ASTRA RROCI Satellite
0867-EX-CN-2022
Supplemental Responses January 27, 2022

The following pages contain information that responds to questions posed to ASTRA by the FCC in messages sent on January 13 and January 20, 2022.

An updated, signed ODAR has been submitted to show that the post-mission disposal will only use a circular orbit, there will be no elliptical orbit for PMD.

Please address the following questions and concerns:

1) There will need to be a Globalstar companion filing, regardless if Globalstar will be transmitting to your spacecraft or not. Please provide the license number provided by Globalstar.

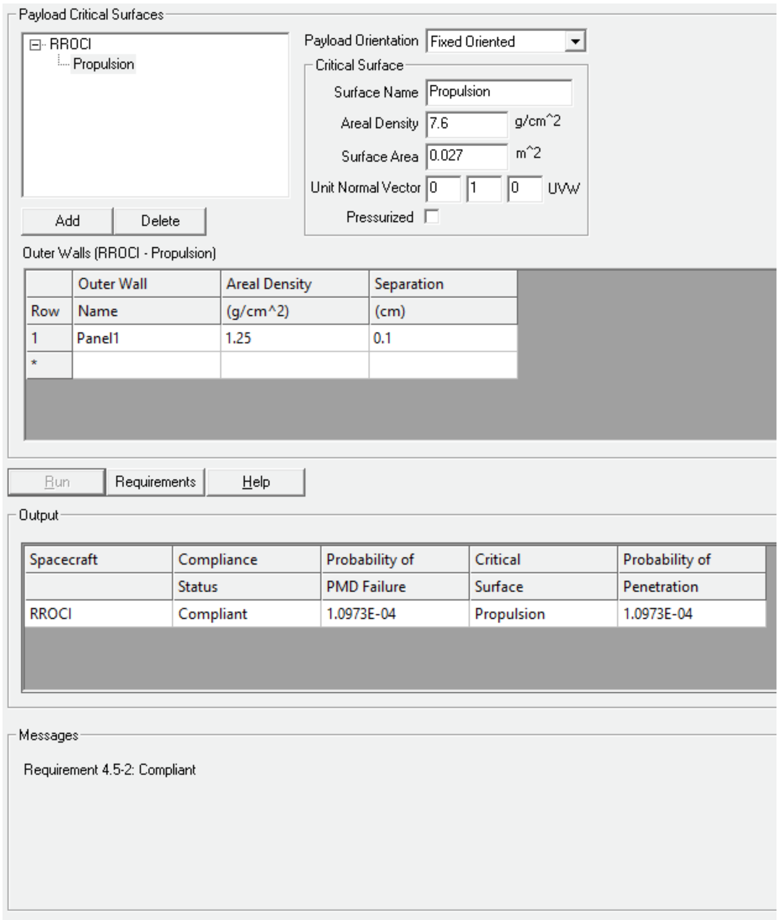
Application has been amended to remove the Globalstar link. The radio will not be used, because Globalstar declined to file a companion filing.

2) Please provide the tolerances for altitude, inclination, etc that will be maintained through use of propulsion.

Analysis shows that unless RROCI is inserted at the lower end of the launch tolerance (642 +/- 20 km), the natural decay of the orbit over the year planned operational lifetime is approximately 10km. The simulation was performed with MSIS drag, Spherical Harmonics (degree=20), Sun/Moon Gravity, and SRP and showed that our LTAN and inclination remained within tolerance over the year lifetime, so no correction will be necessary. The current RROCI plan is to operate for the year lifetime with no active orbital maintenance. If RROCI is inserted at the upper bound of the launch tolerance, no actions will be performed. If RROCI is inserted at the lower bound of the launch tolerance (<632 km), an initial burn to orbit raise (still within the launch tolerance window) will be performed, then the thruster will be turned off and the orbit will naturally decay with no additional maintenance performed. This approach reserves the thruster for re-entry only.

3) The small object risk calculations provided show a single panel as the only object that would prevent PMD if damaged. Please provide an explanation for the sole selection of this object.

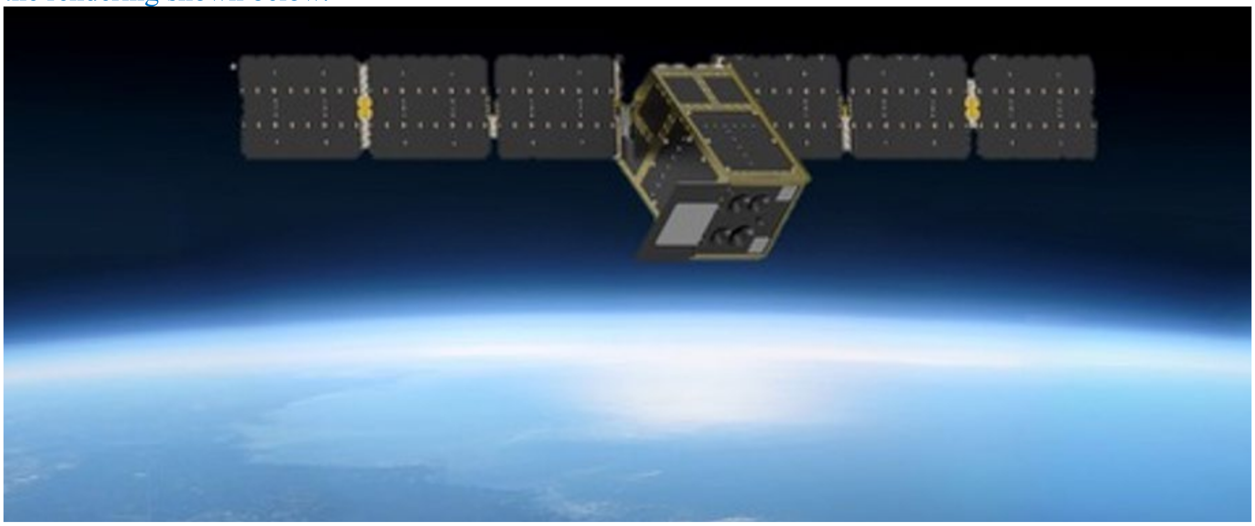
The Propulsion system was identified as the key critical component that would prevent PMD if damaged (or require the mission to revert to a drag-only re-entry). The single calculation was taken on the worst-case face of the overall system, or the least number of protection surfaces for the system. All other directions would pass through more than one layer of protection (outer shell, inner shell, etc.), so this was shown to be the worst-case scenario. A secondary analysis was performed to show even if the spacecraft was pointed worst-case with the propulsion system facing the RAM direction (yaw-flipped from normal flight orientation) [U = Zenith, V = Velocity, W = Port], the requirement is still met using the NASA DAS software package:



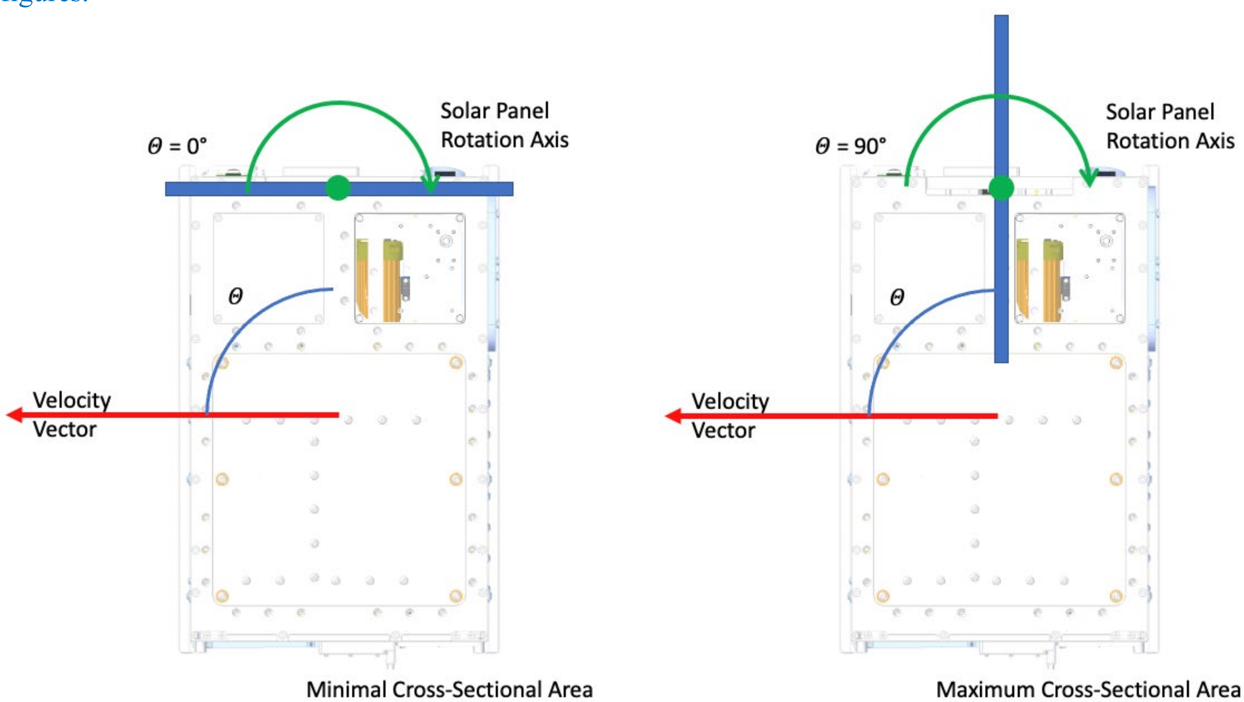
4) In attachment A, please explain the 5 provided cross-sectional area values. What does each of these values represent in a real-world scenario?

The cross-sectional areas in Attachment A show the relative area of the vehicle facing the velocity vector, modified by tuning the angle of the solar panels with the velocity vector. Both panels can rotate independently to modify our drag profile as needed, and in the event of a thruster failure, would be locked into the highest drag profile possible to reduce our orbit lifetime in the 5.23 years shown in the analysis in Attachment A. In real-world, the cross-sectional areas are applied as shown in the following figures. The below figure shows the spacecraft in its stowed state, with the panels folded down against the spacecraft body.

After ejection, the solar panels will deploy and the spacecraft will go into a sun-tracking state, similar to the rendering shown below.



The solar panels rotate around an axis perpendicular to the velocity vector, as shown in the following figures.



By modifying the angle of attack into the velocity vector direction, we can modify the drag profile of the spacecraft system. The mission will already perform this angle modification maneuver multiple times per orbit to track the sun and maximize the solar power generation for the system.

5) The table provided in response to Q13 provides two surface areas, not area-to-mass values. Please provide the area-to-mass values for both the stowed and deployed configurations, in m^2/kg. Additionally, please explain why the surface area of the solar panels was not included in these calculations.

	Description	Stowed	Deployed	Deployed @ 90°
	Solar Arrays	7.27	7.55	683.13
	12U Body	119.89	119.89	119.89
	Solar Array Bumpers	0.25	0.25	
	Panel Hinge Mechanism (Exposed)		0.04	
			0.20	
			0.67	
Total (in^2)		127.41	127.69	803.02

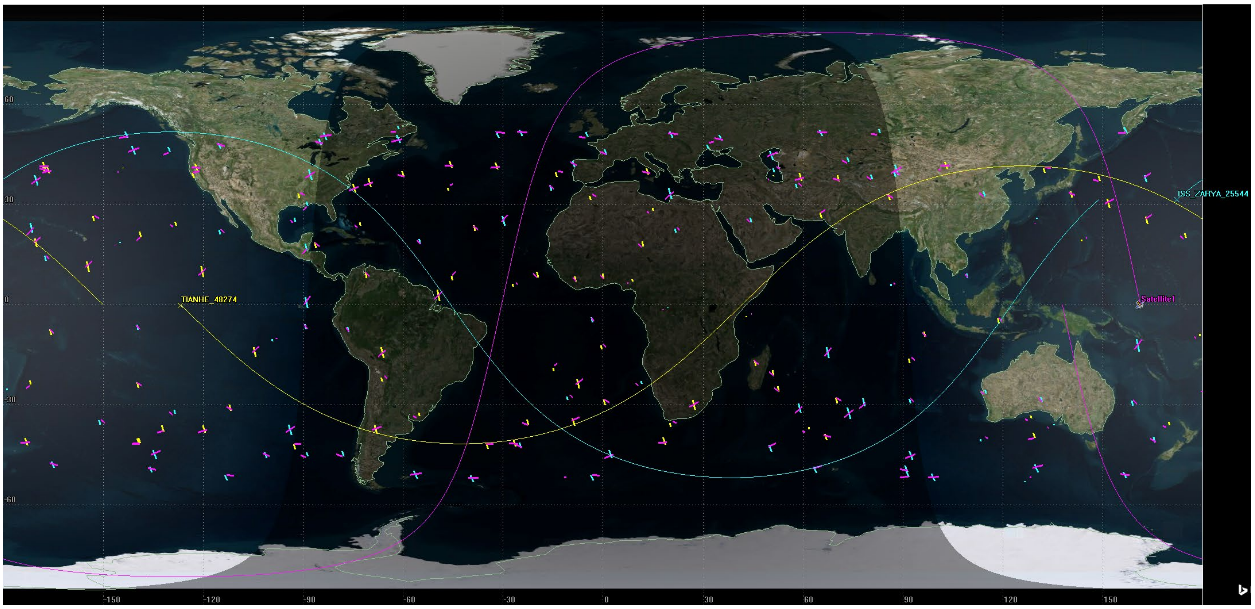
Spacecraft Mass: 18.4839 kg
Stowed Cross Sectional Area: 0.0822 m^2
Deployed Cross Sectional Area: 0.0824 m^2
Deployed @ 90° Cross Sectional Area: 0.5181 m^2
Stowed Area-to-Mass Value: 0.004447 m^2/kg
Deployed Area-to-Mass Value: 0.004458 m^2/kg
Deployed @ 90° Area-to-Mass Value: 0.028030 m^2/kg

The surface area of the solar panels is included in all three scenarios as the "Solar Arrays". When stowed, they are tucked against the spacecraft body and therefore contribute minimally to the overall cross section. When deployed, two orientations are possible. The first, shown in the middle column, is when the solar panels are deployed but they are edge-on to the velocity vector. These panels are only 0.062" thick, so the contribution is again minimal for both deployed panels to the overall cross section. The second, shown in the last column, is when the solar panels are deployed but they are face-on to the velocity vector (maximum drag area). This greatly increases the cross sectional area in the orbital velocity direction as shown.

6) As your proposed PMD orbit is highly elliptical, please provide information regarding any precautions/coordination that have been undertaken or considered regarding protecting inhabitable spacecraft in this altitude range, such as the ISS and Chinese Space Station.

No current coordination has been performed with the ISS or the Chinese Space Station.

Utilizing the proposed PMD elliptical orbit disposal maneuver, analysis in STK shows a close approach (<200 km [NASA current standard]) occurring once every 4-5 days between RROCI and the ISS, and once every 3-5 days between RROCI and the Chinese Space Station. The following orbital simulations shows the close approach, marked with colored stripes showing each close approach.



In a one year time period, the closest approach experienced between RROCI and the ISS is 28.9 km, with a mean range of 159.9 km when inside the 200km limit. The closest approach between RROCI and the Chinese Space Station is 18.6 km, with a mean range of 170.9 km when inside the 200km limit.

Based on these analyses, and to ensure reduction of risk to human flight, following the recommendation in the NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook (NASA/SP-20205011318) section 4.1 "Ascent to / Disposal from the Constellation's Operational Orbit", we will modify our current PMD plan to perform a circular-orbit altitude reduction approach versus the highly inclined disposal orbit approach. This will avoid a perigee-lowering approach that poses persistent and problematic orbital crossings with ISS and other HSF assets. The electric thruster on RROCI can support the circular-orbit altitude reduction approach.

ODAR has been updated and signed.

The items indicated above must be submitted before processing can continue on the above referenced application. Failure to provide the requested information within 30 days of 01/13/2022 may result in application dismissal pursuant to Section 5.67 and forfeiture of the filing fee pursuant to Section 1.1108.