From: Craig Scheffler

To: Doug Young
Date: August 11, 2017

Subject: Request for Info - File # 0305-EX-CN-2017

Message:

A complete response has been attached as an exhibit to this application titled "Response to Correspondence ref 38209". Also the text is provided here for your convenience.

Response to FCC’s International Bureau/Satellite Divisions Concerns
Subject: Request for Info - File # 0305-EX-CN-2017
Reference number : 38209
Dated: August 11, 2017

ODAR comments/issues:

Q: Please provide the full dimensions of the antennae (thickness, length, width).
ANS:
Two antenna segments (forming a Dipole).
49.5 cm long each
0.6 cm wide
0.01 cm thick

Q: Do we understand correctly that the DAS collision analysis was completed for a single satellite, and with an area-to-mass figure based on the satellite body, excluding the antenna? If not, please describe in more detail the analysis undertaken, and address whether the satellites' largest dimension has been adequately accounted for in the analysis.
ANS:
The DAS collision analysis was completed for a single satellite, and with an area-to-mass figure based on the satellite body (the average area-to-mass ratio of the satellite while tumbling), including the antennas.

Q: Please provide an analysis or estimate of the average A/M of the satellites if tumbling.
ANS:
The average area-to-mass ratio of the satellite while tumbling is approximately 0.028 m2/kg with antenna area included.

Q: Please provide an estimate of the altitude at which satellite attitude stability is expected to degrade substantially, and/or cease.
ANS:
Above 650km, and the aero drag becomes too small for the satellite to stabilize within a reasonable mission lifetime (1yr). The satellite becomes more stable as the altitude becomes lower.

Q: Please address whether skin friction effects on the antenna can be expected to reduce orbital lifetime.
ANS:
Skin friction due to free molecular flow at our altitude is small but not totally negligible; it appears to add roughly 5% to the drag for our satellite with half-meter antennas. Lifetime is affected weakly. Skin friction was taken into account in our lifetime prediction tools.

Q: Please address whether "skin friction" effects on the antenna can be expected to reduce attitude stability.

ANS:
Skin friction slightly helps stability due to the distribution of skin friction along the length of the antenna.

Q: As launched, will the satellites have a transmission schedule, or is the initiation of satellite transmissions dependent on an initial schedule uploaded via earth station transmissions? Will initial satellite acquisition be solely dependent on radar or other observation data?
ANS:
The satellites first transmit 45 min after deployment, transmitting its 300 bytes of telemetry to the ground on a regular cadence of once every 10 minutes until 48 hrs from deployment or until it receives a command from the ground to stop. After 48 hrs, normal operations require a command from the ground for the satellite to initiate a transmission from space-to-ground.

Q:
Do the Haystack observations require special funding or cooperative research arrangements, or are the observations within the standard scope of Haystack activities?
ANS:
The observations at Haystack do not require separate funding, nor a research agreement, and are part of their normal tracking activities.

Q: Other than a GPS receiver, are there any other measurement devices/sensors on the spacecraft?
ANS:
There are no other sensors of external information on-board the satellites besides GPS. The monitored voltage on the solar cells will be used to determine coarse attitude motion rates initially. The satellites employ a number of internal sensors as follows:
Temperature of CPU
Voltage of solar cells, battery, bus
Current of solar cells, battery, bus
9 degree of freedom Inertial Moment Unit
Acceleration in 3 axes to monitor motion
Gyroscope in 3 axes to monitor motion
Magnetic field strength in 3 axes to monitor motion, absolute pointing, and absolute location

Please note that the MSS allocation in the 137-138 MHz band only allows downlink operations; applicant is proposing to operate in the 137-138 MHz band in the uplink direction which is not in accordance with the Radio Regulation. The applicant has not provided an electromagnetic compatibility (EMC) analysis to show that the uplink operations will not cause harmful interference to other downlink earth stations. Applicant please submit an EMC analysis for the uplink operations to show compatibility other FCC license stations in the 137-138 MHz band. We note that the applicant has obtained consent from ORBCOMM. However, applicant must be aware that the downlink operation will require coordination under No. 9.11A.

Response:
An electromagnetic compatibility analysis is in progress and will be submitted when completed as a separate attachment to the application.

Form 442:

For the 137.95 MHz uplink operations, the application has identified earth station as a MOBILE station class with a radius of operation of 5 km. Applicant please clarify if the uplink earth station is moving while transmitting or does it operate in a fixed location but is transportable within a 5-km radius. Why is there a need to move the earth station?
Response:
We have changed the earth stations in form 442 online to be fixed/base stations with a radius of operation equal to 0. We will constrain experimental operations to the listed fixed location since a

re-locatable ground station test is not necessary at this time.

SpaceCap API file:

Response:
An updated ITU SpaceCap API database file with the corrections below including updated antenna patterns is ready for submission to the Commission.

On the uplink, RX beam:

The box RR 4.4 was NOT checked “Y”; however, this uplink is not in accordance with the ITU RR so this box will need to be checked “Y”.
Response:
The SpaceCap API database parameter C2c is now checked, thus acknowledging that the use of the frequency shall not cause harmful interference to other authorized users.

On the max peak power, it has a value of 3.4 dBW and min peak power has a value of 2.3 dBW; however, Form 442 has this power as 1 W = 0 dBW; applicant please review the power levels in both form and update either form to make the technical parameters consistent.
Response:
The SpaceCap API database parameter is now corrected to 0 dBW.

If the power level changes then the power spectral density value will also need to be updated.
Response:
The SpaceCap API database parameter is now corrected to -48 dBW/hz.

On the associated earth station, the co-polar reference pattern is identified as ND-EARTH (which is non-direction earth); however, we note that the beamwidth is 90 degrees which is directional; therefore, we suggest that we remove this ND-EARTH reference and submit the antenna pattern earth station provided in the application.
Response:
The SpaceCap API database parameter is changed to 180 degrees and the Earth station antenna pattern is attached. The SpaceCap validator reports a warning that 180 degrees is out of the allowed range and provides a range that is inapplicable for this antenna. Therefore 180 degrees was entered to represent a non-directional antenna but with a gain pattern as provided in the attachment. The ground antenna reception pattern is toroidal with most of its gain at elevations above ground up to 65 degrees and at all azimuths.

On the downlink, TX beam:

Box RR No. 4.4 is not marked “Y” which indicates that the applicant will need to coordinate this frequency band.
Response:
The SpaceCap API database parameter C2c is now checked, thus acknowledging that the use of the frequency shall not cause harmful interference to other authorized users.

The minimum elevation angle is given as 0 degrees; however, this value should be 5 degrees.
Response:
The SpaceCap API database parameter B2b was changed to 5 degrees.

On the max peak power, it has a value of -8.7 dBW and min peak power has a value of -9.8 dBW; however, Form 442 has this power as 100 mW = -10 dBW; applicant please review the power levels in both form and update either form to make the technical parameters consistent.
Response:

The SpaceCap API database parameter c8a1 was changed to -10 dBW and C8a2 to -58 dBW/Hz to be consistent with Form 442.

On the associated earth station, the co-polar reference pattern is identified as ND-EARTH (which is non-direction earth); however, we note that the beamwidth is 90 degrees which is directional; therefore, we suggest that we remove this ND-EARTH reference and submit the antenna pattern earth station provided in the application.
Response:
The SpaceCap API database parameter is changed to 180 degrees and the Earth station antenna pattern is attached. The SpaceCap validator reports a warning that 180 degrees is out of the allowed range and provides a range that is inapplicable for this antenna. Therefore 180 degrees was entered to represent a non-directional antenna but with a gain pattern as provided in the attachment. The ground antenna reception pattern is toroidal with most of its gain is at elevations above ground up to 65 degrees and at all azimuths.

Exhibit A document:

On the introductory section, second paragraph, start of the second line, it describes the satellite as microsatellites; however, these satellites would fall under nano-satellite or femto-satellites depending of their weight but not microsatellites.
Response:
Under commonly accepted definition of smallsat weight classes, Swarm BEEs are picosatellites with a mass between 0.1 and 1 kg for each satellite.

NTIA Space record data document:
Response:
An updated NTIA Space record data document has been uploaded as an exhibit to the Application File.

Part A, on Earth Station Data (Receiver #1), antenna dimension, it has the beamwidth as 180 degrees yet API has it as 90 degrees.
Response:
The SpaceCap API database parameter was changed to 180 degrees and is now consistent with the NTIA form. This earth station is the same as the Associated ES for Beam TX in the API.

Part A, on Earth Station Data (Receiver #2), antenna dimension, it has the antenna gain as 1.76 dBi; this antenna is not in the API nor is there an antenna pattern for this antenna.
Response:
The mistake in the NTIA form was corrected to 4.5 dBi. This earth station is the same as ES Receiver 1 and the same as the Associated ES for Beam TX in the SpaceCap API.

Part B, on Earth Station Data (Transmitter Data #1), antenna dimension, it has the antenna gain as 1.76 dBi; this antenna is not in the API nor is there an antenna pattern for this antenna.
Response:
The mistake in the NTIA form was corrected to 4.5 dBi. This earth station is the same as the ES Receiver stations and the same as the Associated ES for Beam RX in the SpaceCap API.

Part B, on Earth Station Data (Transmitter Data #2), antenna dimension, it has the antenna gain as 1.76 dBi and beamwidth of 35 degrees; this antenna is not in the API nor is there an antenna pattern for this antenna.
Response:
The mistake in the NTIA form was corrected to 4.5 dBi. This earth station is the same as the ES transmitter #1 and the same as the Associated ES for Beam RX in the SpaceCap API.

Antenna Pattern documents:

Please redo the antenna patterns provided without the satellite names, antenna height, power levels, orbital parameters; only include technical information related to the antenna characteristics.
Response:
The antenna patterns are updated as provided in the attached exhibit copy of this response. They are also updated in the SpaceCap API database file.