Sherpa-FX1 Orbital Debris Assessment Report (ODAR)

This report is presented in compliance with NASA-STD-8719.14B, APPENDIX A.

Report Version 1
July 27, 2020

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This document contains no proprietary, ITAR, or export-controlled information.

DAS Software Version Used In Analysis: v3.1.0
Report prepared by Mike Coletti, Mission Manager
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VERSION APPROVAL and/or FINAL APPROVAL*:

Mike Coletti
Mission Manager
Spaceflight, Inc.

*Approval signatures indicate acceptance of the ODAR-defined risk.

Table Contents

Self-assessment of the ODAR using the format in Appendix A.2 of NASA-STD- 8719.14:

A self-assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14.

Orbital Debris Self-Assessment Report Evaluation: Sherpa-FX1 on December SpaceX Falcon 9 Rideshare Mission

Requirement #	Launch Vehicle				Spacecraft			Comments
	Compliant	Not Compliant	Incomplete	Standard Non Compliant	Compliant or N/A	Not Compliant	Incomplete	
4.3-1.a	☐	☐	☐	☐	☒	☐	☐	No Debris Released in LEO.
4.3-1.b	☐	☐	☐	☐	☒	☐	☐	No Debris Released in LEO.
4.3-2	☐	☐	☐	☐	☒	☐	☐	No Debris Released in GEO.
4.4-1	☐	☐	☐	☐	☒	☐	☐	
4.4-2	☐	☐	☐	☐	☒	☐	☐	
4.4-3	☐	☐	☐	☐	☒	☐	☐	No planned breakups.
4.4-4	☐	☐	☐	☐	☒	☐	☐	No planned breakups.
4.5-1	☐	☐	☐	☐	☒	☐	☐	
4.5-2	☐	☐	☐	☐	☒	☐	☐	
4.6-1(a)	☐	☐	☐	☐	☒	☐	☐	
4.6-1(b)	☐	☐	☐	☐	☒	☐	☐	
4.6-1(c)	☐	☐	☐	☐	☒	☐	☐	
4.6-2	☐	☐	☐	☐	☒	☐	☐	Spacecraft does not go to GEO.
4.6-3	☐	☐	☐	☐	☒	☐	☐	Spacecraft does not go beyond LEO.
4.6-4	☐	☐	☐	☐	☒	☐	☐	
4.7-1	☐	☐	☐	☐	☒	☐	☐	
4.8-1					☒	☐	☐	No tethers used.

Assessment Report Format:

ODAR Technical Sections Format Requirements:

As Spaceflight, Inc. is based in the U.S., and governed by the rules and regulation of the U.S.; this ODAR follows the format recommended in NASA- STD-8719.14b, Appendix A.1 and includes the content indicated at a minimum in each section 2 through 8 below for the December SpaceX Rideshare Mission. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Project Manager: Mike Coletti

Foreign government or space agency participation: No foreign government or space agency participation

Schedule of upcoming mission milestones:
Launch: December 2020 – January 2021

Mission Overview:
The December SpaceX Rideshare Mission is a commercial rideshare mission, for which the primary objective of Spaceflight Inc., is deploying around 14 customer spacecraft into a planned sun-synchronous circular orbit of 525 km ± 25km, to be down selected by SpaceX at a later date. The launch vehicle will deploy a free flyer spacecraft, called "Sherpa-Flex" or "Sherpa-FX1", which deploys additional customer spacecraft within several hours of liftoff and will carry four hosted payloads through de-orbit.(*Each of these satellite customers are responsible for obtaining an FCC or other agency or administration authorization as appropriate and do not constitute debris*). Sherpa-FX1 will rely on atmospheric drag to fully de-orbit. Sherpa-FX1 has no solar panels, attitude control, propulsion, or pressure vessels.

ODAR Configuration:
The ODAR analyses contained in this report was run at 550 km, as a worst-case scenario. However, we note orbit lifetimes at 525 km to demonstrate significantly reduced orbit lifetimes below the maximum 550 km upper limit. Thus, we demonstrate compliance with FCC requirements at the highest possible altitude without the use of a deorbit device.

The terms *Nominal Mission*, *Partially Failed Mission*, and *Failed Mission* are defined as follows:

- *Nominal Mission*: All customer deployments successful
- *Partially Failed Mission:* Highly unlikely worst case, only the forward Microsat deployment successful, all other spacecraft deployments unsuccessful.
- *Failed Mission:* All spacecraft deployments unsuccessful

ODAR Summary:

- No debris released in normal operations;
- No credible scenario for breakups;
- The collision probability with other objects is compliant with NASA standards;
- The estimated Nominal Mission decay lifetime due to atmospheric drag is under 25 years following operations (7 years at 550 km, and 3.6 years at 525 km, as calculated by DAS 3.1.0).
- For a Failed Mission, DAS 3.1.0 predicts maximum orbit lifetime to be 14.5 years at 550 km and 11.4 years at 525 km.
- For a Partially Failed Mission, DAS 3.1.0 predicts an orbit lifetime to be 15.3 years at 550 km and 12.2 years at 525 km.

Launch vehicle and launch site: Falcon 9**,** Cape Canaveral Air Force Base, Florida

Proposed launch date: December 2020 – January 2021

Mission duration:

Maximum Nominal Operations: < 24 hours after launch.

Post-Mission Orbit lifetime:

- At the highest possible altitude, 550 km, Sherpa-FX1 has a mean lifetime of 12.27 years (maximum of 15.3 years) assuming random tumbling spending equal time in all orientations, until reentry via atmospheric orbital decay.

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination:

	Apogee Altitude	Perigee Altitude	Inclination	Mission Duration
Mission	550 km	550 km	97.593 deg	<1 days
End-of-Life Orbit	550 km	550 km	97.593 deg	<15 years

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:
Sherpa-FX1 is a non-propulsive, free flying spacecraft that is designed to deploy auxiliary spacecraft. Sherpa-FX1 will also carry four hosted payloads that will remain on the spacecraft through deorbit It consists of several structural elements to mount both microsatellites and CubeSat dispensers. For this mission, the current configuration has a microsatellite on the outboard end of Sherpa-FX1, with three affixed microsatellites, two 6U equivalent CubeSat dispensers, and one 12U equivalent CubeSat dispenser, affixed radially on the body of Sherpa-FX1. The internal volume of Sherpa-FX1 will contain the Rapidly Reconfigurable Avionics (R2A) sequencer and batteries. Sherpa-FX1 will be attached to a single port on a SpaceX-provided payload ring. The Falcon 9 will have multiple rings with SpaceX's other customers stacked above and/or below the ring to which Spaceflight's Sherpa FX1 is attached. Once a separation signal is received by Sherpa-FX1's separation system from Falcon 9 avionics, Sherpa-FX1 will separate.

Total satellite mass at launch, including all propellants and fluids, potential mass growth and uncertainties:

Sherpa-FX1 without separating customer spacecraft	130 kg
Sherpa-FX1 with separating customer spacecraft	300 kg

Dry mass of satellites at launch, excluding solid rocket motor propellants, but including potential mass growth and uncertainties:

Sherpa-FX1 without separating customer spacecraft	130 kg
Sherpa-FX1 with separating customer spacecraft	300 kg

Dry mass of satellites at end of mission, excluding solid rocket motor propellants:

Sherpa-FX1 without separating customer spacecraft	130 kg

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear):

Sherpa-FX1 has no propulsion.

Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes: N/A

Fluids in Pressurized Batteries: None. Sherpa-FX1 uses two of the same NiMH battery packs previously used on the Upper Free Flyer and Lower Free Flyer structures from the December 2018 SSO-A mission.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector: None.

Description of any range safety or other pyrotechnic devices: None.

Description of the electrical generation and storage system: Standard COTS lithium iron disulfide and nickel-metal hydride battery cells are charged prior to payload integration and provide electrical energy during the mission.

Identification of any other sources of stored energy not noted above: None.

Identification of any radioactive materials on board: None**.**

ODAR Section 3: Assessment of Spacecraft Debris Released during Normal Operations

Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material: There are no intentional releases other than customer spacecraft deployments (see Mission Overview).

Rationale/necessity for release of each object: N/A.

Time of release of each object, relative to launch time: N/A.

Release velocity of each object with respect to spacecraft: N/A.

Expected orbital parameters (apogee, perigee, and inclination) of each object after release: N/A.

Calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO): N/A.

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v3.1.0)

4.3-1, Mission Related Debris Passing Through LEO: COMPLIANT

4.3-2, Mission Related Debris Passing Near GEO: COMPLIANT

ODAR Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions.

Potential causes of spacecraft breakup during deployment and mission operations:

There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.

Summary of failure modes and effects analyses of all credible failure modes which may lead to an accidental explosion:

An in-mission failure of a battery protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell explosion. The battery safety systems discussed in the FMEA (see requirement 4.4-1 below) describe the combined faults that must occur for any of seven (7) independent, mutually exclusive failure modes to lead to explosion.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:

There are no planned breakups.

List of components which shall be passivated at End of Mission (EOM) including method of passivation and amount which cannot be passivated:

No components require passivation at EOM.

Rationale for all items which are required to be passivated, but cannot be due to their design:

N/A

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:

***Requirement 4.4-1*:** Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon:

For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).

Compliance statement:

Required Probability: 0.001.

Expected probability: 0.000.

Supporting Rationale and FMEA details:

Battery explosion:

Effect: All failure modes below might theoretically result in battery explosion

with the possibility of orbital debris generation. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of the selected space-rated COTS battery cells is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the battery housing / containment device due to the lack of penetration energy.
Probability: Extremely Low. It is believed to be a much less than 0.1% probability that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

Failure mode 1: Internal short circuit.
Mitigation 1: Qualification and acceptance shock, vibration, thermal cycling, and vacuum tests followed by maximum system rate-limited charge and discharge to prove that no internal short circuit sensitivity exists.
Combined faults required for realized failure: Environmental testing and functional charge/discharge tests must both be ineffective in discovery of the failure mode.

Failure Mode 2: Internal thermal rise due to high load discharge rate.
Mitigation 2: Cells were tested in lab for high load discharge rates in a variety of flight-like configurations to determine like likelihood and impact of an out of control thermal rise in the cell. Cells were also tested in a hot environment to test the upper limit of the cells capability. No failures were seen.
*Combined faults required for realized failure: S*pacecraft thermal design must be incorrect and external over-current detection and disconnect function must fail to enable this failure mode.

Failure Mode 3: Excessive discharge rate or short circuit due to external device failure or terminal contact with conductors not at battery voltage levels (due to abrasion or inadequate proximity separation).
Mitigation 4: This failure mode is negated by a) qualification-tested short circuit protection on each external circuit, b) design of battery packs and insulators such that no contact with nearby board traces is possible without being caused by some other mechanical failure, c) obviation of such other mechanical failures by proto-qualification and acceptance environmental tests (shock, vibration, thermal cycling, and thermal-vacuum tests).
Combined faults required for realized failure: An external load must fail/short-circuit and external over-current detection and disconnect function failure must all occur to enable this failure mode.

Failure Mode 4: Inoperable vents.
Mitigation 5: Battery vents are not inhibited by the battery holder design or the spacecraft.
Combined effects required for realized failure: The final assembler fails to install proper venting.

Failure Mode 5: Crushing.
Mitigation 6: This mode is negated by spacecraft design. There are no moving parts in the proximity of the batteries.
Combined faults required for realized failure: A catastrophic failure must occur in an external system and the failure must cause a collision sufficient to crush the batteries leading to an internal short circuit and the satellite must be in a naturally sustained orbit at the time the crushing occurs.

Failure Mode 6: Low level current leakage or short-circuit through battery pack case or due to moisture-based degradation of insulators.
Mitigation 7: These modes are negated by a) battery holder/case design made of non-conductive plastic, and b) operation in vacuum such that no moisture can affect insulators.
Combined faults required for realized failure: Abrasion or piercing failure of circuit board coating or wire insulators and dislocation of battery packs and failure of battery terminal insulators and failure to detect such failure modes in environmental tests must occur to result in this failure mode.

Failure Mode 7: Excess temperatures due to orbital environment and high discharge combined.
Mitigation 8: The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that batteries do not exceed normal allowable operating temperatures, which are well below temperatures of concern for explosions.
Combined faults required for realized failure: Thermal analysis and thermal design and mission simulations in thermal-vacuum chamber testing and over-current monitoring and control must all fail for this failure mode to occur.

Requirement 4.4-2: Design for passivation after completion of mission operations while in orbit about Earth or the Moon:

Design of all spacecraft and launch vehicle orbital stages shall include the ability to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or post-mission disposal or control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).

Compliance statement:
Sherpa-FX1 is designed such that when mission operations begin, all energy from the secondary batteries will dissipate within 24 hours. The primary batteries will dissipate all energy within 24 hours. Additionally, Sherpa-FX1 battery charge circuits include overcharge protection and active thermal monitoring to limit the risk of battery failure. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such

that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

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

Compliance statement:
This requirement is not applicable. There are no planned breakups.

Requirement 4.4-4: Limiting the short-term risk to other space systems from planned breakups:

Compliance statement:
This requirement is not applicable. There are no planned breakups.

ODAR Section 5: Assessment of Spacecraft Potential for On-Orbit Collisions

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v3.1.0, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):

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 (Requirement 56506).

Large Object Impact and Debris Generation Probability:

Spacecraft	Nominal Mission	Partially Failed Mission	Failed Mission	Status
Sherpa-FX1	0.000013185	0.00003382	0.000042605	COMPLIANT

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 post-mission disposal requirements is less than 0.01 (Requirement 56507).

Small Object Impact and Debris Generation Probability:

Spacecraft	Nominal Mission	Partially Failed Mission	Failed Mission	Status
Sherpa-FX1	0.00002272	0.00002272	0.00002272	COMPLIANT

Identification of all systems or components required to accomplish any post-mission disposal operation, including passivation and maneuvering:

Sherpa-FX1 batteries will deplete in less than 24 hours after separation. Sherpa-FX1 will deorbit naturally and rely on atmospheric drag. Sherpa-FX1 does not have propellants or pressure vessels.

Recontact Analysis. Although beyond the scope of a standard orbital debris analysis, Spaceflight has conducted extensive testing and modeling so as to limit the risk that individual spacecraft that will be deployed on this mission will re-contact with each other after release. That analysis is presented as attachment titled *Sherpa-FX1 Long-Term Recontact Probability* to Spaceflight's STA application.

ODAR Section 6: Assessment of Spacecraft Post-mission Disposal Plans and Procedures

6.1 Description of spacecraft disposal option selected: Sherpa-FX1 will deorbit naturally by atmospheric re-entry.

6.2 Plan for any spacecraft maneuvers required to accomplish post-mission disposal:

Sherpa-FX1 does not have propulsion or attitude control. There is no plan for post-mission disposal maneuvers.

6.3 Calculation of area-to-mass ratio after post-mission disposal if the controlled reentry option is not selected:

Spacecraft Mass:

	Nominal Mission	Partially Failed Mission	Failed Mission
Sherpa-FX1	130 kg	242 kg	300 kg

Cross-sectional Area: (arithmetic mean for random tumbling attitude)

	Nominal Mission	Partially Failed Mission	Failed Mission
Sherpa-FX1	1.014 m^2	0.920 m^2	1.23 m^2

Area to mass ratio: (arithmetic mean for random tumbling attitude)

	Nominal Mission	Partially Failed Mission	Failed Mission
Sherpa-FX1	0.0078 m^2/kg	0.0038 m^2/kg	0.0041 m^2/kg

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v 3.1.0 and NASA-STD-8719.14 section):

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:
(Requirement 56557)
a. Atmospheric reentry option:

- *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*
- *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.

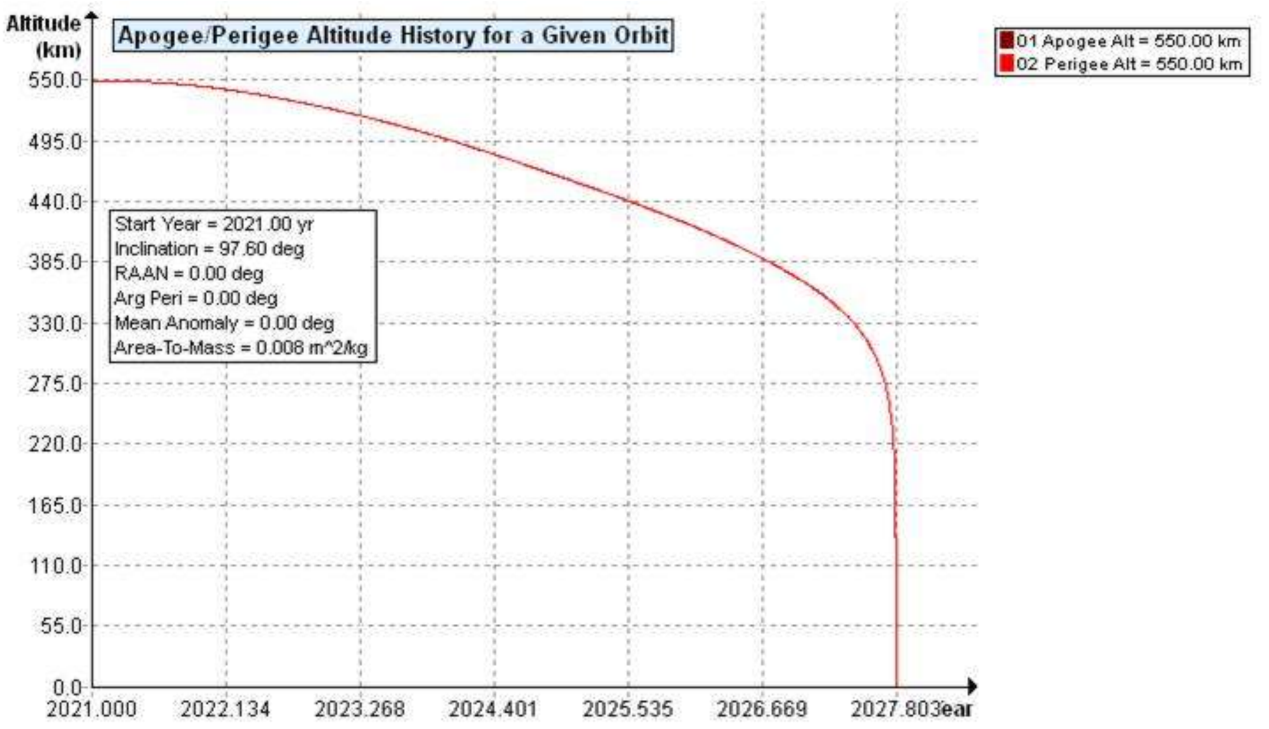

Figure 2 Sherpa-FX1 (Nominal Mission) orbit history with apogee (brown) & perigee (red)

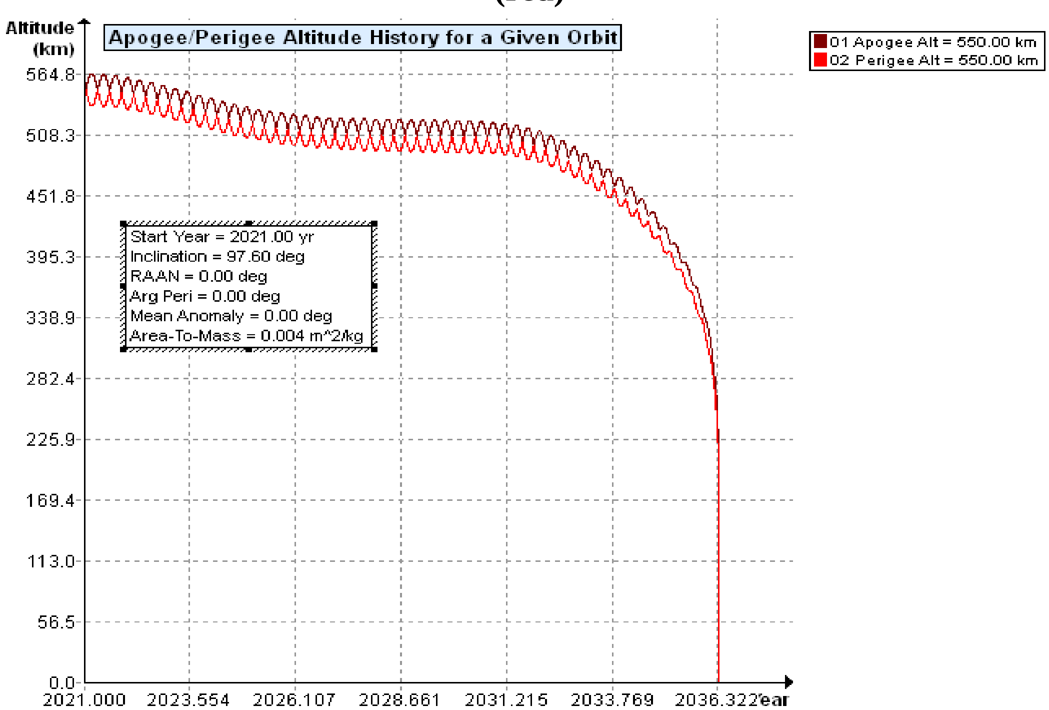

Figure 3 Sherpa-FX1 (Partially Failed Mission) orbit history with apogee (brown) & perigee (red)

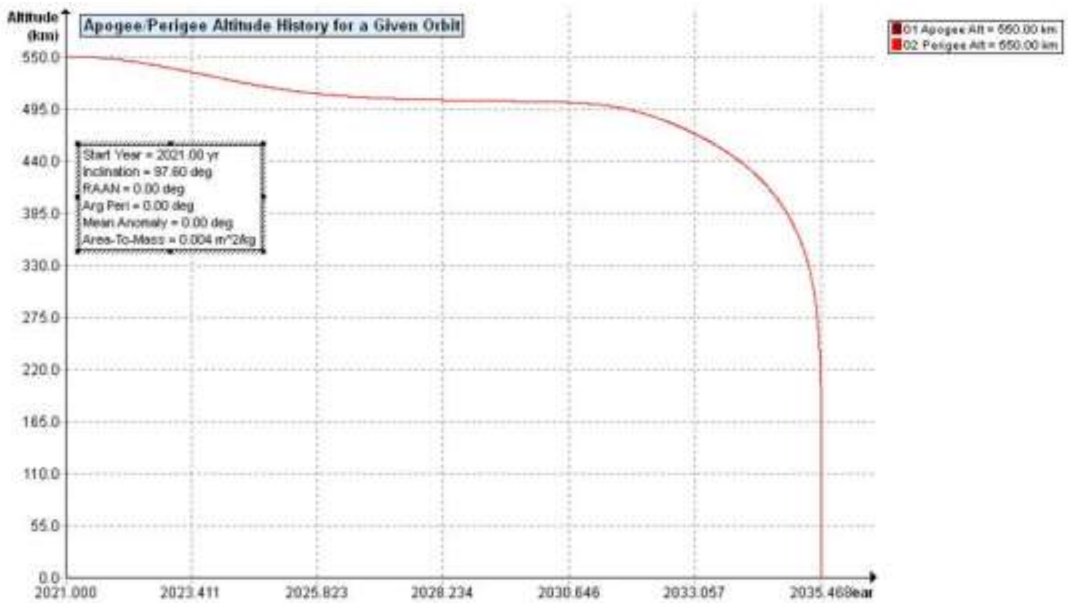

Figure 4 Sherpa-FX1 (Failed Mission) orbit history with apogee (brown) & perigee (red)

Analysis: Sherpa-FX1 reentry is COMPLIANT using method "a".

Satellite Name	**Sherpa-FX1**
BOL Orbit (Drop off)	550 x 550 km
Operational Orbit	550 x 550 km
EOM Orbit	550 x 550 km
Total Lifetime	7 years
Lifetime for Nominal Mission	7 years
Lifetime if Partial Mission Failure	15.3years
Lifetime if Total Mission Failure	14.5 years

Requirement 4.6-2. Disposal for space structures near GEO.

Analysis: Not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO.

Analysis: Not applicable.

Requirement 4.6-4. Reliability of Post-mission Disposal Operations

Reliability: Sherpa-FX1 will rely on atmospheric drag to fully de-orbit. Spaceflight shows DAS analysis cases here for: (i) its planned or Nominal Mission (successful deployment of all spacecraft planned to be deployed); (ii) were there to be an off-nominal case, the most likely failure scenario, a Total Mission Failure where no spacecraft are deployed; and (iii) a highly unlikely, but worst case scenario in terms of orbital lifetime, a Partial Mission Failure in which only the forward payload is successfully deployed, all also assuming a worst case target orbital altitude of 550 km. For each of the Nominal Mission and the Total Mission Failure cases, there is in excess of a 99% probability of a lifetime of 25 years or less. Even in the unlikely, worst-case, Partial Mission Failure scenario that combines the partial deployment of spacecraft from the current mission manifest in a fixed, minimum drag orientation, at the maximum 550 km initial orbit altitude, there is a 92% probability of a lifetime of 25 years or less.

That probability (92%), in reality is significantly understated, because it assumes so many stacked failures and worst case scenarios, without taking into account the unlikely chance that each worst case element would all occur on the same mission: (i) that the target orbit is raised to the maximum 550 km altitude; (ii) the probability that R2A fails in such an unlikely, worst-case partial deployment scenario; (iii) Sherpa-FX1 trims to the lowest drag attitude; and (iv) it remains in that orientation for the duration of its on-orbit lifetime. In terms of these elements, Spaceflight believes it is highly unlikely that a partial deployment will occur as thorough qualification and acceptance testing, along with rigorous mission assurance principles, are used on the Sherpa-FX1 program. These methods are employed to minimize the risk of any off-nominal deployment scenario as auxiliary spacecraft deployments are the sole focus of the Sherpa-FX1 mission. In addition, this off-nominal orbit lifetime scenario assumes that the Sherpa-FX1 spacecraft is deployed at a 550 km orbit altitude, and maintains a fixed, minimum drag orientation throughout its orbital lifetime. This is an unlikely scenario, as the spacecraft will certainly have some angular rate following separation from the launch vehicle (no separation results in exactly zero body rates), and partial separation of the Sherpa-FX1 auxiliary satellites will impart even greater body rates. As such, the aggregate drag configuration should be much higher than is analyzed in this worst-case scenario and, therefore, reduce orbital lifetime. As with SSO-A, Spaceflight has a team of highly qualified engineers, and a well-established process for rideshare missions such as this. In the event Sherpa-FX1's avionics fail, it will most likely succumb to the launch environment, which occurs prior to any deployments from Sherpa-FX1, resulting in a shorted orbital lifetime (the "Total Mission Failure" case presented above). Furthermore, Spaceflight believes a successful mission, "Nominal Mission" case, is most probable. The analysis contained above shows compliance with FCC regulation and guidelines, with significant margin to spare.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Assessment of spacecraft compliance with Requirement 4.7-1:

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) (Requirement 56626).

Summary Analysis Results:

DAS calculates Sherpa-FX1 has a 1:58400 risk of human casualty and thus that spacecraft meets the requirement.

Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because the Sherpa-FX1 Mission does not use controlled reentry.

4.7-1, b) **NOT APPLICABLE.** 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 (Requirement 56627).
4.7-1 c) **NOT APPLICABLE.** 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) (Requirement 56628).

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers in the mission.

Raw DAS Output – Mission Success (all customers separated)
06 22 2020; 09:04:56AM Activity Log Started
06 22 2020; 09:04:56AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-3\DAS Config B post-deploy\
06 22 2020; 09:05:24AM Processing Requirement 4.3-1: Return Status : Not Run

=====================
No Project Data Available
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=============== End of Requirement 4.3-1 ===============
06 22 2020; 09:05:26AM Processing Requirement 4.3-2: Return Status : Passed

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-2 ===============
06 22 2020; 09:15:17AM Processing Requirement 4.5-1: Return Status : Passed

==============
Run Data
==============

INPUT

Space Structure Name = Free-flyer
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.593 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0078 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 300.000 (kg)
Final Mass = 130.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 1.3185E-05

Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==============

=============== End of Requirement 4.5-1 ===============

06 22 2020; 09:15:21AM Project Data Saved To File
06 22 2020; 09:17:42AM Requirement 4.5-2: Compliant

===
Spacecraft = Free-flyer
Critical Surface = NSTT
===

INPUT

Apogee Altitude = 550.000 (km)
Perigee Altitude = 550.000 (km)
Orbital Inclination = 97.593 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0078 (m^2/kg)
Initial Mass = 130.000 (kg)
Final Mass = 130.000 (kg)
Station Kept = No
Start Year = 2021.000 (yr)
Duration = 0.010 (yr)
Orientation = Random Tumbling
CS Areal Density = 0.500 (g/cm^2)
CS Surface Area = 0.0225 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 2.700 (g/cm^2) Separation: 1.000 (cm)

OUTPUT

Probability of Penetration = 2.2720E-05 (2.2720E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

=============== End of Requirement 4.5-2 ===============

06 22 2020; 09:17:43AM Processing Requirement 4.6 Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = Free-flyer
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.593000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.007815 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 300.000000 (kg)
Final Mass = 130.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.382331 (km)
PMD Apogee Altitude = 551.598587 (km)
PMD Inclination = 97.594101 (deg)
PMD RAAN = 3.586213 (deg)
PMD Argument of Perigee = 173.987191 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.382331 (km)
Suggested Apogee Altitude = 551.598587 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2027 (yr)
Requirement = 61
Compliance Status = Pass

==============

============== End of Requirement 4.6 ==============
06 22 2020; 09:17:50AM *********Processing Requirement 4.7-1

Return Status : Passed

***********INPUT****
Item Number = 1

name = Free-flyer
quantity = 1
parent = 0
materialID = 8
type = Cylinder
Aero Mass = 130.000000
Thermal Mass = 130.000000
Diameter/Width = 0.813000

name = F
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 130.000000
Thermal Mass = 130.000000
Diameter/Width = 0.813000
Length = 0.425000

**************OUTPUT****
Item Number = 1

name = Free-flyer
Demise Altitude = 77.999779
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = F
Demise Altitude = 0.000000
Debris Casualty Area = 1.410902
Impact Kinetic Energy = 388091.218750

****

============== End of Requirement 4.7-1 ===============
06 22 2020; 09:17:51AM Project Data Saved To File

Raw DAS Output – Mission Failure (no customers separated)

06 22 2020; 09:27:47AM Activity Log Started
06 22 2020; 09:27:47AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-3\DAS Config B pre-deploy\
06 22 2020; 09:27:58AM Processing Requirement 4.3-1: Return Status : Not Run

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-1 ===============
06 22 2020; 09:28:01AM Processing Requirement 4.3-2: Return Status : Passed

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-2 ===============
06 22 2020; 09:51:11AM Processing Requirement 4.5-1: Return Status : Passed

==============
Run Data
==============

INPUT

Space Structure Name = Free-flyer
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.593 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0041 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 300.000 (kg)
Final Mass = 300.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 4.2605E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==============

=============== End of Requirement 4.5-1 ===============

06 22 2020; 09:51:14AM Project Data Saved To File
06 22 2020; 09:53:15AM Requirement 4.5-2: Compliant

===
Spacecraft = Free-flyer
Critical Surface = NSTT
===

INPUT

Apogee Altitude = 550.000 (km)
Perigee Altitude = 550.000 (km)
Orbital Inclination = 97.593 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0041 (m^2/kg)
Initial Mass = 300.000 (kg)
Final Mass = 300.000 (kg)
Station Kept = No
Start Year = 2021.000 (yr)
Duration = 0.010 (yr)
Orientation = Random Tumbling
CS Areal Density = 0.500 (g/cm^2)
CS Surface Area = 0.0225 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 2.700 (g/cm^2) Separation: 1.000 (cm)

OUTPUT

Probability of Penetration = 2.2720E-05 (2.2720E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

=============== End of Requirement 4.5-2 ===============

06 22 2020; 09:53:16AM   Processing Requirement 4.6   Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = Free-flyer
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.593000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004142 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 300.000000 (kg)
Final Mass = 300.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.380948 (km)
PMD Apogee Altitude = 551.595711 (km)
PMD Inclination = 97.594101 (deg)
PMD RAAN = 3.586214 (deg)
PMD Argument of Perigee = 174.701379 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.380948 (km)
Suggested Apogee Altitude = 551.595711 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2035 (yr)
Requirement = 61
Compliance Status = Pass

==============

============== End of Requirement 4.6 ==============

06 22 2020; 09:53:20AM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 1

name = Free-flyer
quantity = 1
parent = 0
materialID = 8
type = Cylinder
Aero Mass = 300.000000
Thermal Mass = 300.000000
Diameter/Width = 0.813000

name = Sherpa-FX1
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 130.000000
Thermal Mass = 130.000000
Diameter/Width = 0.813000
Length = 0.425000

name = MicroSat
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 60.000000
Thermal Mass = 60.000000
Diameter/Width = 0.585000
Length = 0.885000
Height = 0.540000

name = loaded dispensers
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 27.500000
Thermal Mass = 27.500000
Diameter/Width = 0.270000
Length = 0.400000

Height = 0.270000

**************OUTPUT****
Item Number = 1

name = Free-flyer
Demise Altitude = 77.997986
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Sherpa-FX1
Demise Altitude = 49.409019
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = MicroSat
Demise Altitude = 58.804379
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = loaded dispensers
Demise Altitude = 58.739067
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

=============== End of Requirement 4.7-1 ===============
06 22 2020; 09:53:20AM Project Data Saved To File
06 22 2020; 09:53:23AM Project Data Saved To File

Raw DAS Output – Partial Mission Failure (only forward microsatellite separation successful, all other separations unsuccessful)

06 22 2020; 14:52:01PM Activity Log Started
06 22 2020; 14:52:01PM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-3\DAS Config B partial-deploy\
06 22 2020; 14:52:24PM Processing Requirement 4.3-1: Return Status : Not Run

====================

No Project Data Available
=====================

=============== End of Requirement 4.3-1 ===============
06 22 2020; 14:52:26PM Processing Requirement 4.3-2: Return Status : Passed

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-2 ===============
06 22 2020; 15:26:13PM Processing Requirement 4.5-1: Return Status : Passed

==============
Run Data
==============

INPUT

Space Structure Name = Free-flyer
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.593 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0038 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 300.000 (kg)
Final Mass = 242.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 3.3382E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==============

=============== End of Requirement 4.5-1 ===============

06 22 2020; 15:26:16PM Project Data Saved To File
06 22 2020; 15:28:41PM Requirement 4.5-2: Compliant

===
Spacecraft = Free-flyer
Critical Surface = NSTT
===

INPUT

Apogee Altitude = 550.000 (km)
Perigee Altitude = 550.000 (km)
Orbital Inclination = 97.593 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0038 (m^2/kg)
Initial Mass = 242.000 (kg)
Final Mass = 242.000 (kg)
Station Kept = No
Start Year = 2021.000 (yr)
Duration = 0.010 (yr)
Orientation = Random Tumbling
CS Areal Density = 0.500 (g/cm^2)
CS Surface Area = 0.0225 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 2.700 (g/cm^2) Separation: 1.000 (cm)

OUTPUT

Probability of Penetration = 2.2720E-05 (2.2720E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

============== End of Requirement 4.5-2 ===============

06 22 2020; 15:28:42PM Processing Requirement 4.6 Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = Free-flyer
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.593000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003777 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 300.000000 (kg)
Final Mass = 242.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.383043 (km)
PMD Apogee Altitude = 551.599790 (km)
PMD Inclination = 97.594101 (deg)
PMD RAAN = 3.586213 (deg)
PMD Argument of Perigee = 173.665977 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.383043 (km)
Suggested Apogee Altitude = 551.599790 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2036 (yr)
Requirement = 61
Compliance Status = Pass

==============

============== End of Requirement 4.6 ==============
06 22 2020; 15:29:06PM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 1

name = Free-flyer
quantity = 1

parent = 0
materialID = 8
type = Cylinder
Aero Mass = 242.000000
Thermal Mass = 242.000000
Diameter/Width = 0.813000

name = Sherpa-FX1
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 130.000000
Thermal Mass = 130.000000
Diameter/Width = 0.813000
Length = 0.425000

name = loaded dispensers
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 27.500000
Thermal Mass = 27.500000
Diameter/Width = 0.270000
Length = 0.400000
Height = 0.270000

**************OUTPUT****
Item Number = 1

name = Free-flyer
Demise Altitude = 77.998238
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Sherpa-FX1
Demise Altitude = 46.591339
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = loaded dispensers
Demise Altitude = 57.379322

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

=============== End of Requirement 4.7-1 ===============
06 22 2020; 15:29:06PM Project Data Saved To File
06 22 2020; 15:29:10PM Project Data Saved To File

END of Sherpa-FX1 Orbital Debris Assessment Report (ODAR)