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April 30, 2021

**<u>FILED ELECTRONICALLY VIA IBFS</u>**
Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street, N.E.
Washington, DC 20554

Re: Spaceflight, Inc.;
Request for Special Temporary Authority
<u>IBFS File No. SAT-STA-20210205-00017</u>

Dear Ms. Dortch:

Submitted herewith on behalf of Spaceflight, Inc. ("Spaceflight") are Spaceflight's responses to questions raised with Spaceflight regarding the above referenced application, including updated exhibits relevant thereto. The questions are formatted in italics with Spaceflight's responses below.

1. *We ask that you please file in the IBFS the current, most updated manifest for the mission, including the updated ODAR, and please indicate how the ODAR assessment takes into consideration the non-separating mass models as well. What would the re-entry casualty risk analysis be if none of the customer spacecraft were deployed (for both the FX-2 and LTE-1)?*

With this submission, Spaceflight provides an update to the manifest for both Sherpa vehicles on the mission, including an updated ODAR for the Sherpa-LTE1 vehicle. The ODAR for the Sherpa-FX2 vehicle remains the same, as there are no material changes to the configuration of the Sherpa-FX2 vehicle itself or to its separating payloads. As illustrated in the Sherpa-FX2 updated manifest, a single 3U spacecraft was swapped with another slightly less massive 3U spacecraft. At most, this would do no more than theoretically produce de minimis improved orbital lifetime results for the Failed Mission (DOA) case.

Spaceflight provides an updated ODAR for Sherpa-LTE1 since a non-separating mass model will be used in place of a customer spacecraft that was required to be remanifested to an entirely new mission. We account for this non-separating mass model in our updated DAS results for a "Nominal Mission without PMD" case for Sherpa-LTE1 at 550 km, since the mass of the non-separating mass model will remain with the Sherpa-LTE1 vehicle at the end of this mission. The mass model fully demises upon reentry and does not contribute to any increase in human casualty risk. While the inclusion of additional mass models is not anticipated at this moment, the DOA ODAR scenarios reflect worst case ODAR analyses and therefore provide an outer bound for cases that would consider additional mass models, being no worse in terms of orbit lifetime and human casualty risk than already presented.

We address cases when no customer spacecraft are deployed in the "Mission Failed" cases of the ODAR reports for both vehicles. In this case, as the Sherpa vehicle begins to demise, customer payloads will break free and should demise consistent with the ODAR assessments individual customers would have made in connection with their own separately licensed spacecraft.

Finally, we note that as indicted in the updated Sherpa-LTE1 ODAR report, the launch site for the mission will be Cape Canaveral Air Force Station, Florida. This will also, of course, apply to the Sherpa-FX2 mission as well.

2. *Please also indicate in the information for the file whether any changes to the manifest (since originally provided) would result in updates to the re-contact analysis regarding the deployment - for example, whether these or the prior changes would result in more or fewer satellites with propulsion capabilities, and how that might affect the re-contact analysis.*

With this submission, Spaceflight provides an official update to both Sherpa vehicle recontact analyses as a result of the manifest changes. Since there are a reduced number of separating objects on Sherpa-LTE1 we see improved recontact results. The number of separating objects on Sherpa-FX2 remained the same, so as expected we see largely the same recontact probability for this vehicle's separations.

3. *Has the final determination been made at this point on the installation of propulsion modules into the LTE-1?*

Currently, the propulsion system is on track for integration to Sherpa-LTE1. However, should unforeseen issues prevent it from making the mission, Spaceflight would install a mass model to simulate the mass properties of the propulsion system.

4. *What is the mass of the LTE-1 spacecraft without payloads and xenon gas propellant? For the DAS calculations with the LTE-1, it appears that Spaceflight included the propellant mass as part of the LTE-1 throughout the analysis, including at end of mission for re-entry casualty risk. Was this meant as a worst case approach? How would the DAS analysis change if the propellant is not taken into account?*

The mass of the Sherpa-LTE1 spacecraft without payloads and xenon is 200 kg. In our analyses, we account for the mass of the propellant in the 5% mass that DAS allows to be unspecified for fasteners, harnesses, etc, since DAS does not have a default material for Xenon or other noble gases. Spaceflight chose this approach after consulting with one of the developers of DAS at NASA. This approach is conservative, as not accounting for the mass of the propellant would reduce the overall mass of the Sherpa-LTE1 spacecraft and result in reduced orbital lifetime values. Additionally, while the mass of the gas would affect orbital lifetime, which has been accounted for in the analysis, the gas would not affect human casualty risk.

5. *We also noted that there is a piece of debris from the LTE-1 that may survive reentry, resulting in a casualty risk for the LTE-1 of 1:57,300. Has Spaceflight considered any insurance arrangements at this point, given the potential risk of surviving debris and associated reentry casualty risk?*

The debris identified above is the reaction wheels that comprise the command and control system manifested on Sherpa-LTE1. As with prior missions, Spaceflight does not intend to procure reentry casualty insurance.

Please direct any questions regarding this submission to the undersigned.

Sincerely,

Jonathan L. Wiener
*Attorney for Spaceflight, Inc.*

Attachments

# Sherpa-LTE1 Orbital Debris Assessment Report (ODAR)

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

**Report Version 2**
**April 22, 2021**

**Document Data is Not Restricted.**

**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**
**Analysis prepared by Eric Lund, Lead Systems Engineer**

**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-LTE1 on June 2021 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 US, and governed by the rules and regulation of the US; 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 June 2021 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: June 2021 – July 2021

**Mission Overview:**
The June 2021 SpaceX Rideshare Mission ("Transporter-2") is a commercial rideshare mission, for which the primary objective of Spaceflight Inc., is deploying around 10 customer spacecraft into a planned sun-synchronous circular orbit of 525 km ± 25 km, from a free flyer Sherpa vehicle. The launch vehicle will deploy a free flyer spacecraft called "Sherpa-LTE1", which will deploy additional customer spacecraft within several hours of liftoff 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*).

Spaceflight's Sherpa-LTE1 is an upgraded version of the Sherpa vehicle variant, similar to the previously licensed Sherpa-FX1. Upgrades include attitude control, electric propulsion, and a new forward port adapter to accommodate additional microsatellites. The Sherpa-LTE1 demonstration mission consists of two mission phases. The first (primary) mission phase is the deployment of customer spacecraft, the same as Sherpa-FX1. This phase is anticipated to last for less than six (6) hours after launch. During this phase, the Sherpa-LTE1 vehicle deploys customer spacecraft in the same way as the previously licensed Sherpa-FX1. What is materially different about the Sherpa-LTE mission is that, instead of being finished at the conclusion of its deployments and naturally deorbiting over time, a secondary mission phase no longer than 6 months, to reduce the altitude of the spacecraft begins, before reaching the final 350 km altitude. During this time, two new modular systems will be enabled and tested. The first is an onboard computer with sensors and effectors to provide command and control over the Sherpa vehicle. This system will make use of traditional, flight-proven, small satellite control systems (reaction wheels, star trackers, magnetic torque rods, etc.) to detumble and stabilize the Sherpa vehicle in a known attitude, then pointing the vehicle to sun-normal for solar panel charging. Also, during this time, the second modular system, an electric propulsion deck from Apollo Fusion, will be commissioned to be used to lower the Sherpa vehicle altitude from 525 km to approximately 350 km. Orbit lowering will be accomplished through a series of ~20-minute retrograde impulsive maneuvers. This set of maneuvers will demonstrate rapid deorbit of the Sherpa system, while providing key performance data for the Apollo Fusion propulsion system. From that altitude, Spaceflight will decommission Sherpa for reentry by atmospheric drag, which at this lower altitude, will take a matter of months.

**ODAR Configuration:**
The ODAR analyses contained in this report was run at the target 525 km altitude and the upper range of the of the mission altitude range of 550 km. ODAR was run for two potential scenarios, at each altitude to provide a comprehensive analysis of various mission success results. Through both of the scenarios described below, at both altitudes, we demonstrate compliance with FCC requirements without the use of a deorbit device.
What
The terms *Nominal Mission*, *Nominal Mission without PMD*, and *Failed Mission* are defined as follows:

- *Nominal Mission*: All customer deployments successful for Sherpa-LTE1. Sherpa-LTE1 attitude control and electric propulsion demonstration to perform a post mission disposal maneuver to the lower 350 km altitude is also successful.
- *Nominal Mission without PMD:* All customer deployments successful for Sherpa-LTE1. Sherpa-LTE1 attitude control and electric propulsion demonstration to perform a post mission disposal maneuver to the lower 350 km altitude is not successful, and thus Sherpa-LTE1 altitude decays naturally from the 525 km (or 550 km) altitude.
- *Failed Mission*[1]*:* All spacecraft deployments are unsuccessful, along with Sherpa-LTE1's attitude control and electric propulsion demonstration, and thus Sherpa-LTE1 altitude decays naturally from the 525 km (or 550 km) altitude. In an entirely separate case, where spacecraft deployments are unsuccessful, but the secondary mission of altitude reduction is still viable, orbit lifetime would only be improved compared to this *Failed Mission* case where both primary and secondary mission are unsuccessful. Thus, the *Failed Mission* case presented here is the worst-case scenario.

[1] Previously for Sherpa-FX1, Spaceflight presented a Partial Mission Failure case, wherein the deployment sequence was interrupted by an anomaly, resulting in only some of the customers being deployed. Through many successful mission sequence tests and a successful Sherpa-FX1 mission, Spaceflight feels a mid-sequence anomaly would be an exceptionally rare case. Spaceflight feels the most probable off-nominal case would be that the device succumbs to the launch environment before deployments are initiated, hence we only present that case here.

**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 decay lifetime due to atmospheric drag is under 25 years, through the possible range altitudes and mission cases presented herein, as predicted by DAS 3.1.0.

| | **525 km** | **550 km** |
|---|---|---|
| **Sherpa-LTE1 Nominal Mission** | 1.2 year | 1.2 year |
| **Sherpa-LTE1 Nominal Mission without PMD** | 13 years | 14.5 years |
| **Sherpa-LTE1 Failed Mission** | 15.3 years | 19.15 |

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

**Proposed launch date:** June 2021 – July 2021

**Mission duration:**

Maximum Sherpa-LTE1 Nominal Operations:

- <6 months.

Post-Mission Orbit lifetime:

- For a Nominal Mission at 525 ± 25 km, Sherpa-LTE1 has a predicted post-mission orbit lifetime < 1 year.

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

**Sherpa-LTE1**

| | **Apogee Altitude** | **Perigee Altitude** | **Inclination** | **Mission Duration** |
|---|---|---|---|---|
| **Mission** | 525 ± 25 km | 525 ± 25 km | 97.384 ± 0.1 deg | <6 months |
| **End-of-Life Orbit** | 350 km | 350 km | 97.384 ± 0.1 deg | <1 year |

## ODAR Section 2: Spacecraft Description

**Physical description of the spacecraft:**

Sherpa-LTE1 base structure or CAB is identical to the previously licensed Sherpa-FX1[2]. It also contains an identical R2A-core separation sequencer, which will provide separation signals to the various separation systems. Sherpa-LTE1 will have an adapter on the forward port which will accommodate two microsatellites. Radially, Sherpa-LTE1 will have the attitude determination and control system, four 12U dispensers, and a 6U dispenser affixed radially on the body of Sherpa-LTE1. The internal volume of Sherpa-LTE1 will contain its R2A-Core sequencer and batteries, in addition to the electronic propulsion subsystem. Like Sherpa-FX1, Sherpa-LTE1 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-LTE1 is attached. Once a separation signal is received by Sherpa-LTE1's separation system from Falcon 9 avionics, Sherpa-LTE1 will separate.

In a case where any combination of spacecraft are unable to make the mission, a non-separating mass dummy will be either inserted into a locked dispenser door or affixed directly to the Sherpa-LTE1 structure, depending on the missing spacecraft's form factor. In the case where either the components to perform the PMD are unable to be integrated onto Sherpa for launch, Spaceflight would either affix mass models in place of these components or simply revert to another Sherpa-FX variant, like Sherpa-FX1, which simply removes the PMD components. These mass dummies would be materially and physically the same as those evaluated in Spaceflight's Sherpa-FX1 submission. In that STA, examples for a microsat mass model, entire 12U and 6U dispenser mass models, or a single CubeSat mass model within a flight dispenser were all shown to fully demise and not contribute to any human casualty risk. Some customers are responsible for providing their own mass model. If a case arises that a customer mass model will need to be integrated for flight, Spaceflight will re-run DAS analysis incorporating that specific mass model and its corresponding material properties to ensure demise and no worse risk of casualty than what is presented here, before integration onto the Sherpa-LTE1 structure. In fact, in all cases where final mission configuration changes compared to the configuration presented here, DAS analysis will be rerun for the final configuration in order to verify results equal to or better than those presented here.

As of April 2021, there will be at least one 3U, non-separating mass model. This mass model is the same type as what was analyzed in previous licensing submissions, and has been analyzed to ensure it does not contribute to any additional human casualty risk. The additional mass that remains with Sherpa-LTE1 after its payload deployments, as a result of including this non-separating mass model, does not materially affect the orbit lifetime of the Sherpa-LTE1 vehicle since it comprises a small percentage of the total mass of the Sherpa-LTE1 vehicle.

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

| | |
|---|---|
| Sherpa-LTE1 without separating customer spacecraft | 203 kg |
| Sherpa-LTE1 with separating customer spacecraft | 335 kg |

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

[2] SAT-STA-20200728-00089 Spaceflight, Inc. Sherpa-FX1 STA

**and uncertainties:**

| | |
|---|---|
| Sherpa-LTE1 without separating customer spacecraft | 200 kg |
| Sherpa-LTE1 with separating customer spacecraft | 332 kg |

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

| | |
|---|---|
| Sherpa-LTE1 without separating customer spacecraft | 200 kg |

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

Sherpa-LTE1 has an electric propulsion system provided by Apollo Fusion, using xenon gas as fuel.

**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:** Up to 5 kg of Xenon at 2,700 psi in a DOT approved propellant tank, to be fueled at Spaceflight's Integration Facility.

**Fluids in Pressurized Batteries:** None.

**Power System #1:** Sherpa-LTE1 uses two of the same NiMH battery packs previously used on the Sherpa-FX1 mission.

**Power System #2:** New batteries contained in the attitude and control system, called Command and Control System (CCS), are four unpressurized COTS Lithium-ion battery cells.

**Power System #3:** The spacecraft also includes a high voltage electrical system which consists of two batteries made up of nine cells each in series.

**Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector:**
Fifteen minutes after activation, the reaction wheels will be used to detumble the spacecraft from any initial deployment rates and the spacecraft will enter a sun pointing safe mode with the star tracker pointed anti-nadir.

- A *sun pointing safe mode* that is optimized for solar power generation from the satellite. The spacecraft's large fixed panels will be oriented towards the sun and the star tracker will be clocked anti-nadir. This mode will make use of magnetometers, sun sensors, gyroscope, reaction wheels, and magnetic torquers to orient the spacecraft correctly.
- A *sun pointing link mode* that is optimized for solar power generation and allows the satellite to maintain an intersatellite link with the +Z OISL. The spacecraft's large fixed panels will be oriented towards the sun and the star tracker will be clocked to point along the velocity vector. This mode will make use of magnetometers, sun sensors, gyroscope, reaction wheels, and magnetic torquers to orient the spacecraft correctly.
- A *velocity tracking mode,* which will be used to point the thrust head face along the velocity or anti-velocity vector to allow for phasing maneuvers between the two spacecraft. This mode will also be used to lower the spacecraft's orbit at End-Of-Life. This mode will make use of the reaction wheels and a star tracker to orient the spacecraft.

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

**Description of the electrical generation and storage system:**

**Power System #1:** Standard COTS lithium iron disulfide and nickel-metal hydride battery cells are charged prior to payload integration and provide electrical energy during the primary phase of the mission to separate customer spacecraft. Total energy capacity is ~228 W·hr and the maximum voltage is 36 VDC. These batteries have no ability to recharge once Sherpa is in orbit. The electrical load on this circuit has a low-voltage cut-off at ~23 VDC, below which the batteries have <1% energy capacity remaining. These batteries are at the very center of the structure. In the event of an unlikely battery explosion, the structure would contain any fragments or debris.

**Power System #2:** For the secondary mission, standard COTS Lithium-Ion battery cells are charged before payload integration and provide electrical energy during eclipse and during high power consumption modes. All power required for the operation of the bus electronics (CCS) is supplied through an “all-parallel” battery arrangement that results in increased safety thanks to natural voltage balancing between cells. The capacity of this battery is 68 W-hrs. Sherpa-LTE1 includes 4 “backup” solar panels on non-typically-sun-pointing faces to provide power in the case of a safe mode tumble.

**Power System #3:** The main solar panels are equipped with 12 strings of 16 cells in series (192 cells total). The all-parallel bus battery is charged through these solar panels and also through a higher voltage “payload battery” that consists of 2 batteries with 9 battery cells in series each. This results in a robust architecture where the bus electronics are effectively always being charged as if in sunlight, even in eclipse or intensive operations modes. The capacity of the payload battery is 252 W-hrs.

Typical bus operations consume 12 watts of power on average. The thruster can consume up to 400 Watts during operation. The charge/discharge cycle is managed by a power management system overseen by the Flight Computer and Electrical Power Subsystem, which is part of the CCS.

**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:**

Twenty-eight (22) Lithium-Ion Battery Cells. Solar array charging will be disabled, which will fully discharge all cells within two days.

**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 3:* 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 4:* 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 5:* 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 6:* 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 7:* 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-LTE1's primary mission batteries are designed such that when mission operations begin, all energy from the primary and secondary batteries will dissipate within 24 hours. Additionally, Sherpa-LTE1 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.

The CCS have the ability to fully disconnect the Lithium-Ion cells from the charging current of the solar arrays. At End-Of-Life, this feature will be used to completely passivate the batteries by removing all energy from them. 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, the debris from the battery rupture should be contained within the spacecraft due to the lack of penetration energy to the multiple enclosures surrounding the batteries.

***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:***

Assess probability of collision with intact space systems or large debris (>10cm)

**Large Object Impact and Debris Generation Probability:**

| Spacecraft | Nominal Mission | Nominal Mission w/o PMD | Failed Mission | Status |
|---|---|---|---|---|
| Sherpa-LTE1 | 0.00000372 | 0.0000470 | 0.00004087 | COMPLIANT |

***Requirement 4.5-2:*** Assess and limit the probability of damage to critical components as a result of impact with small debris

**Probability of Damage from Small Debris:**

While there are subsystems onboard that provide the ability to perform a post mission disposal maneuver, the Sherpa-LTE1 is compliant with all orbit lifetime requirements without the use of a postmission disposal maneuver. On this mission, postmission disposal maneuvering will be employed as a technology demonstration and is considered as a secondary mission to the primary mission of separating customer spacecraft in orbit. If the secondary mission of demonstrating postmission disposal maneuvering to a lower disposal orbit is successful for Sherpa-LTE1, future missions may include maneuvering to an orbit where post mission disposal is required and this requirement will be evaluated in that case. We demonstrate in this report that the *Nominal Mission without PMD* and *Failed Mission* cases are still compliant with orbit lifetime requirements. The *Nominal Mission without PMD* and *Failed Mission* cases show that, akin to an MMOD strike that incapacitates the attitude control or electric propulsion system, Sherpa-LTE1 is still compliant with orbit lifetime requirements in the case that that attitude control or electric propulsion system fails.

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

Sherpa-LTE1 will conduct controlled deorbit by means of enabling and testing new attitude control and electric propulsion systems. The controlled deorbit phase will last no longer than six months. During this time, two new modular systems will be enabled and tested. The first is an onboard computer with sensors and effectors to provide command and control over the Sherpa vehicle. This system will make use of traditional, flight-proven, small satellite control systems (reaction wheels, star trackers, magnetic torque rods, etc.) to detumble and stabilize the Sherpa vehicle in a known attitude, then pointing the vehicle to sun-normal for solar panel charging. Also, during this time, the second modular system, an electric propulsion deck from Apollo Fusion, will be commissioned to be used to lower the Sherpa vehicle altitude from the initial altitude to approximately 350 km. Orbit lowering will be accomplished through a series of ~20-minute retrograde impulsive maneuvers. This set of maneuvers will demonstrate rapid deorbit of the Sherpa system, while providing key performance data for the Apollo Fusion propulsion system. From that altitude, Spaceflight will decommission Sherpa for reentry, which at this lower altitude, will take a matter of months.

In the case where the commissioning of the attitude control or propulsion devices is unsuccessful, Sherpa-LTE1 will still abide by orbit lifetime requirements by deorbiting naturally via atmospheric drag.

**Recontact Analysis.** Although beyond the scope of a standard orbital debris analysis, Spaceflight has conducted extensive testing and modeling 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-LTE1 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-LTE1 will deorbit to a 350 km disposal altitude via an electric propulsion system, and finally naturally decay via atmospheric drag.

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

Sherpa-LTE1 orbit lowering will be accomplished through a series of ~20-minute retrograde impulsive maneuvers. These maneuvers are not required to maintain compliance with ODAR requirements (see Figure 2) but are an attempt to significantly diminish the post-mission orbit lifetime of Sherpa-LTE1.

Spaceflight understands that during the secondary mission, Sherpa-LTE1 will traverse through the ISS operational orbit. Spaceflight is in the process of coordinating with NASA and other intergovernmental agencies to safely plan the Sherpa-LTE1 transit through the ISS orbit.

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

**Spacecraft Mass:**

| | Nominal Mission | Nominal Mission w/o PMD | Failed Mission |
|---|---|---|---|
| Sherpa-LTE1 | 200 kg | 203 kg | 335 kg |

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

| | Nominal Mission | Nominal Mission w/o PMD | Failed Mission |
|---|---|---|---|
| Sherpa-LTE1 | 1.2400 $m^2$ | 1.2586 $m^2$ | 1.2325 $m^2$ |

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

| | Nominal Mission | Nominal Mission w/o PMD | Failed Mission |
|---|---|---|---|
| Sherpa-LTE1 | 0.0062 $m^2$/kg | 0.0062 $m^2$/kg | 0.003679 $m^2$/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.*

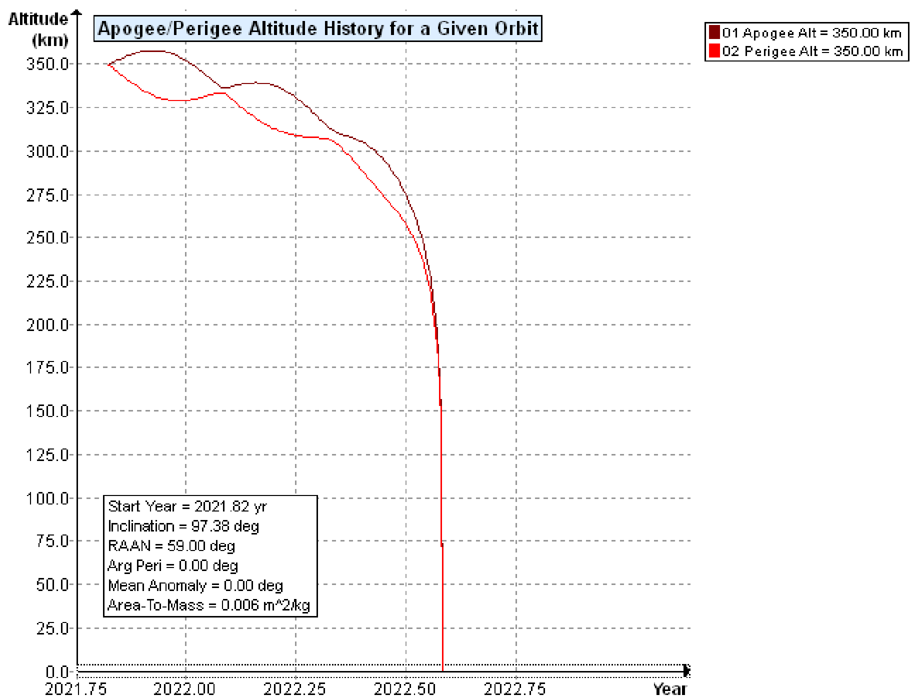


**Figure 1 - Sherpa-LTE1 orbit history (Nominal Mission at 550 km) once it has reached its final disposal altitude (350 km). Due to the limitations of DAS the initial primary mission (<1 day at 550 km), and the deorbit maneuvering (<6 months, from 550 km – 350 km) could not be depicted. That portion of the mission would be appended to the beginning of this graph.**

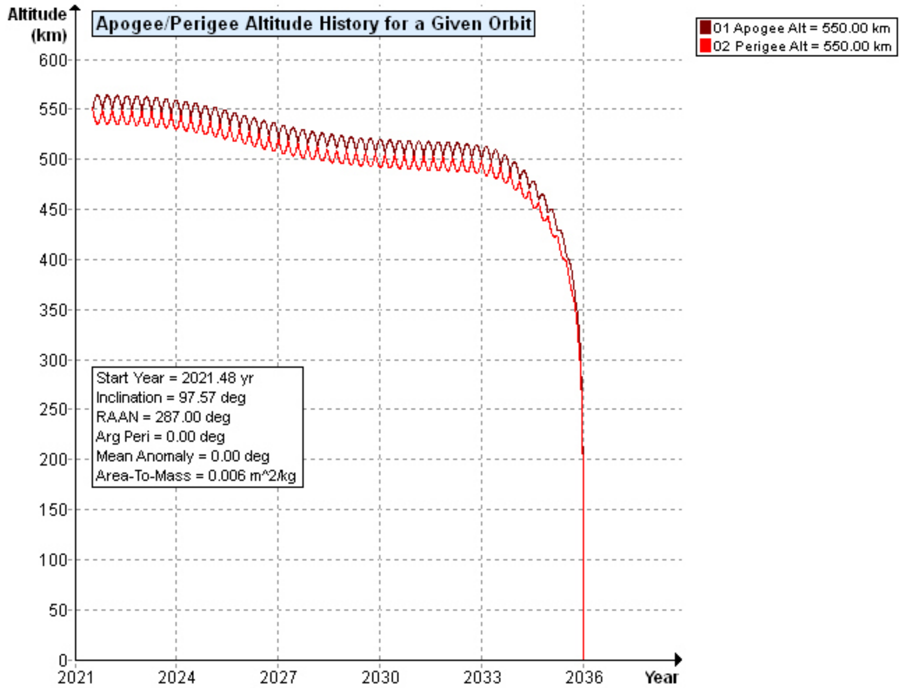


**Figure 2 - Sherpa-LTE1 orbit history (Nominal Mission without PMD at 550 km). In this case the propulsion and/or attitude control system could not be commissioned and Sherpa-LTE1 altitude would decay naturally over time.**

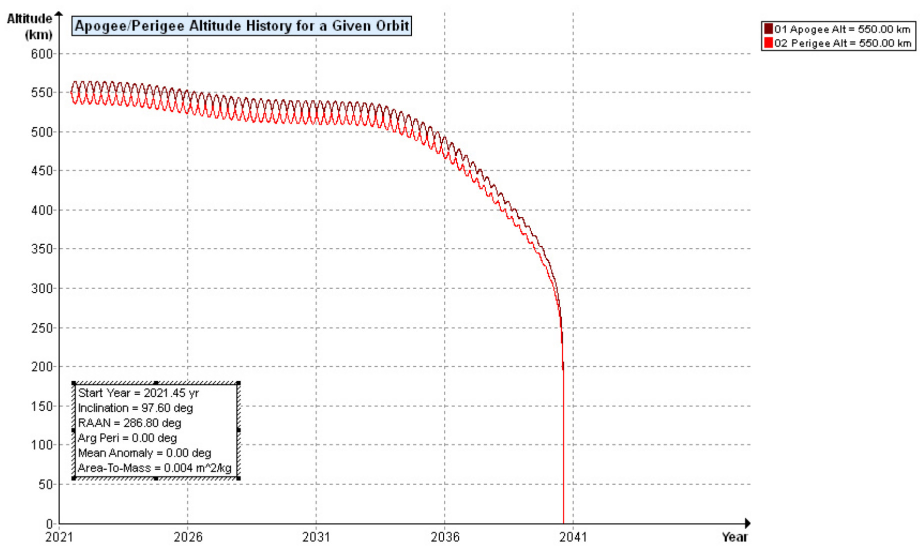


**Figure 3 - Sherpa-LTE1 orbit history (Failed Mission at 550 km). In this case the propulsion and/or attitude control system could not be commissioned, no customer deployments were successful, and Sherpa-LTE1 altitude would decay naturally over time.**

**Analysis:** Sherpa-LTE1 reentry is COMPLIANT using method “a”.

| **Satellite Name** | **Sherpa-LTE1** | **Sherpa-LTE1** |
|---|---|---|
| **BOL Orbit (Drop off)** | 525 x 525 km | 550 x 550 km |
| **Operational Orbit** | 525 x 525 km | 550 x 550 km |
| **EOM Orbit** | 350 x 350 km | 350 x 350 km |
| **Total Lifetime for Nominal Mission** | 1.2 years | 1.2 year |
| **Total Lifetime if Nominal Mission without PMD (EOM Orbit remains at Operational Orbit)** | 13 years | 14.5 years |
| **Total Lifetime if Total Mission Failure** | 15.3 years | 19.15 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:** Spaceflight’s plan is to drastically reduce post-mission orbit lifetime by reducing Sherpa-LTE1 altitude with electric propulsion. The ADCS on Sherpa-LTE1 is a flight proven system operating with a highly flexible flight software package. In addition, the electric propulsion system has accumulated many thousands of seconds of integrated test time, in vacuum. In order to perform the disposal acceleration burn, the spacecraft requires the proper functioning of its attitude determination and control subsystem (ADCS) as well as its Apollo Fusion propulsion system in order to successfully execute the planned deorbit maneuver. Accordingly, redundancy and reliability have been carefully considered in these disposal-critical areas.

Functional redundancy is provided in the attitude determination subsystem. The spacecraft uses a blend of the high-accuracy gyro, sun sensors, and magnetometers as a secondary method.

Attitude control is accomplished with the reaction wheels. Three wheels, one oriented along each axis, are used for precision pointing. The magnetic torquers provide momentum desaturation for the reaction wheels. The spacecraft requires the ability to fire magnetic torquers along a minimum of two independent axes to maintain attitude control. A total of six torque coils are included in the spacecraft in two groups with different reliability chains to prevent a systematic failure. In the unlikely case of a reaction wheel failure, the magnetic torquers can be used for primary attitude control to continue the deorbit maneuver. Once Sherpa-LTE1 arrives at 350 km, its EOM orbit, it 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 and successful orbit reduction); (ii) were there to be an off-nominal case, the most likely failure scenario, a Mission Failure where no spacecraft are deployed and the electric propulsion system is not commissioned; and (iii) a Nominal Mission without PMD, in which customers are successfully deployed, but the secondary mission to commission attitude control and electric propulsion systems is unsuccessful, and thus naturally decays from its 525 km or 550 km altitude via atmospheric drag. In each case DAS returns a total on-orbit lifetime of 25 years or less. In an entirely separate case, where spacecraft deployments are unsuccessful, but the secondary mission of altitude reduction is still viable, orbit lifetime would only be improved compared to this Failed Mission case where both primary and secondary mission are unsuccessful. Thus, the Failed Mission case presented here is the worst-case scenario. Since this scenario is bounded by the others, it is not discussed further.

As with SSO-A and Sherpa-FX1, Spaceflight has a team of highly qualified engineers, and a well-established process for rideshare missions such as this. Spaceflight finds that an avionics failure in the middle of the separation sequence is highly unlikely and has previously demonstrated flight heritage on the Sherpa-FX1 mission. If the primary avionics systems were to fail, it will most likely succumb to the launch environment, which occurs prior to any deployments from Sherpa-LTE1. Furthermore, in case the secondary mission to reduce the Sherpa-LTE1 orbit to 350 km is unsuccessful ("Nominal Mission without PMD"), we demonstrate requirement compliance via atmospheric drag. Finally, Spaceflight believes a successful mission, "Nominal Mission" case, is most probable. The analysis contained above shows compliance with FCC regulation and guidelines.

## 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-LTE1 has a 1:57,300 risk of human casualty and thus that spacecraft meets the requirement.
- The sole surviving component is the Reaction Wheel Assembly (RWA) rotors, of which there are three. The RWA rotors are comprised of stainless steel 410. An extract from the DAS results showing the single surviving object:
  - <u>Input</u>
    name = RWA rotor
    quantity = 3
    parent = 1
    materialID = 62
    type = Box
    Aero Mass = 0.400000
    Thermal Mass = 0.400000

Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

- Output
  name = RWA rotor
  Demise Altitude = 0.000000
  Debris Casualty Area = 1.502729
  Impact Kinetic Energy = 128.077042

Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because the Sherpa-LTE1 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 – Nominal Mission at 525 km (all customers separated; Sherpa-LTE orbit lowered to 350 km)**

01 20 2021; 12:59:11PM Activity Log Started
01 20 2021; 12:59:11PM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA post-deploy\
01 20 2021; 12:59:23PM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ==============
01 20 2021; 12:59:25PM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ==============
01 20 2021; 13:21:21PM Processing Requirement 4.5-1: Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.384 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0059 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 415.000 (kg)
Final Mass = 203.000 (kg)
Duration = 0.500 (yr)
Station-Kept = False
PMD Perigee Altitude = 350.000 (km)
PMD Apogee Altitude = 350.000 (km)
PMD Inclination = 97.370 (deg)
PMD RAAN = 0.000 (deg)
PMD Argument of Perigee = 0.000 (deg)
PMD Mean Anomaly = 0.000 (deg)

**OUTPUT**

Collision Probability = 3.7246E-06
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

01 20 2021; 13:21:23PM Processing Requirement 4.6 Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.384300 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005906 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = False
PMD Perigee Altitude = 350.000000 (km)
PMD Apogee Altitude = 350.000000 (km)
PMD Inclination = 97.370000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 350.000000 (km)
Suggested Apogee Altitude = 350.000000 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2022 (yr)
Requirement = 61
Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
01 20 2021; 13:21:34PM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 2

name = Sherpa-LTE1
quantity = 1
parent = 0
materialID = 5

type = Cylinder
Aero Mass = 203.000000
Thermal Mass = 203.000000
Diameter/Width = 0.813000

name = LT upper 24-in separation sytem
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.610000
Length = 0.610000
Height = 0.031000

name = 24inch Jchannel spacer ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.260000
Thermal Mass = 5.260000
Diameter/Width = 0.666750
Length = 0.666750
Height = 0.082550

name = solar panel wing
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

name = LT Hex Plate
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 12.000000
Thermal Mass = 12.000000
Diameter/Width = 0.822000
Length = 0.822000
Height = 0.070000

name = LT Interior Wall
quantity = 6
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.162000
Thermal Mass = 1.162000
Diameter/Width = 0.118000

Length = 0.318000

name = LT Corner Brace
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.040000
Thermal Mass = 2.040000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT DuoPack adapter plate
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000
Diameter/Width = 0.311000
Length = 0.350000

name = LT QuadPack adapter plate
quantity = 4
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

name = LT avionics deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = LT R2A-Core
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.200000
Thermal Mass = 3.200000
Diameter/Width = 0.285000
Length = 0.285000
Height = 0.090000

name = LT battery module
quantity = 2

parent = 1
materialID = 5
type = Box
Aero Mass = 2.650000
Thermal Mass = 2.650000
Diameter/Width = 0.100000
Length = 0.139000
Height = 0.100000

name = LT EyeStar Black Box
quantity = 6
parent = 1
materialID = 5
type = Box
Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000
Length = 0.089000
Height = 0.047000

name = LT empty DuoPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 4.550000
Thermal Mass = 4.550000
Diameter/Width = 0.250000
Length = 0.405000
Height = 0.145000

name = empty 2-way PSL12U
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 7.720000
Thermal Mass = 7.720000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = empty 1-way PSL12U
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 6.760000
Thermal Mass = 6.760000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = LT lower 8-in separation system
quantity = 4
parent = 1
materialID = 5

type = Box
Aero Mass = 1.190681
Thermal Mass = 1.190681
Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

name = RPG base ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.080000
Thermal Mass = 5.080000
Diameter/Width = 0.625500
Length = 0.628650
Height = 0.038100

name = RPG leg
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 0.630000
Thermal Mass = 0.630000
Diameter/Width = 0.050800
Length = 0.196000
Height = 0.050800

name = RPG triangle plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.470000
Thermal Mass = 4.470000
Diameter/Width = 0.346280
Length = 0.399740
Height = 0.076200

name = RPG plinth
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.220000
Length = 0.220000

name = RPG MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.430000
Thermal Mass = 2.430000

Diameter/Width = 0.255115
Length = 0.322040
Height = 0.057150

name = torque rod
quantity = 3
parent = 1
materialID = 38
type = Cylinder
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.020000
Length = 0.300000

name = AD avionics
quantity = 5
parent = 1
materialID = 8
type = Box
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.120000
Length = 0.150000
Height = 0.100000

name = RWA enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.570000
Thermal Mass = 0.570000
Diameter/Width = 0.140000
Length = 0.150000
Height = 0.042000

name = RWA rotor
quantity = 3
parent = 1
materialID = 62
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

name = propulsion deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = Apollo Fusion tank
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.115000
Length = 0.425000

name = Apollo Fusion feed system
quantity = 16
parent = 1
materialID = 58
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

name = Apollo Fusion thruster
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 0.850000
Thermal Mass = 0.850000
Diameter/Width = 0.090000
Length = 0.090000

name = camera bracket
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.620000
Thermal Mass = 0.620000
Diameter/Width = 0.146000
Length = 0.177800

name = IMPERX camera
quantity = 2
parent = 1
materialID = 5
type = Box

Aero Mass = 0.115000
Thermal Mass = 0.115000
Diameter/Width = 0.037000
Length = 0.072000
Height = 0.037000

name = camera lens assembly
quantity = 2
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.134000
Thermal Mass = 0.134000
Diameter/Width = 0.034000
Length = 0.047000

**************OUTPUT****
Item Number = 2

name = Sherpa-LTE1
Demise Altitude = 77.999336
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT upper 24-in separation sytem
Demise Altitude = 75.898750
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 24inch Jchannel spacer ring
Demise Altitude = 72.898727
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = solar panel wing
Demise Altitude = 75.442299
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Hex Plate
Demise Altitude = 64.883186
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Interior Wall
Demise Altitude = 73.480865
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Corner Brace
Demise Altitude = 73.309532

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT DuoPack adapter plate
Demise Altitude = 73.720757
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT QuadPack adapter plate
Demise Altitude = 73.612000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT avionics deck plate
Demise Altitude = 72.615952
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT R2A-Core
Demise Altitude = 71.241478
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT battery module
Demise Altitude = 68.315735
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT EyeStar Black Box
Demise Altitude = 75.187706
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT empty DuoPack
Demise Altitude = 72.385681
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = empty 2-way PSL12U
Demise Altitude = 71.589348
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = empty 1-way PSL12U
Demise Altitude = 72.372330
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT lower 8-in separation system
Demise Altitude = 70.274437
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG base ring
Demise Altitude = 72.273560
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG leg
Demise Altitude = 74.991920
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG triangle plate
Demise Altitude = 71.535995
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG plinth
Demise Altitude = 73.804039
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG MLB adapter plate
Demise Altitude = 73.262718
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = torque rod
Demise Altitude = 69.685234
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = AD avionics
Demise Altitude = 68.472267
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RWA enclosure
Demise Altitude = 75.014076
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RWA rotor
Demise Altitude = 0.000000

Debris Casualty Area = 1.502729
Impact Kinetic Energy = 128.081192

************************************
name = propulsion deck plate
Demise Altitude = 72.615952
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion tank
Demise Altitude = 74.795181
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion feed system
Demise Altitude = 69.440941
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion PPU
Demise Altitude = 71.224663
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion thruster
Demise Altitude = 67.657211
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = camera bracket
Demise Altitude = 74.523315
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = IMPERX camera
Demise Altitude = 76.296890
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = camera lens assembly
Demise Altitude = 71.778572
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************

============== End of Requirement 4.7-1 ==============
01 20 2021; 13:21:34PM Project Data Saved To File
01 20 2021; 13:21:38PM Project Data Saved To File

**Raw DAS Output – Nominal Mission without PMD at 525 km (all customers separated; propulsion system failed)**

01 29 2021; 06:48:56AM Activity Log Started
01 29 2021; 06:48:56AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA post-deploy no PMD\
01 29 2021; 06:49:05AM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ==============
01 29 2021; 06:49:07AM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ==============
01 29 2021; 07:29:52AM Processing Requirement 4.5-1: Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.384 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0059 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 415.000 (kg)
Final Mass = 203.000 (kg)
Duration = 0.500 (yr)
Station-Kept = False
Abandoned = True

**OUTPUT**

Collision Probability = 2.9740E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

01 29 2021; 07:30:01AM Processing Requirement 4.6 Return Status : Passed

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

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.384300 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005906 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 514.307061 (km)
PMD Apogee Altitude = 535.313313 (km)
PMD Inclination = 97.393722 (deg)
PMD RAAN = 176.804366 (deg)
PMD Argument of Perigee = 41.146773 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 514.307061 (km)
Suggested Apogee Altitude = 535.313313 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2034 (yr)
Requirement = 61
Compliance Status = Pass

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

============== End of Requirement 4.6 ==============
01 29 2021; 07:31:25AM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 2

name = Sherpa-LTE1
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 203.000000
Thermal Mass = 203.000000
Diameter/Width = 0.813000

name = LT upper 24-in separation sytem
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.610000
Length = 0.610000
Height = 0.031000

name = 24inch Jchannel spacer ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.260000
Thermal Mass = 5.260000
Diameter/Width = 0.666750
Length = 0.666750
Height = 0.082550

name = solar panel wing
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

name = LT Hex Plate
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 12.000000
Thermal Mass = 12.000000
Diameter/Width = 0.822000
Length = 0.822000
Height = 0.070000

name = LT Interior Wall
quantity = 6
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.162000
Thermal Mass = 1.162000
Diameter/Width = 0.118000
Length = 0.318000

name = LT Corner Brace
quantity = 6
parent = 1

materialID = 8
type = Box
Aero Mass = 2.040000
Thermal Mass = 2.040000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT DuoPack adapter plate
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000
Diameter/Width = 0.311000
Length = 0.350000

name = LT QuadPack adapter plate
quantity = 4
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

name = LT avionics deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = LT R2A-Core
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.200000
Thermal Mass = 3.200000
Diameter/Width = 0.285000
Length = 0.285000
Height = 0.090000

name = LT battery module
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 2.650000
Thermal Mass = 2.650000

Diameter/Width = 0.100000
Length = 0.139000
Height = 0.100000

name = LT EyeStar Black Box
quantity = 6
parent = 1
materialID = 5
type = Box
Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000
Length = 0.089000
Height = 0.047000

name = LT empty DuoPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 4.550000
Thermal Mass = 4.550000
Diameter/Width = 0.250000
Length = 0.405000
Height = 0.145000

name = empty 2-way PSL12U
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 7.720000
Thermal Mass = 7.720000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = empty 1-way PSL12U
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 6.760000
Thermal Mass = 6.760000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = LT lower 8-in separation system
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 1.190681
Thermal Mass = 1.190681
Diameter/Width = 0.117508
Length = 0.117508

Height = 0.045466

name = RPG base ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.080000
Thermal Mass = 5.080000
Diameter/Width = 0.625500
Length = 0.628650
Height = 0.038100

name = RPG leg
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 0.630000
Thermal Mass = 0.630000
Diameter/Width = 0.050800
Length = 0.196000
Height = 0.050800

name = RPG triangle plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.470000
Thermal Mass = 4.470000
Diameter/Width = 0.346280
Length = 0.399740
Height = 0.076200

name = RPG plinth
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.220000
Length = 0.220000

name = RPG MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.430000
Thermal Mass = 2.430000
Diameter/Width = 0.255115
Length = 0.322040
Height = 0.057150

name = torque rod

quantity = 3
parent = 1
materialID = 38
type = Cylinder
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.020000
Length = 0.300000

name = AD avionics
quantity = 5
parent = 1
materialID = 8
type = Box
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.120000
Length = 0.150000
Height = 0.100000

name = RWA enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.570000
Thermal Mass = 0.570000
Diameter/Width = 0.140000
Length = 0.150000
Height = 0.042000

name = RWA rotor
quantity = 3
parent = 1
materialID = 62
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

name = propulsion deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = Apollo Fusion tank
quantity = 1
parent = 1
materialID = 8

type = Cylinder
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.115000
Length = 0.425000

name = Apollo Fusion feed system
quantity = 16
parent = 1
materialID = 58
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

name = Apollo Fusion thruster
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 0.850000
Thermal Mass = 0.850000
Diameter/Width = 0.090000
Length = 0.090000

name = camera bracket
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.620000
Thermal Mass = 0.620000
Diameter/Width = 0.146000
Length = 0.177800

name = IMPERX camera
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.115000
Thermal Mass = 0.115000
Diameter/Width = 0.037000
Length = 0.072000
Height = 0.037000

name = camera lens assembly
quantity = 2
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.134000
Thermal Mass = 0.134000
Diameter/Width = 0.034000
Length = 0.047000

**************OUTPUT****
Item Number = 2

name = Sherpa-LTE1
Demise Altitude = 77.999336
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT upper 24-in separation sytem
Demise Altitude = 75.898750
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 24inch Jchannel spacer ring
Demise Altitude = 72.898727
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = solar panel wing
Demise Altitude = 75.442299
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Hex Plate
Demise Altitude = 64.883186
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Interior Wall
Demise Altitude = 73.480865
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Corner Brace
Demise Altitude = 73.309532
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT DuoPack adapter plate

Demise Altitude = 73.720757
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT QuadPack adapter plate
Demise Altitude = 73.612000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT avionics deck plate
Demise Altitude = 72.615952
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT R2A-Core
Demise Altitude = 71.241478
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT battery module
Demise Altitude = 68.315735
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT EyeStar Black Box
Demise Altitude = 75.187706
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT empty DuoPack
Demise Altitude = 72.385681
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = empty 2-way PSL12U
Demise Altitude = 71.589348
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = empty 1-way PSL12U
Demise Altitude = 72.372330
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT lower 8-in separation system
Demise Altitude = 70.274437
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG base ring
Demise Altitude = 72.273560
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG leg
Demise Altitude = 74.991920
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG triangle plate
Demise Altitude = 71.535995
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG plinth
Demise Altitude = 73.804039
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG MLB adapter plate
Demise Altitude = 73.262718
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = torque rod
Demise Altitude = 69.685234
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = AD avionics
Demise Altitude = 68.472267
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA enclosure
Demise Altitude = 75.014076
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA rotor
Demise Altitude = 0.000000
Debris Casualty Area = 1.502729
Impact Kinetic Energy = 128.081192

************************************
name = propulsion deck plate

Demise Altitude = 72.615952
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion tank
Demise Altitude = 74.795181
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion feed system
Demise Altitude = 69.440941
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion PPU
Demise Altitude = 71.224663
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion thruster
Demise Altitude = 67.657211
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = camera bracket
Demise Altitude = 74.523315
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = IMPERX camera
Demise Altitude = 76.296890
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = camera lens assembly
Demise Altitude = 71.778572
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************

=============== End of Requirement 4.7-1 ===============
01 29 2021; 07:31:25AM Project Data Saved To File
01 29 2021; 07:31:29AM Project Data Saved To File

**Raw DAS Output –Mission Failure at 525 km (no customers separated; propulsion system failed)**

03 26 2021; 12:45:38PM Activity Log Started
03 26 2021; 12:45:38PM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevD DoA\
03 26 2021; 12:45:57PM Processing Requirement 4.3-1: Return Status : Not Run

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

=============== End of Requirement 4.3-1 ===============
03 26 2021; 12:45:58PM Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
03 26 2021; 13:38:36PM Processing Requirement 4.5-1: Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.384 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0037 (m^2/kg)
Start Year = 2021.482 (yr)
Initial Mass = 331.000 (kg)
Final Mass = 331.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

**OUTPUT**

Collision Probability = 4.0873E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

03 26 2021; 13:38:41PM Processing Requirement 4.6 Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.384300 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003679 (m^2/kg)
Start Year = 2021.482190 (yr)
Initial Mass = 331.000000 (kg)
Final Mass = 331.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 523.360478 (km)
PMD Apogee Altitude = 526.628887 (km)
PMD Inclination = 97.385285 (deg)
PMD RAAN = 3.532287 (deg)
PMD Argument of Perigee = 169.120154 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 523.360478 (km)
Suggested Apogee Altitude = 526.628887 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

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

03 26 2021; 13:38:44PM Project Data Saved To File

**Raw DAS Output – Nominal Mission at 550 km (all customers separated; Sherpa-LTE orbit lowered to 350 km)**

01 29 2021; 11:23:21AM Activity Log Started
01 29 2021; 11:23:21AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA post-deploy\
01 29 2021; 11:23:51AM Mission Editor Changes Applied
01 29 2021; 11:23:51AM Project Data Saved To File
01 29 2021; 11:23:54AM Processing Requirement 4.3-1: Return Status : Not Run

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

=============== End of Requirement 4.3-1 ===============
01 29 2021; 11:23:56AM Processing Requirement 4.3-2: Return Status : Passed

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

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

=============== End of Requirement 4.3-2 ===============
01 29 2021; 11:50:05AM Processing Requirement 4.5-1: Return Status : Passed

==============
Run Data
==============
**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.500 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0059 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 415.000 (kg)
Final Mass = 203.000 (kg)
Duration = 0.500 (yr)
Station-Kept = False
PMD Perigee Altitude = 350.000 (km)
PMD Apogee Altitude = 350.000 (km)
PMD Inclination = 97.450 (deg)
PMD RAAN = 0.000 (deg)
PMD Argument of Perigee = 0.000 (deg)
PMD Mean Anomaly = 0.000 (deg)

**OUTPUT**

Collision Probability = 4.5878E-06
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

01 29 2021; 11:50:08AM Processing Requirement 4.6 Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)

RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005906 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = False
PMD Perigee Altitude = 350.000000 (km)
PMD Apogee Altitude = 350.000000 (km)
PMD Inclination = 97.450000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 350.000000 (km)
Suggested Apogee Altitude = 350.000000 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2022 (yr)
Requirement = 61
Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
01 29 2021; 11:50:12AM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 2

name = Sherpa-LTE1
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 203.000000
Thermal Mass = 203.000000
Diameter/Width = 0.813000

name = LT upper 24-in separation sytem
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.610000
Length = 0.610000
Height = 0.031000

name = 24inch Jchannel spacer ring

quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.260000
Thermal Mass = 5.260000
Diameter/Width = 0.666750
Length = 0.666750
Height = 0.082550

name = solar panel wing
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

name = LT Hex Plate
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 12.000000
Thermal Mass = 12.000000
Diameter/Width = 0.822000
Length = 0.822000
Height = 0.070000

name = LT Interior Wall
quantity = 6
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.162000
Thermal Mass = 1.162000
Diameter/Width = 0.118000
Length = 0.318000

name = LT Corner Brace
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.040000
Thermal Mass = 2.040000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT DuoPack adapter plate
quantity = 2
parent = 1
materialID = 8

type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000
Diameter/Width = 0.311000
Length = 0.350000

name = LT QuadPack adapter plate
quantity = 4
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

name = LT avionics deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = LT R2A-Core
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.200000
Thermal Mass = 3.200000
Diameter/Width = 0.285000
Length = 0.285000
Height = 0.090000

name = LT battery module
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 2.650000
Thermal Mass = 2.650000
Diameter/Width = 0.100000
Length = 0.139000
Height = 0.100000

name = LT EyeStar Black Box
quantity = 6
parent = 1
materialID = 5
type = Box
Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000

Length = 0.089000
Height = 0.047000

name = LT empty DuoPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 4.550000
Thermal Mass = 4.550000
Diameter/Width = 0.250000
Length = 0.405000
Height = 0.145000

name = empty 2-way PSL12U
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 7.720000
Thermal Mass = 7.720000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = empty 1-way PSL12U
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 6.760000
Thermal Mass = 6.760000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = LT lower 8-in separation system
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 1.190681
Thermal Mass = 1.190681
Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

name = RPG base ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.080000
Thermal Mass = 5.080000
Diameter/Width = 0.625500
Length = 0.628650
Height = 0.038100

name = RPG leg
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 0.630000
Thermal Mass = 0.630000
Diameter/Width = 0.050800
Length = 0.196000
Height = 0.050800

name = RPG triangle plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.470000
Thermal Mass = 4.470000
Diameter/Width = 0.346280
Length = 0.399740
Height = 0.076200

name = RPG plinth
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.220000
Length = 0.220000

name = RPG MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.430000
Thermal Mass = 2.430000
Diameter/Width = 0.255115
Length = 0.322040
Height = 0.057150

name = torque rod
quantity = 3
parent = 1
materialID = 38
type = Cylinder
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.020000
Length = 0.300000

name = AD avionics
quantity = 5
parent = 1

materialID = 8
type = Box
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.120000
Length = 0.150000
Height = 0.100000

name = RWA enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.570000
Thermal Mass = 0.570000
Diameter/Width = 0.140000
Length = 0.150000
Height = 0.042000

name = RWA rotor
quantity = 3
parent = 1
materialID = 62
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

name = propulsion deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = Apollo Fusion tank
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.115000
Length = 0.425000

name = Apollo Fusion feed system
quantity = 16
parent = 1
materialID = 58
type = Box
Aero Mass = 0.200000

Thermal Mass = 0.200000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

name = Apollo Fusion thruster
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 0.850000
Thermal Mass = 0.850000
Diameter/Width = 0.090000
Length = 0.090000

name = camera bracket
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.620000
Thermal Mass = 0.620000
Diameter/Width = 0.146000
Length = 0.177800

name = IMPERX camera
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.115000
Thermal Mass = 0.115000
Diameter/Width = 0.037000
Length = 0.072000
Height = 0.037000

name = camera lens assembly
quantity = 2
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.134000
Thermal Mass = 0.134000
Diameter/Width = 0.034000
Length = 0.047000

**************OUTPUT****

Item Number = 2

name = Sherpa-LTE1
Demise Altitude = 77.996948
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT upper 24-in separation sytem
Demise Altitude = 75.906479
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 24inch Jchannel spacer ring
Demise Altitude = 72.915138
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = solar panel wing
Demise Altitude = 75.450325
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Hex Plate
Demise Altitude = 64.950798
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Interior Wall
Demise Altitude = 73.484108
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Corner Brace
Demise Altitude = 73.321823
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT DuoPack adapter plate
Demise Altitude = 73.718803
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT QuadPack adapter plate
Demise Altitude = 73.608978
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT avionics deck plate

Demise Altitude = 72.632278
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT R2A-Core
Demise Altitude = 71.251724
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT battery module
Demise Altitude = 68.327492
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT EyeStar Black Box
Demise Altitude = 75.185242
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT empty DuoPack
Demise Altitude = 72.389244
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = empty 2-way PSL12U
Demise Altitude = 71.597191
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = empty 1-way PSL12U
Demise Altitude = 72.386795
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT lower 8-in separation system
Demise Altitude = 70.288551
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG base ring
Demise Altitude = 72.268845
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG leg
Demise Altitude = 74.987495
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG triangle plate
Demise Altitude = 71.540443
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG plinth
Demise Altitude = 73.807907
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG MLB adapter plate
Demise Altitude = 73.265541
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = torque rod
Demise Altitude = 69.704956
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = AD avionics
Demise Altitude = 68.499886
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA enclosure
Demise Altitude = 75.011490
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA rotor
Demise Altitude = 0.000000
Debris Casualty Area = 1.502729
Impact Kinetic Energy = 128.077042

************************************
name = propulsion deck plate
Demise Altitude = 72.632278
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion tank
Demise Altitude = 74.799332
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion feed system

Demise Altitude = 69.473869
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion PPU
Demise Altitude = 71.245445
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion thruster
Demise Altitude = 67.685791
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = camera bracket
Demise Altitude = 74.531754
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = IMPERX camera
Demise Altitude = 76.289703
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = camera lens assembly
Demise Altitude = 71.791626
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************

============== End of Requirement 4.7-1 ==============
01 29 2021; 11:50:12AM Project Data Saved To File

**Raw DAS Output – Nominal Mission without PMD at 550 km (all customers separated; propulsion system failed)**

04 23 2021; 07:49:35AM Activity Log Started
04 23 2021; 07:49:35AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA post-deploy no PMD\
04 23 2021; 07:50:47AM Mission Editor Changes Applied
04 23 2021; 07:50:47AM Project Data Saved To File
04 23 2021; 07:50:48AM Project Data Saved To File
04 23 2021; 07:50:56AM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ==============
04 23 2021; 07:50:58AM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ==============
04 23 2021; 08:35:42AM Processing Requirement 4.5-1: Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.500 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0062 (m^2/kg)
Start Year = 2021.480 (yr)
Initial Mass = 335.000 (kg)
Final Mass = 203.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

**OUTPUT**

Collision Probability = 4.6952E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

04 23 2021; 08:35:46AM Project Data Saved To File
04 23 2021; 08:36:04AM Processing Requirement 4.6 Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.006192 (m^2/kg)
Start Year = 2021.480000 (yr)
Initial Mass = 335.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.387689 (km)
PMD Apogee Altitude = 551.604794 (km)
PMD Inclination = 97.500753 (deg)
PMD RAAN = 3.542183 (deg)
PMD Argument of Perigee = 169.422221 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 548.387689 (km)
Suggested Apogee Altitude = 551.604794 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

=============== End of Requirement 4.6 ===============
04 23 2021; 08:39:17AM Activity Log Started
04 23 2021; 08:39:18AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA post-deploy no PMD\
04 23 2021; 08:40:06AM Processing Requirement 4.6 Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1

Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.006192 (m^2/kg)
Start Year = 2021.480000 (yr)
Initial Mass = 335.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.387689 (km)
PMD Apogee Altitude = 551.604794 (km)
PMD Inclination = 97.500753 (deg)
PMD RAAN = 3.542183 (deg)
PMD Argument of Perigee = 169.422221 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 548.387689 (km)
Suggested Apogee Altitude = 551.604794 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

============== End of Requirement 4.6 ===============
04 23 2021; 08:40:08AM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 2

name = Sherpa-LTE1
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 203.000000
Thermal Mass = 203.000000
Diameter/Width = 0.813000

name = LT upper 24-in separation sytem
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000

Diameter/Width = 0.610000
Length = 0.610000
Height = 0.031000

name = 24inch Jchannel spacer ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.260000
Thermal Mass = 5.260000
Diameter/Width = 0.666750
Length = 0.666750
Height = 0.082550

name = solar panel wing
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

name = LT Hex Plate
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 12.000000
Thermal Mass = 12.000000
Diameter/Width = 0.822000
Length = 0.822000
Height = 0.070000

name = LT Interior Wall
quantity = 6
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.162000
Thermal Mass = 1.162000
Diameter/Width = 0.118000
Length = 0.318000

name = LT Corner Brace
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.040000
Thermal Mass = 2.040000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT DuoPack adapter plate
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000
Diameter/Width = 0.311000
Length = 0.350000

name = LT QuadPack adapter plate
quantity = 4
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

name = LT avionics deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = LT R2A-Core
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.200000
Thermal Mass = 3.200000
Diameter/Width = 0.285000
Length = 0.285000
Height = 0.090000

name = LT battery module
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 2.650000
Thermal Mass = 2.650000
Diameter/Width = 0.100000
Length = 0.139000
Height = 0.100000

name = LT EyeStar Black Box
quantity = 6
parent = 1

materialID = 5
type = Box
Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000
Length = 0.089000
Height = 0.047000

name = LT empty DuoPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 4.550000
Thermal Mass = 4.550000
Diameter/Width = 0.250000
Length = 0.405000
Height = 0.145000

name = empty 2-way PSL12U
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 7.720000
Thermal Mass = 7.720000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = empty 1-way PSL12U
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 6.760000
Thermal Mass = 6.760000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = LT lower 8-in separation system
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 1.190681
Thermal Mass = 1.190681
Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

name = RPG base ring
quantity = 1
parent = 1
materialID = 8
type = Box

Aero Mass = 5.080000
Thermal Mass = 5.080000
Diameter/Width = 0.625500
Length = 0.628650
Height = 0.038100

name = RPG leg
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 0.630000
Thermal Mass = 0.630000
Diameter/Width = 0.050800
Length = 0.196000
Height = 0.050800

name = RPG triangle plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.470000
Thermal Mass = 4.470000
Diameter/Width = 0.346280
Length = 0.399740
Height = 0.076200

name = RPG plinth
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.220000
Length = 0.220000

name = RPG MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.430000
Thermal Mass = 2.430000
Diameter/Width = 0.255115
Length = 0.322040
Height = 0.057150

name = torque rod
quantity = 3
parent = 1
materialID = 38
type = Cylinder
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.020000

Length = 0.300000

name = AD avionics
quantity = 5
parent = 1
materialID = 8
type = Box
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.120000
Length = 0.150000
Height = 0.100000

name = RWA enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.570000
Thermal Mass = 0.570000
Diameter/Width = 0.140000
Length = 0.150000
Height = 0.042000

name = RWA rotor
quantity = 3
parent = 1
materialID = 62
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

name = propulsion deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = Apollo Fusion tank
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.115000
Length = 0.425000

name = Apollo Fusion feed system

quantity = 16
parent = 1
materialID = 58
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

name = Apollo Fusion thruster
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 0.850000
Thermal Mass = 0.850000
Diameter/Width = 0.090000
Length = 0.090000

name = camera bracket
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.620000
Thermal Mass = 0.620000
Diameter/Width = 0.146000
Length = 0.177800

name = IMPERX camera
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.115000
Thermal Mass = 0.115000
Diameter/Width = 0.037000
Length = 0.072000
Height = 0.037000

name = camera lens assembly
quantity = 2
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.134000

Thermal Mass = 0.134000
Diameter/Width = 0.034000
Length = 0.047000

name = 1506-11-100 Delrin Block
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.100000
Length = 0.340500
Height = 0.100000

name = 1506-11-202 Steel mass
quantity = 4
parent = 1
materialID = 58
type = Box
Aero Mass = 0.750000
Thermal Mass = 0.750000
Diameter/Width = 0.064287
Length = 0.171450
Height = 0.009525

**************OUTPUT****
Item Number = 2

name = Sherpa-LTE1
Demise Altitude = 77.996948
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT upper 24-in separation sytem
Demise Altitude = 75.906479
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 24inch Jchannel spacer ring
Demise Altitude = 72.915138
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = solar panel wing
Demise Altitude = 75.450325
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Hex Plate
Demise Altitude = 64.950798
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Interior Wall
Demise Altitude = 73.484108
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Corner Brace
Demise Altitude = 73.321823
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT DuoPack adapter plate
Demise Altitude = 73.718803
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT QuadPack adapter plate
Demise Altitude = 73.608978
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT avionics deck plate
Demise Altitude = 72.632278
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT R2A-Core
Demise Altitude = 71.251724
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT battery module
Demise Altitude = 68.327492
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT EyeStar Black Box
Demise Altitude = 75.185242
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT empty DuoPack
Demise Altitude = 72.389244
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = empty 2-way PSL12U

Demise Altitude = 71.597191
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = empty 1-way PSL12U
Demise Altitude = 72.386795
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT lower 8-in separation system
Demise Altitude = 70.288551
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG base ring
Demise Altitude = 72.268845
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG leg
Demise Altitude = 74.987495
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG triangle plate
Demise Altitude = 71.540443
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG plinth
Demise Altitude = 73.807907
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = RPG MLB adapter plate
Demise Altitude = 73.265541
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = torque rod
Demise Altitude = 69.704956
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = AD avionics
Demise Altitude = 68.499886
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA enclosure
Demise Altitude = 75.011490
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA rotor
Demise Altitude = 0.000000
Debris Casualty Area = 1.502729
Impact Kinetic Energy = 128.077042

************************************
name = propulsion deck plate
Demise Altitude = 72.632278
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion tank
Demise Altitude = 74.799332
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion feed system
Demise Altitude = 69.473869
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion PPU
Demise Altitude = 71.245445
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Apollo Fusion thruster
Demise Altitude = 67.685791
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = camera bracket
Demise Altitude = 74.531754
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = IMPERX camera
Demise Altitude = 76.289703
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = camera lens assembly

Demise Altitude = 71.791626
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = 1506-11-100 Delrin Block
Demise Altitude = 76.857849
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = 1506-11-202 Steel mass
Demise Altitude = 65.346573
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************

=============== End of Requirement 4.7-1 ===============
04 23 2021; 08:40:08AM Project Data Saved To File
04 23 2021; 08:40:18AM Project Data Saved To File

**Raw DAS Output – Mission Failure at 550 km (no customers separated)**

03 30 2021; 13:35:19PM Activity Log Started
03 30 2021; 13:35:19PM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevD DoA\
03 30 2021; 13:35:27PM Processing Requirement 4.6 Return Status : Passed

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

**INPUT**

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.597600 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003679 (m^2/kg)
Start Year = 2021.482190 (yr)
Initial Mass = 331.000000 (kg)
Final Mass = 331.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.392066 (km)
PMD Apogee Altitude = 551.601095 (km)
PMD Inclination = 97.598592 (deg)
PMD RAAN = 3.588194 (deg)
PMD Argument of Perigee = 169.281172 (deg)
PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

Suggested Perigee Altitude = 548.392066 (km)
Suggested Apogee Altitude = 551.601095 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2045 (yr)
Requirement = 61
Compliance Status = Pass

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

============== End of Requirement 4.6 ==============
03 30 2021; 13:35:28PM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 2

name = Sherpa-LTE1
quantity = 1
parent = 0

materialID = 5
type = Cylinder
Aero Mass = 331.000000
Thermal Mass = 331.000000
Diameter/Width = 0.813000

name = LT upper 24-in separation sytem
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.610000
Length = 0.610000
Height = 0.031000

name = 24inch Jchannel spacer ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.260000
Thermal Mass = 5.260000
Diameter/Width = 0.666750
Length = 0.666750
Height = 0.082550

name = solar panel wing
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

name = LT Hex Plate
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 12.000000
Thermal Mass = 12.000000
Diameter/Width = 0.822000
Length = 0.822000
Height = 0.070000

name = LT Interior Wall
quantity = 6
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.162000
Thermal Mass = 1.162000

Diameter/Width = 0.118000
Length = 0.318000

name = LT Corner Brace
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.040000
Thermal Mass = 2.040000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT DuoPack adapter plate
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000
Diameter/Width = 0.311000
Length = 0.350000

name = LT QuadPack adapter plate
quantity = 4
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

name = LT avionics deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000
Height = 0.022000

name = LT R2A-Core
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.200000
Thermal Mass = 3.200000
Diameter/Width = 0.285000
Length = 0.285000
Height = 0.090000

name = LT battery module

quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 2.650000
Thermal Mass = 2.650000
Diameter/Width = 0.100000
Length = 0.139000
Height = 0.100000

name = LT EyeStar Black Box
quantity = 6
parent = 1
materialID = 5
type = Box
Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000
Length = 0.089000
Height = 0.047000

name = LT empty DuoPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 4.550000
Thermal Mass = 4.550000
Diameter/Width = 0.250000
Length = 0.405000
Height = 0.145000

name = empty 2-way PSL12U
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 7.720000
Thermal Mass = 7.720000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = empty 1-way PSL12U
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 6.760000
Thermal Mass = 6.760000
Diameter/Width = 0.270000
Length = 0.431000
Height = 0.270000

name = LT lower 8-in separation system
quantity = 4
parent = 1

materialID = 5
type = Box
Aero Mass = 1.190681
Thermal Mass = 1.190681
Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

name = RPG base ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.080000
Thermal Mass = 5.080000
Diameter/Width = 0.625500
Length = 0.628650
Height = 0.038100

name = RPG leg
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 0.630000
Thermal Mass = 0.630000
Diameter/Width = 0.050800
Length = 0.196000
Height = 0.050800

name = RPG triangle plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.470000
Thermal Mass = 4.470000
Diameter/Width = 0.346280
Length = 0.399740
Height = 0.076200

name = RPG plinth
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.220000
Length = 0.220000

name = RPG MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.430000

Thermal Mass = 2.430000
Diameter/Width = 0.255115
Length = 0.322040
Height = 0.057150

name = torque rod
quantity = 3
parent = 1
materialID = 38
type = Cylinder
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.020000
Length = 0.300000

name = AD avionics
quantity = 5
parent = 1
materialID = 8
type = Box
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.120000
Length = 0.150000
Height = 0.100000

name = RWA enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.570000
Thermal Mass = 0.570000
Diameter/Width = 0.140000
Length = 0.150000
Height = 0.042000

name = RWA rotor
quantity = 3
parent = 1
materialID = 62
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

name = propulsion deck plate
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.544000
Length = 0.544000

Height = 0.022000

name = Apollo Fusion tank
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.115000
Length = 0.425000

name = Apollo Fusion feed system
quantity = 16
parent = 1
materialID = 58
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

name = Apollo Fusion thruster
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 0.850000
Thermal Mass = 0.850000
Diameter/Width = 0.090000
Length = 0.090000

name = camera bracket
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.620000
Thermal Mass = 0.620000
Diameter/Width = 0.146000
Length = 0.177800

name = IMPERX camera
quantity = 2
parent = 1
materialID = 5

type = Box
Aero Mass = 0.115000
Thermal Mass = 0.115000
Diameter/Width = 0.037000
Length = 0.072000
Height = 0.037000

name = camera lens assembly
quantity = 2
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.134000
Thermal Mass = 0.134000
Diameter/Width = 0.034000
Length = 0.047000

**************OUTPUT****
Item Number = 2

name = Sherpa-LTE1
Demise Altitude = 77.998085
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT upper 24-in separation sytem
Demise Altitude = 76.261864
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 24inch Jchannel spacer ring
Demise Altitude = 73.630585
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = solar panel wing
Demise Altitude = 75.864487
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Hex Plate
Demise Altitude = 66.732880
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Interior Wall
Demise Altitude = 74.163879
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT Corner Brace

Demise Altitude = 74.027786
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT DuoPack adapter plate
Demise Altitude = 74.357491
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT QuadPack adapter plate
Demise Altitude = 74.272034
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT avionics deck plate
Demise Altitude = 73.370506
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT R2A-Core
Demise Altitude = 72.118301
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT battery module
Demise Altitude = 69.456589
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT EyeStar Black Box
Demise Altitude = 75.658791
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = LT empty DuoPack
Demise Altitude = 73.161842
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = empty 2-way PSL12U
Demise Altitude = 72.456856
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = empty 1-way PSL12U
Demise Altitude = 73.165710
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = LT lower 8-in separation system
Demise Altitude = 71.252037
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG base ring
Demise Altitude = 73.054573
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG leg
Demise Altitude = 75.501221
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG triangle plate
Demise Altitude = 72.408653
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG plinth
Demise Altitude = 74.384270
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RPG MLB adapter plate
Demise Altitude = 73.947609
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = torque rod
Demise Altitude = 70.022896
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = AD avionics
Demise Altitude = 69.615959
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA enclosure
Demise Altitude = 75.501060
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = RWA rotor

Demise Altitude = 0.000000
Debris Casualty Area = 1.502729
Impact Kinetic Energy = 128.074615

*************************************
name = propulsion deck plate
Demise Altitude = 73.370506
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion tank
Demise Altitude = 75.327286
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion feed system
Demise Altitude = 69.756912
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion PPU
Demise Altitude = 72.137329
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Apollo Fusion thruster
Demise Altitude = 68.053467
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = camera bracket
Demise Altitude = 75.083237
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = IMPERX camera
Demise Altitude = 76.600853
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = camera lens assembly
Demise Altitude = 72.409813
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************

============== End of Requirement 4.7-1 ==============
03 30 2021; 13:35:28PM Project Data Saved To File
03 30 2021; 13:35:30PM Project Data Saved To File

**END of Sherpa-LTE1 Orbital Debris Assessment Report (ODAR)**

# Sherpa-FX2 Long-Term Recontact Probability

**REVISION / DATE**

B / 22 April 2021

SPACEFLIGHT, INC.
1505 WESTLAKE AVENUE NORTH SUITE 600
SEATTLE, WASHINGTON 98109

| REV | DATE | PREPARED BY | ANALYSIS BY | CHANGES |
|---|---|---|---|---|
| A | 2021-01-21 | M. Coletti | E. Lund | Initial Release |
| B | 2021-04-22 | M. Coletti | E. Lund | Analysis updates to reflect manifest changes |

## 1. Introduction

The Sherpa-FX2 Mission (hereinafter "Sherpa-FX2 Mission", or "Mission") on a SpaceX Rideshare launch, currently planned for June – July 2021, is a commercial rideshare mission with the primary Spaceflight, Inc. ("Spaceflight") objective of hosting 1 customer payload which will remain attached to the Sherpa-FX2, and deploying 25 customer spacecraft into a planned sun-synchronous circular orbit of 525 ± 25 km. SpaceX's Falcon 9 launch vehicle will deploy the free flyer spacecraft, called Sherpa-FX2, which subsequently deploys the additional customer spacecraft within several hours of liftoff.[1]

The separation system and customer payload layout on Sherpa-FX2 can be variable, depending on the number of microsatellites and CubeSats manifested to the mission. CubeSat and Microsatellite separation systems are interchangeable and can be affixed radially on the body of the Sherpa-FX2 vehicle. A microsatellite, CubeSat dispenser, or other adapter for separation system mounting can be affixed on the outboard end of Sherpa-FX2. The Sherpa-FX2 structure upon which the separation systems are affixed is identical to the previously licensed Sherpa-FX1. Thus, Sherpa-FX2 will deploy customers in the same fashion as the previously licensed Sherpa-FX1. For this Mission, the planned configuration has a microsatellite on the outboard end of Sherpa-FX2, with three microsatellites, two 6U equivalent CubeSat dispensers, two 3U dispensers, and one 12U equivalent CubeSat dispenser, attached radially on the body of Sherpa-FX2.[2] The Sherpa-FX2 Mission configuration also includes an S-band receive antenna and an L-band transmitter as part of its avionics.

This report has been updated as of April 22, 2021 to account for manifest changes since the initial submission of this document. We observe very similar, but slightly improved recontact results in comparison to the initial submission in Rev A (probability of recontact for just non-propulsive spacecraft reduced to $1.267 \times 10^{-3}$, from $1.268 \times 10^{-3}$). This is expected since the number of separating bodies remained the same, but there was a slight difference in mass between the spacecraft that were swapped between the Sherpa vehicles on the mission. Note that as of this update, all Swarm spacecraft no longer contain propulsion. The recontact results capture that the Swarm spacecraft are no longer contain propulsion systems.

This report presents the probability of recontact for this configuration over two-year time period between the spacecraft on this mission and with resident space objects.

[1] Spaceflight notes that, as with any rideshare mission, there is a possibility that one or more customers will either not be ready, not be able to meet one or more of Spaceflight and/or SpaceX's readiness criteria for flight or, choose to remove their spacecraft from the mission. Removed customers will be replaced by a non-separating mass model to keep the various launch and mission analyses valid. Since the Sherpa-FX2 does not have any attitude control system, dispersion is dependent on the momentum change after each deployment. This momentum change is based on the specific mass of each spacecraft and the spring energy in their separation system. Therefore, replacing a separating customer spacecraft with a non-separating mass model will change the momentum of the Sherpa FX2 and thus the deployment vector for subsequent spacecraft. In such event, a new recontact analysis will be run to verify that the mission cumulative recontact probability is $1.743 \times 10^{-3}$ or less. If the probability of recontact would be greater than this threshold, a new sequence will be developed and tested to ensure that this threshold is met.

[2] None of the spacecraft to be deployed will themselves deploy additional spacecraft.

## 2. Methodology

Spaceflight has performed a high-fidelity analysis set forth below, using the same analytic techniques that Spaceflight described for its previously successful SSO-A and Sherpa-FX1 mission. As a general matter, spacecraft with propulsion or differential drag capabilities should be able to avoid conjunction with other spacecraft. There are 8 spacecraft on board Sherpa-FX2 with propulsion. Spaceflight has completed its evaluation and concluded that the propulsion systems on customer spacecraft identified in the STA filing are sufficient to enable them to perform collision avoidance. There are, however, a number of variables, such as time to closest approach (TCA), ground pass availability to command the spacecraft to perform a debris avoidance maneuver, that affect the ability of a given spacecraft to perform a avoidance maneuver. Therefore, we present analyses here with and without this assumption factored in. There is also some risk of conjunction in the period immediately following launch which is mitigated through the use of collision avoidance analysis between the launch vehicle and the Combined Space Operations Center (CSpOC). Additionally, the nature of that risk, and more generally of conjunctions involving spacecraft deployed as part of the Sherpa-FX2 Mission, is one better described as recontact rather than collision because of the low-speed nature of any possible conjunction. Contact at this low speed may cause minor damage to a spacecraft, but little or no debris.

The high-fidelity approach is based on a Monte Carlo analysis of the full Sherpa-FX2 deployment sequence. This analysis approach considers the mass and separation system properties for all Spaceflight customer spacecraft. Appropriate distributions are applied to these parameters based on customer and vendor inputs, and Monte Carlo simulations of the full Sherpa-FX2 Mission are run using a six degree-of-freedom orbit and attitude dynamics model with relative distances tracked between all spacecraft.

Sub-3U spacecraft will be grouped together in the same slot of their separation system, and therefore considered a single aggregate 3U spacecraft in these analyses. Sub-3U spacecraft are modeled as a single 3U spacecraft only when they are consolidated in a single dispenser slot (in the case of this mission, in a single instance, twelve 0.25U SpaceBEEs). In this configuration, all the spacecraft in the slot are deployed simultaneously and in the same direction and same initial velocity. These sub-3U spacecraft have very small springs between them to help push them apart gradually over time. The change in velocity caused by these small springs is substantially less than the spring energy variation margin that is included in in Spaceflight's Monte Carlo deployment simulation that applies for each dispenser slot. This means that the dispersal of the three sub-3U spacecraft will fall within the volume of space that is accounted for in that simulation therefore creating no greater recontact risk as so modeled than would be the case for single 3U spacecraft. These spacecraft would be deployed in the same velocity vector and thus relative velocities between them would be negligible compared to relative velocities between other spacecraft on the mission, or between Resident Space Objects. Ordering of the spacecraft within the dispenser will also help mitigate the chance of recontact, since they are intentionally designed with slightly different masses. By placing the least massive spacecraft with the highest separation velocity such that it is separated first, we thereby minimize the chance a spacecraft "catches up" to another spacecraft it was deployed with.

The probability of recontact for the Sherpa-FX2 Mission is then found by counting the number of recontact events, which are said to occur if an object pair's relative distance falls below that particular object pair's combined hard-body radius and dividing by the total number of simulations run.

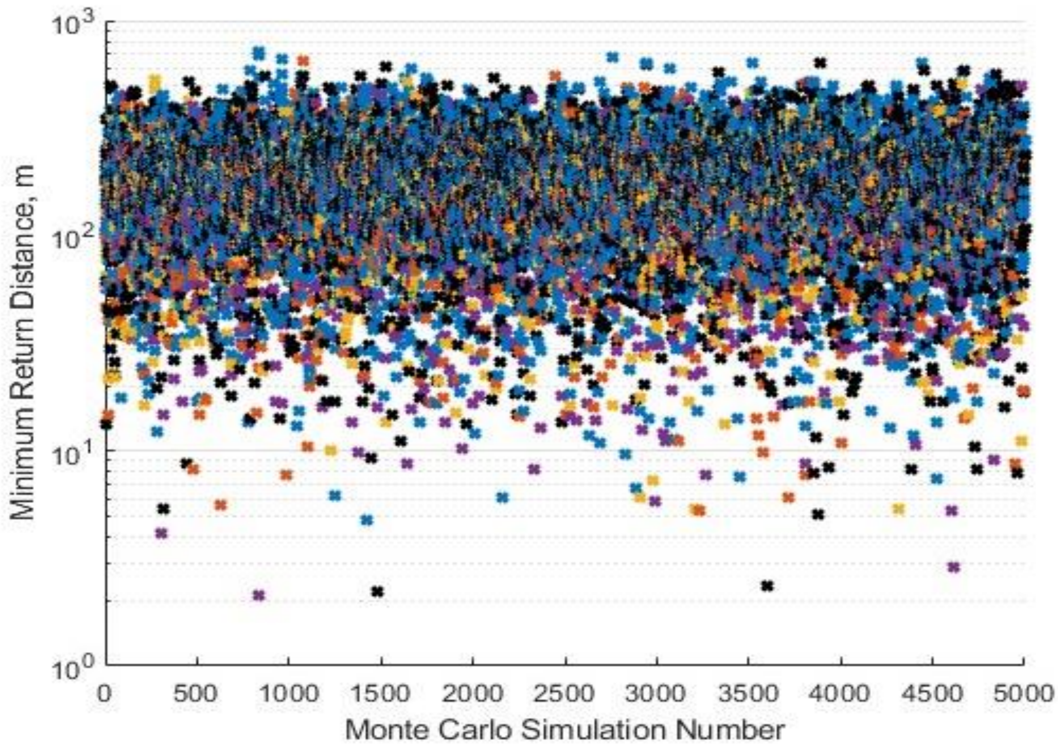


**Figure 1: 5000 simulation Monte Carlo analysis over five orbits. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-FX2-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach. Purple data points indicate Sherpa-FX2-Microsat close approach.**

A 5,000-run Monte Carlo analysis was performed using this approach over a period that lasted five orbits after the last spacecraft is deployed from Sherpa-FX2 (a duration of approximately 8 hours) (Figure 1). The analysis was based on a deployment sequence that was chosen to reduce the probability of recontact. Any final modifications to deployment sequence order or timing from that which was used as inputs to the analysis here, shall have an equal or reduced probability of recontact than those presented herein. The five-orbit time period was chosen for detailed analysis because of the divergence of spacecraft that naturally occurs over this period, as further analyzed below. During this time (five orbits), one recontact event was observed (Pr(recontact) = $2 \times 10^{-4}$) with a $\Delta v < 1.0$ m/s. There was a 99.0% probability that all relative miss distances remained above 10.9 m, a 95% probability of all miss distances being greater than 25.0 m, and a 90.0% probability of all miss distances being greater than 35.6 m. Further, this estimate encompasses the period of highest spacecraft density where recontact events are most probable.

2000 further full deployment sequence simulations were run over a longer seven-day duration to substantiate this claim. In previous recontact analysis[3] we showed through binning of the relative miss distances, that the period immediately following separation through the first few orbits is the period of highest congestion, and the spacecraft diverge over time. With that in mind, we can conservatively

[3] SAT-STA-20200728-00089 Spaceflight, Inc. Sherpa-FX1 STA, Sherpa-FX1 Long Term Recontact Probability

assume this 2000 sequence, 7-day simulation's probability of recontact is fixed through two years, after the initial five orbit time period. Therefore, Spaceflight calculates the probability of recontact between the all spacecraft on the Sherpa-FX2 Mission over a two-year period, even if none of the spacecraft to be deployed are capable of performing propulsive maneuvers, is $1.70 \times 10^{-3}$. Considering the assumption that propulsive spacecraft will be able to perform debris avoidance maneuvers, the probability of recontact would be reduced to $1.24 \times 10^{-3}$.

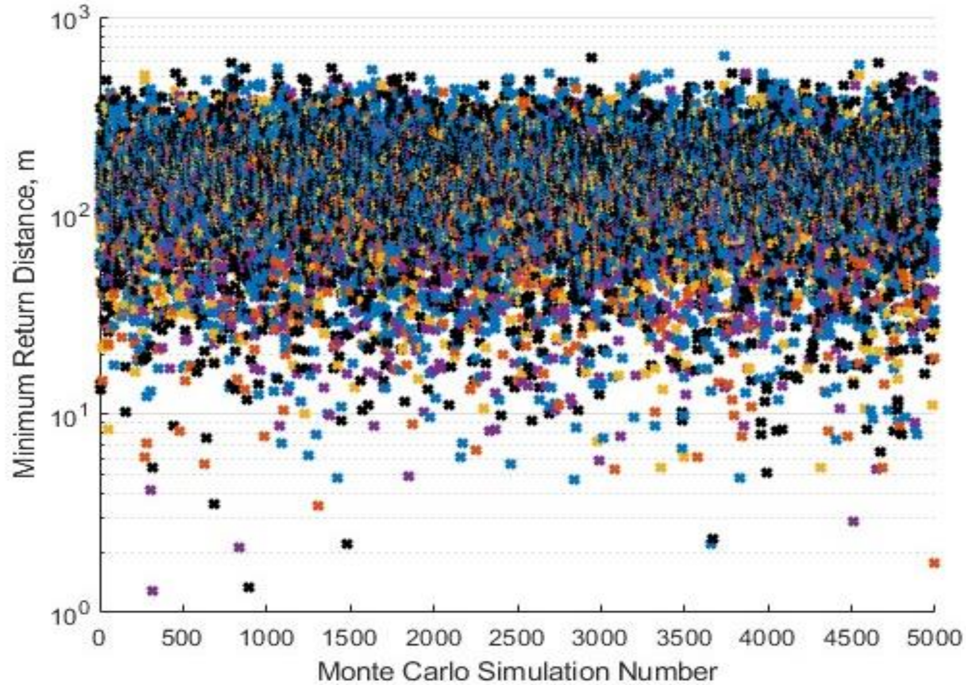


**Figure 2: 2000 simulation Monte Carlo analysis over seven days. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-FX2-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach. Purple data points indicate Sherpa-FX2-Microsat close approach.**

## 2.1 Conjunction with Resident Space Objects

The analyses above addresses recontact between spacecraft on the Sherpa-FX2 Mission, which would be low velocity events. Another concern is the probability of a conjunction with a Resident Space Object (RSO) that is not part of the Sherpa-FX2 Mission. Each spacecraft is responsible for performing this analysis as part of their Orbit Debris Assessment Report (ODAR). Overall probability of conjunction with an RSO for all spacecraft can be estimated based on the individual spacecraft size and mass as an input into the Debris Assessment Software (DAS v3.1.0) RSO collision analysis. DAS predicts that Sherpa-FX2 and its deployed spacecraft, even if none of the spacecraft to be deployed are capable of performing propulsive maneuvers, have a probability of collision with RSOs of $4.30 \times 10^{-5}$ over the entire orbit lifetime of the spacecraft. Assuming that the spacecraft to be deployed with propulsion systems would be able to avoid RSO collisions if given advance warning, the probability of collision for non-propulsive objects, including the FX2 vehicle itself, with RSOs would be $2.88 \times 10^{-5}$.

# 3. Conclusions

Spaceflight estimates that the combined probability of recontact for all objects on the Sherpa-FX2 mission is between $1.24 \times 10^{-3}$ (assuming debris avoidance capability of propulsive spacecraft) and $1.7 \times 10^{-3}$ (assuming none of those spacecraft have such capability), in each case using the approach described in Section 2. Adding the probability of deployed spacecraft and Sherpa-FX2 conjunction with a non-Sherpa-FX2 Resident Space Object provides a probability of recontact or conjunction with RSO of between $1.267 \times 10^{-3}$ and $1.743 \times 10^{-3}$ , depending on whether propulsive spacecraft have debris avoidance capability.

# Sherpa-LTE1 Long-Term Recontact Probability

**REVISION / DATE**

B / 22 April 2021

**SPACEFLIGHT, INC.**
**1505 WESTLAKE AVENUE NORTH, SUITE 600**
**SEATTLE, WASHINGTON 98109**

| REV | DATE | PREPARED BY | ANALYSIS BY | CHANGES |
|---|---|---|---|---|
| A | 2021-02-21 | M. Coletti | E. Lund | Initial Release |
| B | 2021-04-22 | M. Coletti | E. Lund | Analysis updates to reflect manifest changes |

# 1. Introduction

The Sherpa-LTE1 Mission (hereinafter "Sherpa-LTE1 Mission" or "Mission") on a SpaceX Rideshare launch, currently planned for June – July 2021, is a commercial rideshare mission with the primary objective of deploying 10 customer spacecraft into a planned sun-synchronous circular orbit of 525 ± 25 km. SpaceX's Falcon 9 launch vehicle will deploy the free flyer spacecraft, Sherpa-LTE1, which subsequently deploys the additional customer spacecraft within several hours of liftoff.[1] Once the primary mission is complete, a secondary mission to reduce the altitude of the empty Sherpa-LTE1 vehicle to 350 km via electric propulsion will be performed. Mission operations for this secondary mission will be performed in coordination with NASA and other interagency partners. Further detail is provided in the ODAR.

The separation system and customer payload layout on Sherpa-LTE1 is variable, depending on the number of microsatellites and CubeSats manifested to the mission. Structurally, Sherpa-LTE1 is very similar to the previously licensed Sherpa-FX1. CubeSat and Microsatellite separation systems are interchangeable and can be affixed radially on the body of either Sherpa vehicle. Sherpa-LTE1's structure will have an added adapter to the forward port, to accommodate up to four microsatellite customers. Sherpa-LTE1 also contains an attitude control and electronic propulsion system, which will be demonstrated only after the primary mission of separating customer spacecraft is complete. For this Mission, the planned configuration has two microsatellites on the adapter fixed to the forward port of Sherpa-LTE1. Radial ports have four 12U equivalent dispensers, one 6U equivalent CubeSat dispenser, and the Astro Digital Command & Communications System (CCS), attached radially on the body of Sherpa-LTE1.[2] The Sherpa-LTE1 Mission configuration also includes an S-band receive antenna, an L-band transmitter, a UHF transmitter, and a UHF receiver as part of its avionics.

This report has been updated as of April 22, 2021 to account for manifest changes since the initial submission of this document. Due to the reduction in total number of separated objects we see improved recontact results in comparison to the initial submission in Rev A. Total recontact probability between objects on this mission and with RSOs was reduced to $7.47 \times 10^{-4}$ from $9.56 \times 10^{-4}$ (for all objects), and $3.88 \times 10^{-4}$ from $7.53 \times 10^{-4}$(for just non-propulsive objects).

This report presents the probability of recontact for this configuration over two-year period between the spacecraft on this mission and with resident space objects.

[1] Spaceflight notes that, as with any rideshare mission, there is a possibility that one or more customers will either not be ready, not be able to meet one or more of Spaceflight and/or SpaceX's readiness criteria for flight or, choose to remove their spacecraft from the mission. Removed customers will be replaced by a non-separating mass model to keep the various launch and mission analyses valid. Since Sherpa-LTE1 will only have an attitude control system to be demonstrated after the primary mission of customer deployment the separation is complete, dispersion is dependent on the momentum change after each deployment. This momentum change is based on the specific mass of each spacecraft and the spring energy in their separation system. Therefore, replacing a separating customer spacecraft with a non-separating mass model will change the momentum of the Sherpa-LTE1, and thus the deployment vector for subsequent spacecraft. In such event, a new recontact analysis will be run to verify that the mission cumulative recontact probability is $9.56 \times 10^{-4}$ or less. If the probability of recontact would be greater than this threshold, a new sequence will be developed and tested to ensure that this threshold is met.

[2] None of the spacecraft to be deployed will themselves deploy additional spacecraft.

# 2. Methodology

Spaceflight has performed a high-fidelity analysis set forth below, using the same analytic techniques that Spaceflight described for its previously successful SSO-A and Sherpa-FX1 missions. As a general matter, spacecraft with propulsion or differential drag capabilities should be able to avoid conjunction with other spacecraft. There are 7 spacecraft on this mission with propulsion, including the Sherpa-LTE1 vehicle itself. Spaceflight has completed its evaluation and concluded that the propulsion systems on customer spacecraft identified in the STA filing are sufficient to enable them to perform collision avoidance. There are, however, a number of variables, such as time to closest approach (TCA), ground pass availability to command the spacecraft to perform a debris avoidance maneuver, that affect the ability of a given spacecraft to perform a avoidance maneuver. Therefore, we present analyses here with and without this assumption factored in. There is some risk of conjunction in the period immediately following launch which is mitigated using collision avoidance analysis between the launch vehicle and the Combined Space Operations Center (CSpOC). Additionally, the nature of that risk, and more generally of conjunctions involving spacecraft deployed as part of the Sherpa-LTE1 Mission, is one better described as recontact rather than collision because of the low-speed nature of any possible conjunction. Contact at this low speed may cause minor damage to a spacecraft, but little or no debris.

The high-fidelity approach is based on a Monte Carlo analysis of the full Sherpa-LTE1 deployment sequence. This analysis approach considers the mass and separation system properties for all Spaceflight customer spacecraft. Appropriate distributions are applied to these parameters based on customer and vendor inputs, and Monte Carlo simulations of the full Sherpa-LTE1 Mission are run using a six degree-of-freedom orbit and attitude dynamics model with relative distances tracked between all spacecraft. The probability of recontact for the Sherpa-LTE1 Mission is then found by counting the number of recontact events, which are said to occur if an object pair's relative distance falls below that particular object pair's combined hard-body radius and dividing by the total number of simulations run.

A 5,000-run Monte Carlo analysis was performed using this approach over a period that lasted five orbits after the last spacecraft is deployed from Sherpa-LTE1 (a duration of approximately 8 hours. The analysis was based on a deployment sequence that was chosen to reduce the probability of recontact. Any final modifications to deployment sequence order or timing from that which was used as inputs to the analysis here, shall have an equal or reduced probability of recontact than those presented herein. The five-orbit time period was chosen for detailed analysis because of the divergence of spacecraft that occurs naturally over this period, as further analyzed below. During this time (five orbits), one recontact event was observed over these 5,000 full deployment sequence simulations, Pr(recontact) = $2 \times 10^{-4}$, each with a $\Delta v < 1.0$ m/s. There was a 99.0% probability that all relative miss distances remained above 14.3 m, a 95% probability of all miss distances being greater than 36.9 m, and a 90.0% probability of all miss distances being greater than 55.6 m. Further, this estimate encompasses the period of highest spacecraft density where recontact events are most probable.

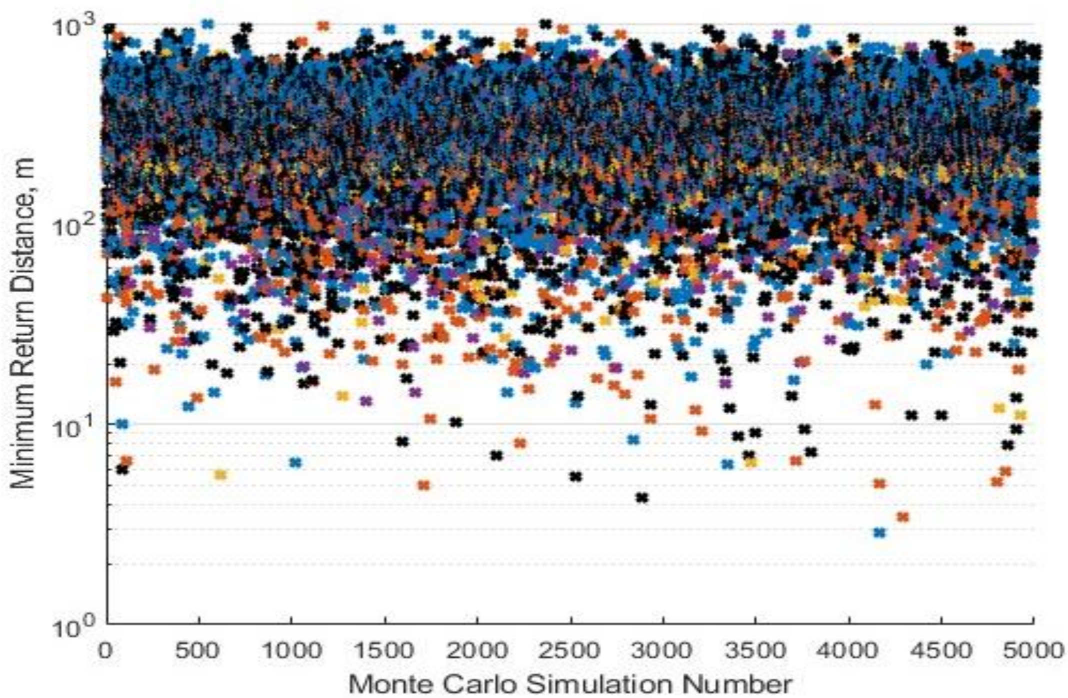


**Figure 1: 5,000 simulation Monte Carlo analysis over five orbits. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-LTE1-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach. Purple data points indicate Sherpa-LTE1-Microsat close approach.**

2000 further full deployment sequence simulations were run over a longer seven-day duration to substantiate this claim (Figure 2). In previous recontact analysis[3] we showed through binning of the relative miss distances, that the period immediately following separation through the first few orbits is the period of highest congestion, and the spacecraft diverge over time. With that in mind, we can conservatively assume this 2000 sequence, 7-day simulation's probability of recontact is fixed through two years, after the initial five orbit time period. Results from this analysis showed no additional recontact events. In an attempt to provide more statistically significant results and out of an abundance of conservatism, we expanded our collision radius to equal the smallest miss distance observed (3.2 m). Therefore, Spaceflight calculates the probability of recontact between all spacecraft on the Sherpa-LTE1 Mission over a two-year period is $7.00 \times 10^{-4}$. Considering the assumption that propulsive spacecraft will be able to perform debris avoidance maneuvers, the probability of recontact would be reduced to $3.82 \times 10^{-4}$.

[3] SAT-STA-20200728-00089 Spaceflight, Inc. Sherpa-FX1 STA, Sherpa-FX1 Long Term Recontact Probability

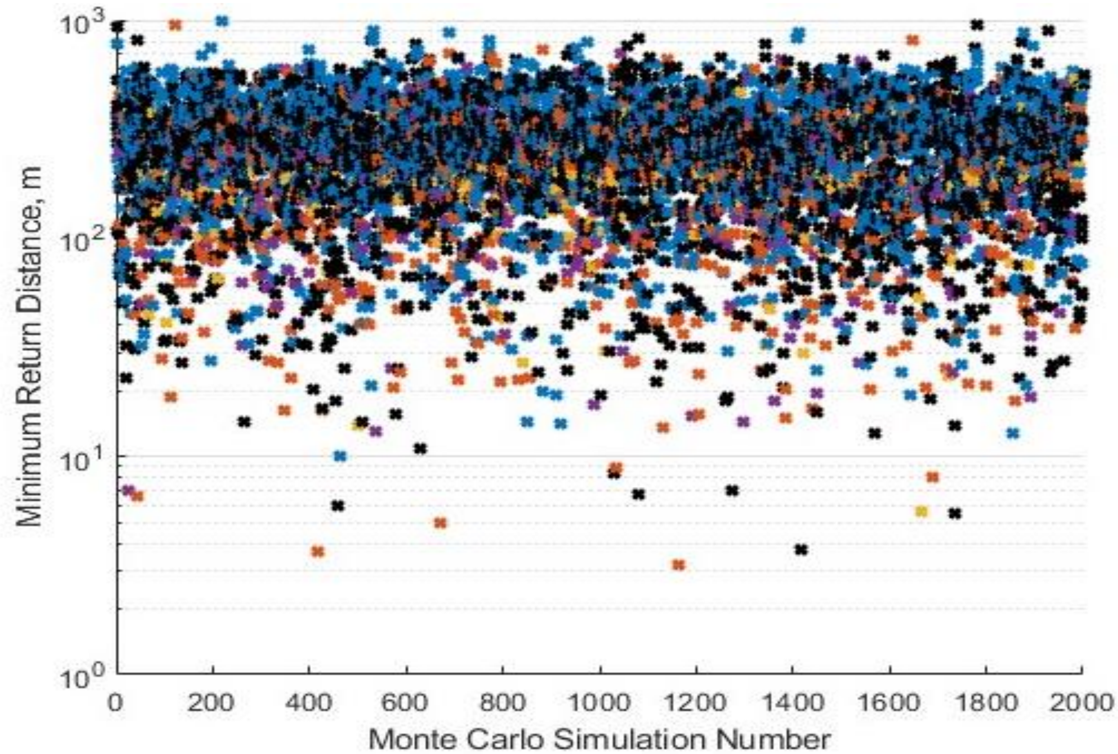


**Figure 2: 2,000 simulation Monte Carlo analysis over seven days. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-LTE1-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach. Purple data points indicate Sherpa-LTE1-Microsat close approach.**

## 2.1 Conjunction with Resident Space Objects

The analyses above addresses recontact between spacecraft on the Sherpa-LTE1 Mission, which would be low velocity events. Another concern is the probability of a conjunction with a Resident Space Object (RSO) that is not part of the Sherpa-LTE1 Mission. Each spacecraft is responsible for performing this analysis as part of their Orbit Debris Assessment Report (ODAR). Overall probability of conjunction with an RSO for all spacecraft can be estimated based on the individual spacecraft size and mass as an input into the Debris Assessment Software (DAS v3.1.0) RSO collision analysis. DAS predicts the sum of all objects on the mission have a probability of collision with RSOs of $4.66 \times 10^{-5}$ over the entire orbit lifetime of the spacecraft. Spacecraft with propulsion systems would theoretically be able to avoid RSO collisions with advance notice of such a possible collision, including the Sherpa-LTE1 spacecraft itself. Considering that assumption, the probability of collision for non-propulsive objects with RSOs would be $6.68 \times 10^{-6}$.

# 3. Conclusions

Spaceflight estimates that the probability of recontact for all objects on the Sherpa-LTE1 Mission is $7.0 \times 10^{-4}$, and $3.82 \times 10^{-4}$ assuming debris avoidance capability of propulsive spacecraft, using the approach described in Section 2. Adding the probability of conjunction with a non-Sherpa-LTE1 Resident

Space Object provides a probability of recontact or conjunction with RSO of $7.47 \times 10^{-4}$ (for all objects), or $3.88 \times 10^{-4}$ (for just non-propulsive objects).

| Parent Free Flyer | Spacecraft Name | Spacecraft Type | Operator | Country Of Operator | Quantity | Comment | Propulsion | Deploys Other Spacecraft |
|---|---|---|---|---|---|---|---|---|
| Sherpa-FX2 | Astrocast | CubeSat | Astrocast | Switzerland | 5 | | Y | N |
| Sherpa-FX2 | LEMUR | CubeSat | Spire Global | USA | 3 | | N | N |
| Sherpa-FX2 | Hawk | Microsatellite | Hawkeye 360 | USA | 3 | | Y | N |
| Sherpa-FX2 | Lynk-06 | Microsatellite | Lynk | USA | 1 | | N | N |
| Sherpa-FX2 | SpaceBEE | CubeSat | Swarm Technologies | USA | 12 | | N | N |
| Sherpa-FX2 | PAINANI-2 | CubeSat | CISESE | Mexico | 1 | | N | N |
| *Sherpa-FX2* | *TagSat-2* | *Hosted Payload* | *NearSpace Launch* | *USA* | *1* | *No separation* | *N* | *N* |

| Parent Free Flyer | Spacecraft Name | Spacecraft Type | Operator | Country Of Operator | Quantity | Comment | Propulsion | Deploys Other Spacecraft |
|---|---|---|---|---|---|---|---|---|
| Sherpa-LTE1 | Shasta | Microsatellite | AstroDigital | USA | 1 | | N | N |
| Sherpa-LTE1 | KSM-2 | CubeSat | Kleos Space | Luxembourg | 4 | | Y | N |
| Sherpa-LTE1 | Faraday Phoenix | CubeSat | InSpace | UK | 1 | | N | N |
| Sherpa-LTE1 | Tiger-2 | CubeSat | OQTech | Rwanda | 1 | | N | N |
| Sherpa-LTE1 | LEMUR | CubeSat | Spire Global | USA | 1 | | N | N |
| Sherpa-LTE1 | ARTHUR-1 | CubeSat | Aerospacelab | Belgium | 1 | | Y | N |
| Sherpa-LTE1 | Tenzing | Microsatellite | Orbit Fab | USA | 1 | | Y | N |