
Receive Noise Figure, dB: 2
Sky Temperature, K: 175
System Noise temperature: 344.6
Receiver G/T, dB/K: -4.37
Data Rate, bps: 9600
Receiver Bandwidth, Hz: 12000
Noise Power, dBm: -132.4
CNR, dB/Hz: 23.7
Implementation Loss: -3.0
Required S/N, dB: 10
System Link Margin, dB: 10.7

c- The orbital debris mitigation plan or re-plan, uplink/downlink and beacon frequencies.

The Orbital Debris Assessment Report (ODAR) has been provided to our NASA Program Office and will also be provided to NOAA for its approval. It can be provided to FCC upon request.
Uplink/Downlink Frequencies: The satellite operates in half-duplex (same uplink and downlink frequency). The center frequency is 400.03 MHz (50kHz request bandwidth).
Beacon Frequencies: None.

d - Information of satellite transmitter antenna including gain, beamwidth, azimuthal range.

Satellite transmitter UHF antenna information:

Parameter, Unit:	Value
Gain, dBi:	+2
Beamwidth, deg:	70
Azimuthal Range, deg:	0 to 360

Satellite transmitter Inter-satellite Link antenna information:

Parameter, Unit:	Value
Gain, dBi:	+5
Beamwidth, deg:	45
Azimuthal Range, deg:	0 to 360

Satellite transmitter S-Band antenna information:

Parameter, Unit:	Value
Gain, dBi:	+2
Beamwidth, deg:	70
Azimuthal Range, deg:	0 to 360

e- Information of earth station receiver antenna including gain, beamwidth, azimuthal range, elevation above mean sea level (m), minimum angle of elevation and antenna height above terrain (m).

Earth station receiver information:

Parameter,Unit: Value
Gain, dBi: 20.2
Beamwidth, deg: 15
Azimuthal Range, deg: 0 to 360
Minimum angle of elevation, deg: 5

Earth station locations (licenses for which will be secured separately):

Location: Elevation above mean sea level; Antenna height above terrain
Irvine, CA: 78 m; 10 m
North Pole, AK: 146 m; 3 m
Columbia, MD: 128 m; 10 m

f- Stop Buzzer information including name and telephone number of person who will terminate the system if having interference occurs.

Al Tsuda
Tyvak Nano-Satellite Systems LLC
15265 Alton Parkway, Suite 200
Irvine, CA 92618
949-237-0833