

From: Mark Caviezel

To: Doug Young

Date: August 16, 2018

Subject: Request for Info - File # 0619-EX-ST-2018

Message:

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Correspondence Reference Number: 43463
ORBITAL-REFLECTOR Satellite

FCC OET(2): Until a recent supplement to provide a mission description, it appeared that this mission was 3U cubesat. The mission description makes clear that there will be a very large inflatable deployed from the cubesat.

RESPONSE (2): Indeed, the mission is a 3U Cubesat and it does include a large inflatable ballute or balloon. This has been the program goal since program inception and clearly announced on the program website and numerous media press releases; we did not see any part to the application that asked about deployables, other than deployable antennas. We apologize if it was not clearly communicated on our FCC application.

FCC OET(3): The ODAR submission consists of screen captures of DAS outputs with a bubble highlighting the "compliant" findings. However, the inputs to DAS are not clear. For example, it's unclear whether the analysis provided is for the 3U cubesat, the deployed version, or both. More generally, the applicant may wish to follow the "long-form" ODAR format, along the lines of what we typically received for the ELaNa missions. Thinsat might be another example. Note that there is probably a pressure vessel involved for deployment of the inflatable, and we will need some description of that, and analysis of whether it presents an explosion or fragmentation risk.

INTERIM RESPONSE (3): We will research the stated missions and expand our response to be similar to the DAS outputs from the stated missions. Resubmission anticipated ASAP. The pressure vessel is a 25 gram CO2 cartridge, COTS, equivalent to:

https://www.amazon.com/SINGLE-CARTRIDGE-CO2-REFILL-THREADED/dp/B007H9MB54/ref=sr_1_8?ie=UTF8&qid=1534446163&sr=8-8&keywords=25g+co2

And is DOT rated for shipment by common carriers.

FCC OET (4): The mission description indicates deployment of the inflatable at a "substantial" interval after deployment from the Spaceflight deployer. The applicant should provide a specific time frame/anticipated altitude for deployment of the inflatable. This is also related to collision risk and it is not clear what the assumed facts were for the analysis of collision risk.

RESPONSE (4): The inflatable is inflated and deployed by timer 610 minutes (ten hours and ten minutes) after ejection from the Spaceflight deployer. At 610 minutes after ejection from the Spaceflight deployer, predicted spacecraft altitude is 575 km. Collision risk is covered in the next response.

FCC OET(5): Trackability - the object will provide good radar data both pre and post deployment - the inflatable would be trackable by the naked eye. However, as a high area to mass object, there will be substantial uncertainty concerning the object's trajectory, and this may present difficulties for other operators in effectively conducting collision avoidance. The applicant should provide an assessment of the number of predicted conjunctions that could be expected during the mission.

RESPONSE (5): Extensive analysis has been conducted on this topic. A Monte Carlo Simulation with 2500 runs has been conducted. The calculated chance of recontact is 0.4×10^{-3} . Further details are available in document ORBITAL REFLECTOR Balloon Deployment Analysis Update.pdf .

FCC OET(6): The applicant should describe any arrangements with the 18th SPCS with respect to

tracking, data sharing (e.g. planned time of deployment of the inflatable).

RESPONSE (6): We been in communication with Cynthia Wilson at 18th SPCS. So far no additional requests for tracking data or data sharing have been levied.

FCC OET(7): The identified time frames for the experiment are not accurate. It is also unclear that an STA is appropriate. Given the initial orbital altitude, it's not clear that this mission would be completed within an STA time frame.

RESPONSE (7): Additional analysis has been concluded since the initial application was made. This additional analysis indicates total orbital endurance between 75 days and 140 days depending on damping rate. Additional detail is available in OR Sat Drag and Orbital Decay.docx

FCC OET(8): Scope of the radio operations is not clear. Is the purpose solely to provide command signals for the inflatable deployment? Anything else? What is the program of experimentation?

RESPONSE (8): The primary requirement for the radio assets is to enable radio-commanded deployment of the balloon. Additionally, the spacecraft's on-board radio can provide limited telemetry (internal temperatures, battery voltages) upon request (ground station interrogation). Note that the primary deployment means is by timer circuitry, the radio command system is a backup. Successful use of the radio system will constitute an in-LEO TRL-9 demonstration the lightweight, low-cost, robust data and command communications radio system which has commercialization potential. Additionally, the radio-command system provides means for a second inflation impulse (re-inflation), to be commanded after one month of LEO flight. Note: The spacecraft's radio ONLY responds to commands; it never beacons. There is no scheduled use of radio beyond 30 days after launch.

FCC OET(9): Unclear whether we have the right applicant. There seems to be substantial involvement from a Nevada Art museum and an artist. The applicant may simply be an agent or supplier for those entities. With the limited information provided in the application, this cannot be determined.

RESPONSE: Global Western is the organization that has designed, built, and tested the spacecraft and will operate the space asset via low power ground station. The Nevada Museum of Art is a non-technical contributor to the project and conducts functions such as fundraising and publicity. Trevor Paglen, US Citizen, is also non-technical contributor and is an internationally recognized artist, is concept originator and artist of record but does not hold a technical stake in the execution of this mission.

FCC OET(10): The AP4 SpaceCap is version 7, needs to be the latest version8.

INTERIM RESPONSE 10: Indeed, we used the most recent version of SpaceCap when preparing the initial filing. We will convert to version 8. Updated submission expected ASAP.

FCC OET(11): Fatal errors need to be corrected in the SpaceCap and all required information should be provided.

INTERIM RESPONSE 11: Will comply, resubmission expected ASAP.

FCC OET(12): For the 900 MHz frequency needs the supporting material to demonstrate compatibility.

RESPONSE(12): The Radio is a digitally synthesized, crystal controller, commercial off the shelf daughterboard compatible with 901 to 929 MHz operation (RFM23BP), the frequency selected was 922.0 MHz for the two on-board diversity patch antennas.

- Link Doppler effects are compensated for on the ground station side in both transmission and reception, using the same daughterboard with different software and support circuitry. The Radios are compatible with themselves in the link, and several software functions eliminate spurious command receptions. (Prefix,CRC, Error detection, multi step command structure, etc)