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November 2, 2015

BY ELECTRONIC FILING

Mr. Jose P. Albuquerque
Chief, Satellite Division
International Bureau
Federal Communications Commission
Washington, D.C. 20554

Re: Spaceflight, Inc.
Request for Special Temporary Authority
IBFS File No. SAT-STA-20150821-00060

Dear Mr. Albuquerque:

Spaceflight, Inc. ("Spaceflight"), by its counsel, responds to your letter of October 6, 2015, in which the International Bureau seeks additional information related to Spaceflight's above-referenced application for Special Temporary Authority ("STA") to communicate with its SHERPA spacecraft.

We are hereby transmitting by IBFS responses to the Bureau's questions. In addition, we are transmitting material that supplements and updates the Orbital Debris Assessment Report that was submitted with the original application request.

Spaceflight also hereby notifies the Bureau that the proposed timeframe of the SHERPA mission has shifted. In its original request, Spaceflight stated that, because of recent delays and uncertainties in the space launch industry, it was requesting STA to cover a timeframe of three months – January 15, 2016 to April 15, 2016 – during which its SHERPA mission was expected to occur. Based upon the most recent information available, Spaceflight expects its SHERPA spacecraft instead to be launched as a single occurrence between March 15, 2015 and June 15, 2015. Spaceflight will file a formal

amendment of its STA requests to reflect this adjustment in the launch schedule if the staff prefers it to do so.

Please direct any further questions with regard to the SHERPA mission to the undersigned.

Respectfully submitted,

Jonathan L. Wiener
Counsel to Spaceflight, Inc.

cc: Indra Hornsby

RE: Spaceflight, Inc. Application for Special Temporary Authority to Communicate with the SHERPA Spacecraft. IBFS File No. SAT-STA-20150821-00060

Supplemental information requested by FCC	Spaceflight Response/Action
1. Publicly-available information indicates that there will be approximately eighty-seven (87 satellites on board to be deployed from SHERPA. Please provide a list of the satellites planned for deployment. Please also indicate the authorizing administration or administrations, current or planned (under the United Nations Outer Space Treaties and International Telecommunication Union Radio Regulations) for each space object to be deployed.	1. Update that there are now planned to be 90 satellites deployed from SHERPA. 2. List of Companies, satellites, Countries (and number of satellites): NovaWurks eXCITe, United States (1) BlackSky Global Pathfinder-1 [SCOUT-1], United States (1) BlackSky Global /Pathfinder-2 [SCOUT-2], United States (1) Instituto Tecnológico de Aeronáutica (ITA) ITASAT-1, Brazil (1) University of Chile SUCHAI, Chile (1) Aalto University Aalto-1, Finland (1) University Montpellier 2 ROBUSTA-1B, France (1) GOSPACE skCube, Slovak Republic (1) Yonsei University CANYVAL-X, South Korea (1) Chungnam University CNUSAIL, South Korea (1) Korea Aerospace University KAUSAT-5, South Korea, Kyung Hee University SIGMA, South Korea (1) Chosun University STEP CUBE LAB, South Korea (1) UPC Barcelona Tech and IEEC 3Cat-1, Spain (1) SpacePharma DIDO-1, Switzerland (1) AUS Nayif-1, UAE (1) Aerospace Corporation AeroCube7 B/C, United States (2) Planetary Resources, Inc. Arkyd-6, United States (1) Aquila Space, Inc. CORVUS-BC, United States (1) Planet Labs, Inc., Flock 2c, United States (56) Tyvak, PROPCUBE, United States (1) NASA Ames Research Center EcAMSat, United States (1) AMSAT Fox-1C, United States (1) AMSAT Fox-1D, United States (1) MicroCosm ICE-Cap, United States (1) AeroSpace Corporation ISARA, United States (1) Spire, Inc. LEMUR, United States (8)
2. The Technical Annex states that "[t]he confirmation of successful payload deployment is given by the transmission of telemetry containing SHERPA state vectors taken upon each discrete	SHERPA uses GPS to determine its position and velocity at 1 Hz. SHERPA also monitors each separation system to determine when/if payloads are deployed. With this data Spaceflight can

deployment event. Please provide additional detail concerning the specific "state vectors." Will this information be shared with the Department of Defense's Joint Space Operations Center (JSpOC)	determine SHERPA's position, velocity, and the time for each discrete payload deployment event. These data will be downlinked and disseminated to Spaceflight's customers as well as JSpOC. Through SpaceX Spaceflight is working with JSpOC to coordinate the tracking and identification of the deployed spacecraft.
3. Please address whether SHERPA could accomplish its mission while attached to the upper stage of the launch vehicle. Does the physical configuration of SHERPA permit such deployment?	The physical configuration of SHERPA prevents operation while attached to the Falcon 9 second stage. The launch vehicle cannot generate enough signals to deploy the secondary spacecraft, and independent operation of SHERPA is an operation requirement of SpaceX.
4. Please also provide the following supplemental information related to the orbital debris mitigation plan submitted with the application: **a.** The Technical Annex states that the inclination of the spacecraft will be 97.4◦, but the orbital debris assessment states that the inclination will be 97.8◦. Please correct the discrepancy and, if necessary, update affected portions of the orbital debris assessment	Updated ODAR Report attached.
b. The Narrative and Technical Annex state that the operational lifetime of the spacecraft will be 12 hours, but the orbital debris assessment states that the operational lifetime will be 6 hours. Please correct the discrepancy.	Updated ODAR Report attached.
c. Please indicate whether a casualty risk assessment using higher fidelity methods can be reasonably expected to predict demise of all components during re-entry, except for components that would impact with an energy less than 15 joules. If so, please provide that analysis, You may wish to take into consideration the breaking up into smaller components of the spacecraft upon re-entry.	Updated ODAR Report attached. Spaceflight has used the NASA DAS software package for the preparation of its orbital debris assessment from which its conclusions relating to casualty risks are drawn. Spaceflight has attempted using the DAS package to produce higher fidelity results; there have been no changes in results from those reported in the attached ODAR Report. During recent conversations with the Bureau's staff, Spaceflight was informed of the potential availability of alternative orbital debris assessment software than the NASA DAS package. The higher fidelity methods employed in these packages may potentially result in conclusions that would bring the potential for casualty risk (already well under the permissible

	standard) to closer to a zero probability. Spaceflight is looking into the practicality of using one of these alternative methodologies as a means of orbital debris risk assessment and will advise the Commission of any updated results if available.
d. Please provide the estimated orbital lifetime of SHERPA assuming that none of the payload spacecraft deploy from SHERPA	24.2 Years
e. What insurance will be obtained for SHERPA operations and re-entry?	Our mission customers may obtain insurance coverage for their spacecraft at their discretion. Further, SpaceX will obtain Third Party Liability coverage for the launch activity. Spaceflight is not planning to have any other insurance coverage for SHERPA.

SPACEFLIGHT

SPACEFLIGHT TECHNICAL MEMORANDUM

MEMO #: AS-6303-MEMO-00011

TO: SPACEFLIGHT, INC.

FROM: E. LUND, SPACEFLIGHT

SUBJECT: SHERPA-0 ORBITAL DEBRIS MITIGATION FOR FORMOSAT-5 MISSION

DATE: 15 OCTOBER 2015

1. Introduction and Background

This memo contains a summary of the analysis related to limiting orbital debris IAW NASA-STD-8719.14. This memo captures the inputs and outputs of NASA Debris Assessment Software (DAS) v2.0.2, which is structured around the requirements of NASA-STD-8719.14 and serves as the sole source of related analyses. This memo is not intended to replace a formal Orbital Debris Assessment Report (ODAR). However, this memo does capture the majority of the technical analysis that is critical to filling out an ODAR.

2. Objective

The objective of this analysis is to verify compliance with all relevant requirements specified in NASA-STD-8719.14 "Process for Liming Orbital Debris." Specific requirements will be covered later in this memo.

3. DAS Inputs and Outputs

This section is structured in parallel with how DAS is structured. In theory, a reader should be able to reproduce the results in DAS with the inputs provided below.

3.1 Mission Editor

This section contains the basic mission inputs. The launch date was set to Q1 2016 for this analysis; the actual launch is not expected to occur before the end of Q1 2016, but this does not impact the results of the analysis. Here is the list of mission components:

- Payloads: SHERPA-0
- Rocket Bodies: none
- Mission-Related Debris: none

Payload Properties:

- Name: SHERPA-0
- Mission Duration: 1.37e-3 years (<12 hrs)
- Operational Perigee Altitude: 450 km
- Operational Apogee Altitude: 720 km
- Operational Inclination: 97.4 deg
- PMD Maneuver: No (unchecked)
- Initial Mass: 1233 kg
- Final Mass: 603 kg
- Final Area-to-Mass:0.0056385 m^2/kg (based on 3.4 m^2)
- Station Keeping: No (unchecked)
- Planned Breakup: No (unchecked)

3.2 Requirements Assessments

In this section, each subsection pertains to a particular subset of the 8719.14 requirements. The requirement text is provided for context. Any DAS message are provided showing compliance (as appropriate) with each requirement. A justification in each subsection to provides further explanation, but is not sourced from DAS. Some of the subsections have unique inputs and/or outputs, so those are provided when applicable.

3.2.1 Requirement 4.3-1 Mission-Related Debris Passing Through LEO

Requirement Text:

(Requirement 4.3-1a & 4.3-1b) - Debris passing through LEO:

For missions leaving debris in orbits passing through LEO, released debris with diameters of 1 mm or larger shall satisfy both Requirement 4.3-1a and Requirement 4.3-1b:

a. All debris released during the deployment, operation, and disposal phases shall be limited to a maximum orbital lifetime of 25 years from date of release.

b. The total object-time product shall be no larger than 100 object-years per mission. The object-time product is the sum of all debris of the total time spent below 2000 km altitude during the orbital lifetime of each object.

Messages: Requirement 4.3-1 Compliant

Justification: The SHERPA-0 Mission for FORMOSAT-5 generates no mission-related debris. All deployment devices are self-contained. The SHERPA-0 spacecraft itself has no ejectable covers or other free-floating debris that are intentionally released.

3.2.2 Requirement 4.3-2 Mission-Related Debris Passing Near GEO

Requirement Text:

(Requirement 4.3-2) - Debris passing near GEO:

For missions leaving debris in orbits with the potential of traversing the GEO (GEO altitude +/- 200 km and +/- 15 degrees latitude), released debris with diameters of 5 cm or greater shall

be left in orbits which will ensure that within 25 years after release the apogee will no longer exceed GEO - 200 km.

Messages: Requirement 4.3-2 Compliant

Justification: The SHERPA-0 Mission has a maximum altitude of 720 km, which is several 10,000 km away from GEO altitude.

3.2.3 Requirement 4.4-3 Long-Term Risk from Planned Breakups

Requirement Text:

(Requirement 4.4-3) - Limiting the long-term risk to other space systems from planned breakups:

Planned explosions or intentional collisions shall:

a) Be conducted at an altitude such that for orbital debris fragments larger than 10 cm the object-time product does not exceed 100 object-years. For example, if the debris fragments greater than 10 cm decay in the maximum allowed 1 year, a maximum of 100 such fragments can be generated by the breakup.

b) Not generate debris larger than 1 mm that shall remain in Earth orbit longer than one year.

Messages: Requirement 4.4-3 Compliant

Justification: The SHERPA-0 Mission has no planned breakup events.

3.2.4 Requirement 4.5-1 Probability of Collision with Large Objects

Requirement Text:

(Requirement 4.5-1) - Limiting debris generated by collisions with large objects when operating in Earth orbit:

For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001.

Output: Collision Probability: 0.00011

Messages: Requirement 4.5-1 Compliant

Justification: DAS computes the collision probability based on the mission orbit, size, area-to-mass ratio, etc.

3.2.5 Requirement 4.5-2 Probability of Damage from Small Objects

Requirement Text:

(Requirement 4.5-2) - Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit:

For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable postmission disposal requirements is less than 0.01.

Payload Orientation: Random Tumbling

Messages: Requirement 4.5-2 Compliant

Justification: The relatively short duration of the SHERPA-0 Mission is a prime factor in compliance with this requirement. The SHERPA-0 spacecraft is not designed with protection from small space debris in mind. However, SHERPA's primary structure is thick enough and large enough to stop or dissipate many smaller particles across a significant number of relative directions.

3.2.6 Requirement 4.6-1 to 4.6-3 Post Mission Disposal:

(Requirement 4.6-1) - Disposal for space structures passing through LEO:

A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods:

a. Atmospheric reentry option:

(1) Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or

(2) Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.

b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.

c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

(Requirement 4.6-2) - Disposal for space structures near GEO:

A spacecraft or orbital stage in an orbit near GEO shall be maneuvered at EOM to a disposal orbit above GEO with a predicted minimum altitude of GEO + 200 km (35,986 km) for a period of at least 100 years after disposal.

(Requirement 4.6-3) - Disposal for space structures between LEO and GEO:

a) A spacecraft or orbital stage may be left in any orbit between 2000 km above the Earth's surface and 500 km below GEO.

b) A spacecraft or orbital stage shall not use nearly circular disposal orbits near regions of high value operational space structures, such as between 19,100 km and 20,200 km.

Messages: Requirement 4.6-1 Compliant

Justification: DAS computes the orbital decay based on the mission orbit, size, area-to-mass ratio, etc. Requirements 4.6-2 and 4.6-3 are not applicable to SHERPA-0 for FORMOSAT-5 Mission based on the mission altitude.

3.2.7 Requirement 4.7-1 Casualty Risk from Reentry Debris

Requirement Text:

(Requirement 4.7-1) - Limit the risk of human casualty:

The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 Joules:

a) For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000).

b) For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 Joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica.

c) For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000).

Input:
Two sub-components of SHERPA were identified and listed in DAS: the individual (total of 21) QuadPacks and the ESPA_assembly, which is comprised of everything else. In this analysis, unique sub-components are those likely to separate from each other during atmospheric entry / breakup. The majority of SHERPA-0 is relatively heavy structure held together with dozens of steel bolts. The QuadPacks are relatively lightweight and are more likely to separate from the structure during reentry. The respective component data as input into DAS is shown in the following figure.

Component Data

	Name	Quantity	Material Type	Object Shape	Thermal Mass (kg)	Diameter/Width (m)	Length (m)	Height (m)
1	SHERPA-Zero	1	Aluminum (generic)	Cylinder	663	3	1.42	
2	ESPA_assembly	1	Aluminum 7075-T6	Cylinder	505.5	1.5748	1.42	
3	QP	21	Aluminum 7075-T6	Box	7.5	0.272	0.404	0.272

Output:

Output

Object Name	Compliance Status	Risk of Human Casualty	SubComponent Object	Demise Altitude (km)	Total Debris Casualty Area ...	Kinetic Energy (J)
SHERPA-Zero	Compliant	1:18800			4.39	
			ESPA_assembly	0.0	4.39	1032313
			QP	69.8	0.00	0

Messages: Requirement 4.7-1 Compliant

Justification: DAS computes the demise altitude, casualty probability, etc. based on the mass, shape, dimensions, material, etc. for each sub-component and computes an overall causality risk value. SHERPA-0 will undergo an uncontrolled re-entry. The predicted risk of human casualty is 1:18,800, which is below the requirement of 1:10,000.

3.2.8 Requirement 4.8-1 Collision Hazards of Space Tethers

Requirement Text:
(Requirement 4.8-1) - Mitigate the collision hazards of space tethers in Earth or Lunar orbits:

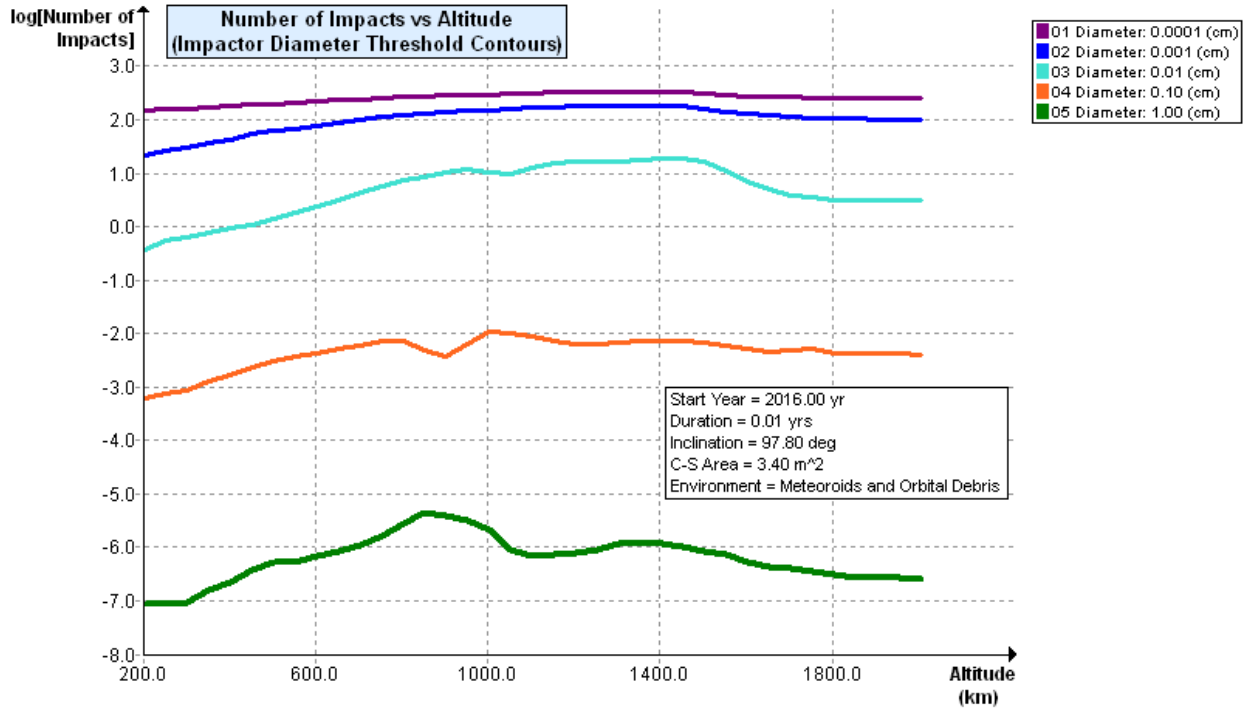
Intact tether systems in Earth and lunar orbit shall meet the requirements limiting the generation of orbital debris from on-orbit collisions (Requirements 4.5-1 and 4.5-2) and the requirements governing postmission disposal (Requirements 4.6-1 through 4.6-4) to the limits specified in those paragraphs. Due to the potential of tether systems being severed by orbital debris or meteoroids, all possible remnants of a severed tether system shall be compliant with the requirements for the collision, debris, and disposal of space structures.

Status: This requirement is not applicable to the SHERPA-0 Mission for FORMOSAT-5 since SHERPA-0 does not have any space tethers.

3.3 Science and Engineering

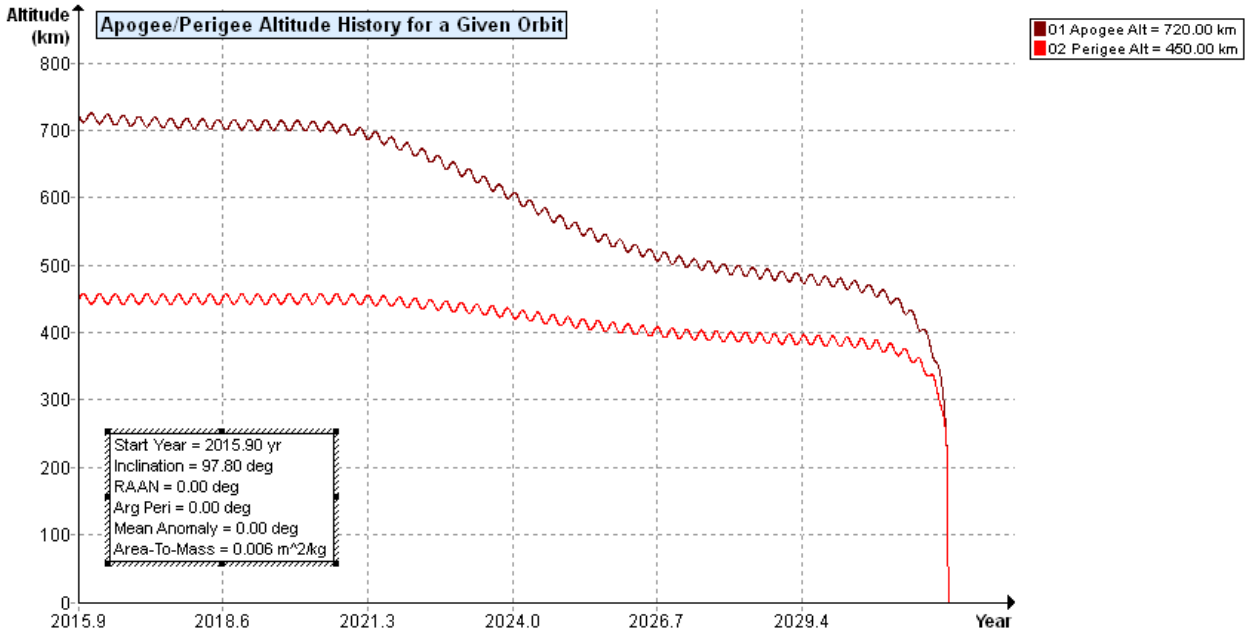
3.3.1 Debris Impact vs. Orbit Altitude

The graph below was generated by DAS and is for a mission duration of 0.01 year (3.65 days), which is more than ten times longer than the SHERPA-0 mission, but is the shortest duration for which DAS will generate a graph. The graph below shows the total number of impacts for various sizes of space debris hitting the SHERPA-0 spacecraft during the 0.01 year duration of the analysis specific to this graph.



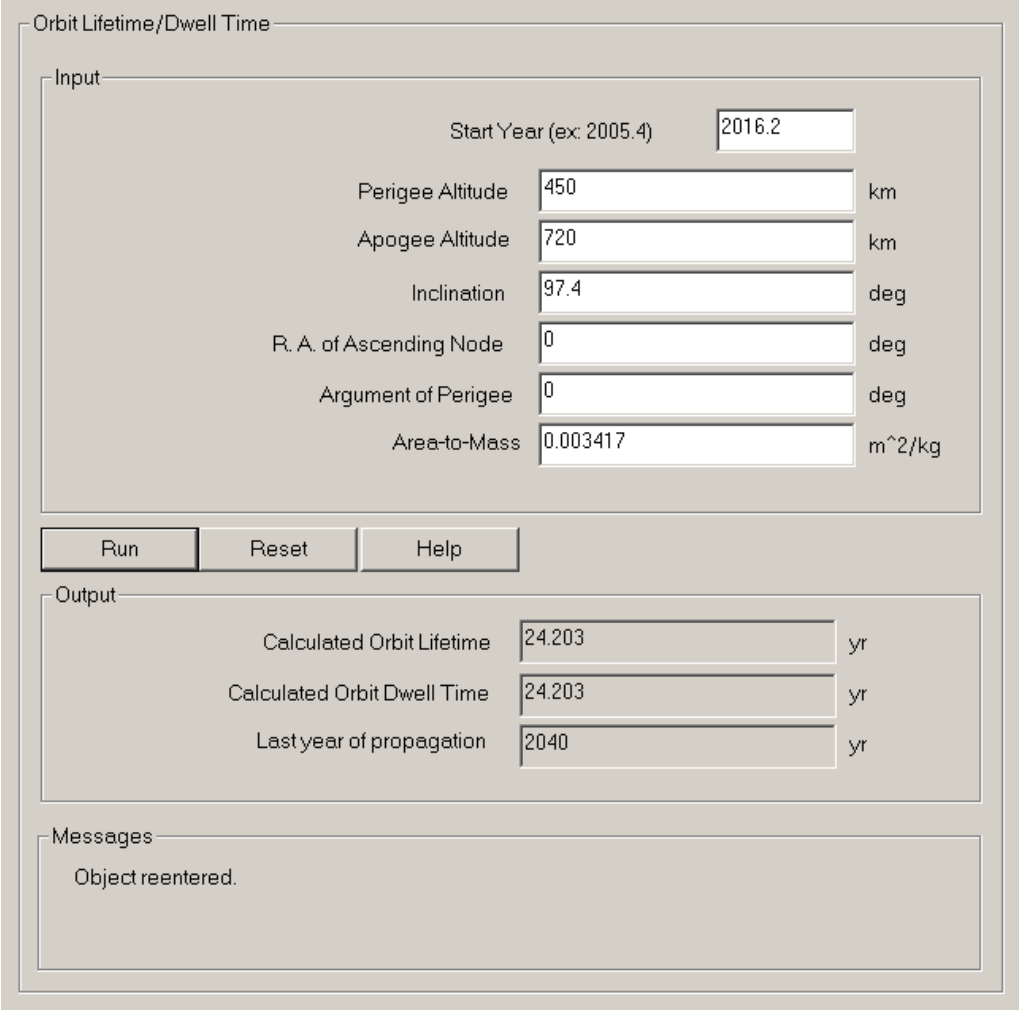
3.3.2 Apogee/Perigee Altitude History

The graph below was generated by DAS using the solarflux_table.dat file from NASA dated April 14, 2014 (most recent available at the time this report was written). The solarflux_table includes historical data as well as forecasted space weather data. This data is used within DAS to predict upper atmosphere density, which determines orbital decay rate.



3.3.3 Orbit Lifetime for Undeployed State

In the event of a major unrecoverable anomaly early in the mission, the payloads may not deploy. In this unique case, the area-to-mass ratio will be ~0.003417 m²/kg (4.12 m² divided by ~1205 kg). The 4.12 m² area is the mean projected surface area for the undeployed configuration determined by 3600 equally-spaced orientations. Output from DAS (see figure below) shows that orbit lifetime is expected to be 24.2 years if no payloads are deployed from SHERPA.



4. Results

DAS has verified that SHERPA-0 meets all relevant 8719.14 requirements with the inputs provided earlier in this report. The following graphic is a screenshot of the summary from DAS. The green checkmarks indicate that the mission meets the associated requirement(s).