REQUEST FOR SPECIAL TEMPORARY AUTHORITY

Spaceflight Inc. ("Spaceflight"), pursuant to Section 25.120 of the Commission's Rules,[1] hereby requests Special Temporary Authority ("STA") to permit it to deploy and operate the Sherpa-LTC1 spacecraft, launching on a SpaceX Falcon 9 for a period not to exceed one hundred eighty (180) days, with such period to commence from their launch and deployment that is scheduled to occur between December 1, 2021, and January 31, 2021. Sherpa-LTC1 will operate for up to one hundred eighty (180) days following launch and deployment.

Overview

The Sherpa LTC1 will be placed in sun synchronous orbit (SSO)at an altitude of 525 km ± 25km at an inclination of 97.59 degrees. At that point and after subsequent delays in accordance with SpaceX requirements, each Rapidly Reconfigurable Avionics (R2A)-Core will initiate a timed sequence of procedures to begin the deployment of its spacecraft from Sherpa-LTC1. Following customer deployment, Sherpa-LTC1 will move on to a demonstration phase, as further detailed below, which will include the deployment of five (5) additional sub-3U spacecraft at 500 km.

Sherpa-LTC1

Spaceflight's Sherpa-LTC1 mission consists of two mission phases, making use of the same Sherpa vehicle the Commission is familiar with. The first (primary) mission phase is the deployment of customer spacecraft, like previous Sherpa missions. This primary mission phase is anticipated to last for less than six (6) hours. During this phase, the Sherpa-LTC1 vehicle deploys customer spacecraft in the same way as the Sherpa-FX1 and Sherpa-FX2. Like those missions, the primary mission phase of Sherpa-LTC1 also uses the Spaceflight R2A-Core sequencer that communicates over L-band with the Globalstar network. Space-to-space communication is used (no space-to-ground link) for the primary mission. It will also carry an S-band receiver and on-board timer.

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[1] Spaceflight also respectfully requests a waiver of Section 25.113(g) of the Commission's rules, requiring orbital deployment approval and operating authority to be applied for and granted prior to orbital deployment and operation of a space station. In this case, given: (1) the short operational life of Sherpa-LTC1; (2) the similarity of its function to that of an upper stage launch vehicle; (3) the descriptions contained herein and in the associated attachments of the spacecraft operations and debris mitigation plans that might otherwise be presented forapproval as part of an application for approval for the orbital deployment and operation of a space station; and (4) the overall public interest of the mission that is presented, Spaceflight urges that the underlying purpose of the rule sought to be waived is met and that the grant of the requested waiver will serve the public interest.

During the primary mission phase, the Sherpa-LTC1 will deploy up to eight (8) spacecraft, seven (7) of which have propulsion.[2] As further described below and in Exhibit A, during a demonstration phase, once the Sherpa-LTC1 has been lowered to 500 km, five (5) additional spacecraft will be deployed.

None of the Sherpa-LTC1 deployed spacecraft will deploy further payloads or spacecraft. The total launch mass ofthe Sherpa-LTC1 will be approximately 362 kg, of which approximately 126.918 kg will be made up of customer spacecraft to be deployed. Sherpa-LTC1 will have two (2) cameras onboard for the purposes of mission assurance and to confirm customer deployments, for which Spaceflight will file for National Oceanic and Atmospheric Administration ("NOAA") licensing.

The Sherpa-LTC1 primary mission phase operates the same way as did the Sherpa-LTE1 primary mission phase. The differences in the overall vehicle missions lie in the demonstration phase. The primary differences are these:

(1) The Sherpa-LTC1 will employ a chemical propulsion system instead of an electronic propulsion system. The chemical propulsion system has undergone the same kind of rigorous testing that was done for the electronic propulsion system used for the ongoing Sherpa-LTE1 mission, which has been performing consistent with mission parameters. Spaceflight anticipates similar results for the chemical system.

(2) The Sherpa-LTC1 will be lowered to an altitude of 500 km, at which time it will deploy the remaining customer spacecraft, five (5) sub 3U spacecraft, including two U.S. Government spacecraft;

(3) Demonstration testing of the Sherpa-LTC1 will continue at that altitude until such time as operations will cease and spacecraft will be left to naturally deorbit; and,

(4) In order to allow higher data rates to enable better command of the space craft as well as video and imaging data that is in high demand for Spaceflight customers, including government customers. additional downlink frequency is being sought, more specifically and as further described below in the 2200-2290 MHZ. These new bands are necessary to support the Sherpa-LTC1 mission which cannot be achieved with just the low UHF downlink that enables limited data rates and was included in the Sherpa-LTE1 mission.

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[2] Currently, 13 spacecraft are expected to be onboard the Sherpa-LTC1. However, the Sherpa-LTC1 manifest may change before launch, Sherpa-LTC1 will carry no more than 13spacecraft on this launch and all risk assessments and analyses of the Sherpa-LTC1 spacecraft factor in the maximum number of spacecraft and highest possible launch mass.

Radio Frequencies To Be Employed

Primary Mission Phase

For the primary mission phase, Spaceflight seeks authority to employ the same frequencies for the LTC1 spacecraft as Spaceflight was authorized for its LTE1 spacecraft. Thus, Spaceflight seeks authority to permit it to establish one-way telemetry link from Sherpa-LTC1 to the Globalstar constellation for an up to 36-hour period during spacecraft deployment. Globalstar will use its own licensed network to downlink the telemetry and is responsible for securing FCC authority to receive signals from R2A-Core on Sherpa-LTC1.[3] The L-band link will permit the Spaceflight technical crew to monitor the deployment of the small spacecraft onboard both Sherpa vehicles. This data will be disseminated both to Spaceflight's customers and to the Combined Space Operations Center (CSpOC).

Spaceflight also seeks authority for the operation of an S-band receive antenna to be connected to Sherpa-LTC1 to enable it to receive signals from a NearSpace Launch owned and operated S-band transmit station.[4] The purpose of this S-band link is to enable the L-band antenna to be shut down from the ground if required to avoid any unanticipated harmful interference and/or as a final failsafe if theL-band antenna is not shut off within 36 hours by operation of its on board timer or lossof battery life. Both Sherpa-LTC1 is equipped with a GPS receive unit to enable it to be more easily tracked. Authority for that unit is also hereby requested.[5]

After the 36-hour period, R2A-Core and communication to or from the EyeStarS3 Black Box Radio will shut down completely. Sherpa-LTC1 will then move on to its demonstration mission phase.

Sherpa-LTC1 Demonstration Mission Phase

For the Sherpa-LTC1's demonstration mission phase, Spaceflight seeks authority for UHF uplink, S-Band uplink and UHF downlink to ground (all of which were authorized and are being employed for Spaceflight's Sherpa-LTE1 mission) and, new to this mission, S-band downlinks. Use of the frequencies below will enable Spaceflight to demonstrate control and propulsive elements, rapidly deorbit the vehicle, and collect data for future missions. To lower the spacecraft to 500 km, an onboard computer (the same one as being used for Sherpa-LTE1) with spacecraft sensors and effectors will provide command and control over the Sherpa-LTC1 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 at 500

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[3] R2A-Core does not transmit signals to the ground, except through the Globalstar constellation network.

[4] This is the same facility for which NearSpace Launch was authorized to use to support Spaceflight's FX1 and FX2 missions.

[5] There may also be a passively modulated radar reflector to help identify Sherpa sooner among the cluster of objects separated by the launch vehicle. This radar reflector does not transmit or receive any radio frequencies and is simply a component to assist identification and tracking.

km, then point the vehicle to sun-normal for solar panel charging. Spaceflight will use flight-proven space-to-ground communications over UHF. In addition, Spaceflight will employ a mixed-mode transceiver that can uplink via S-band. This backup can be used in the event UHF uplink is unavailable.

The additional S-band will be used to issue full command orders to the Sherpa-LTC1. The higher data rates will ensure that Spaceflight can transmit telemetry and command data while the chemical propulsion system is engaged. The downlink will also facilitate the downlink of video and imagery confirming customer separation, another critical and in-demand function for the Sherpa-LTC1. Both needs are consistent with the international Space Operations Service allocation in this band and similar to what the Commission has authorized for launch vehicle frequency use in the past.[6]

A summary of frequencies to be used is detailed in the table below[7]:

Sherpa-LTC1 Transmissions

Parameter	L-band Uplink to Globalstar	UHF Uplink to Sherpa	S-Band Uplink to Sherpa (Primary Mission)	UHF Downlink to GND	S-Band uplink to Sherpa (Demonstration Mission)	S-Band Downlink to GND	S-Band uplink to Sherpa (Demonstration Mission)
Data Rate	100 bps	38.4 Kbps	38.4 Kbps	38.4 Kbps	250 kbps	250 kbps	20.3 Mbps
Modulation	BPSK	2-GFSK	2-GFSK	2-GFSK	2-GFSK	2-GFSK	DVB-S2(X)
Center Frequency or Frequency Range	1616.25 MHz	402.9 MHz	2075 MHz	400.5 MHz	2025-2120 MHz	2200-2290 MHz	2025-2120 MHz
Bandwidth	2.5 MHz	40 KHz	300 KHz	40 KHz	300 KHz	500 KHz	5.0 MHz
Transmit Power	0.10 W (max)			36 dBm (max)	16.5 dBW	3 dBW	13 dBW
Transmit Antenna/Gain	Patch			Monopole/2.0 dBi	5.4m Dish	Patch/+5.5 dBi	5.4m Dish/42.3 dBi
EIRP	-8 dBW			6 dBW (max)	+53.0 dBW	+9 dBW	+53.0 dBW
Polarization	RHCP			Linear	RHCP	RHCP	RHCP
Receive Antennas	Patch (S-band, GPS)/ 4.5 dBi	Monopole/1.9 dBi	Active Patch/5.5 dBi		Active Patch/5.5 dBi	5.4m Dish	Single Patch/5.5 dBi
Receive Noise Temp.	250 K					225 K	330 K
Receive System Figure of Merit (G/T)	-19.5 dB/K					16 dB/K	-20.7 dB/K
Encryption	AES-256	AES-256	AES-256	AES-256	AES-256	AES-256	AES-256
Duty Cycle (max)	50%	50%	50%	50%	50%	50%	50%

[6] See *Allocation of Spectrum for Non-Federal Space Launch Operations, Amendment of Part 2 of the Commission's Rules for Federal Earth Stations Communicating with Non-Federal Fixed Satellite Service Space Stations; and Federal Space Station Use of the 399.9-400.05MHz Band*, Report and Order and Further Notice of Proposed Rulemaking, FCC 21-44 (rel. Apr 22, 2021) at ¶17 ("*Launch Frequency Order and NPRM*"). The Commission identified dozens of STA requests granted to SpaceX and Blue Origin that have been granted for use of the 2200-2900 MHz band by launch vehicles. *Launch Frequency Order and NPRM* at note 57.

[7] The ground facilities to be employed are described in the attached Technical Annex.

With regard to these frequencies, Spaceflight understands that it will need waivers to use 402.9 MHz and the 2200-2290 MHz bands as non-conforming uses. Such waivers are respectfully requested. With regard to use of 400.5 MHz, Spaceflight understands that its use would be permitted only on a secondary, non-interference basis.

With regard to all frequencies to be employed that were and/or are also being employed for Spaceflight's Sherpa FX2/Sherpa LTE1 missions, Spaceflight will observe all operating restrictions and coordination conditions for its new Sherpa LTC1 missions as were specified in the grant to Spaceflight of Special Temporary Authority for its Sherpa FX2/Sherpa LTE1 mission.[8]

With regard to the new downlink frequencies sought to be employed in the 2200-2290 MHz band, Spaceflight understands that any such use will be subject to coordination with NTIA and other federal agencies. To facilitate that coordination, Spaceflight will limit its use to communications with earth stations that are located outside of the United States. Spaceflight notes that its proposed use for Space Operations communications, while a non-conforming use in the United States, would be consistent with the International Table of Frequency Allocations[9] and with Commission precedent for grant of such use.[10] Further, given recent changes in the U.S. Table to permit use of this band for space launch operations and the recognized similarity in function between Spaceflight's Sherpa vehicles and the upper stage of a launch vehicle,[11] not to mention proposals to allow for broader use for payload communications,[12] waiver to permit use of the band on a non-conforming basis by Spaceflight to support the operation of its Sherpa-LTC1 spacecraft, subject to coordination with NTIA, is particularly appropriate.

Customer Manifest:

The current customer manifest for Sherpa LTC1 is attached as Exhibit D Because the availability of customer spacecraft can change closer to the time of launch, Spaceflight requests that the authority it be granted include authority to substitute non-separating mass module(s) for customer spacecraft that are not available.

Responsibilities of Owners/Operators of Spacecraft to be Deployed; Customer Manifests

The spacecraft to be deployed on the Sherpa-LTC1 are owned and to be operated by Spaceflight's customers or, in some cases, their customer operator. Each customer is

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[8] IBFS File No. SES-STA-20210295-00017

[9] 47 C.F.R. § 2.106.

[10] *Stamp Grant*, Loft Orbital Solutions Inc., IBFS File Nos. SAT-LOA-20190807-00072, SAT-AMD-20200527-00063, as corrected Oct 14, 2020, Condition #10.

[11] See 47 C.F.R. § 2.106, note US 96; see also *Launch Frequency Order and NPRM* at ¶22.

[12] *Launch Frequency Order and NPRM* at ¶143.

expressly required under its agreement with Spaceflight to obtain and/or require its customer operator to obtain all licenses, authorization, clearances, and permits from their applicable administrations that may be necessary to operate its individual spacecraft. The above referenced customer manifest includes the identity of customers or, if different, operators, and their authorizing administrations.

Exhibits

A more detailed technical showing is attached as Exhibit A.

An Orbital Debris Assessment Report ("ODAR") for Sherpa-LTC1 is attached hereto as Exhibit B

A Recontact Probability Analysis relative to the customer spacecraft to be deployed by SherpaLTC1 is attached hereto as Exhibit C.

Lists of customers/operators for the spacecraft to be deployed are attached hereto as Exhibit D

Exhibit E, together with Attachment 1 and 2 detailing Spaceflight's ownership information is attached hereto.

An ITU Cost Recovery Letter is provided as Exhibit F hereto. Spaceflight notes that the attached letter does not have the Commission file number for this Request which will only be available after the Request is filed. Once available, Spaceflight will resubmit the ITU Cost Recovery Letter with that file number.

Spaceflight also has under preparation and will submit as soon as possible a SpaceCap filing covering the frequencies requested for use herein.

Conclusion

Spaceflight urges that grant of the instant request for Special Temporary Authority will be in the public interest. Such grant will permit Spaceflight to continue to provide its new and innovative deployment technology for small spacecraft, thereby providing a cost-efficient means for placing them into their designed orbits.

Exhibit A
Technical Annex to STA

Spaceflight's Sherpa-LTC1 Mission

Spaceflight, Inc, ("Spaceflight") is planning to launch and deploy a Sherpa-LTC1 on a Space Exploration Technologies Corporation ("SpaceX") Falcon 9 (the "Mission"). Sherpa-LTC1 consists of **two (2) distinct missions**: (i) deploy customer spacecraft ("Primary Mission"), and (ii) a demonstration orbit lowering and deployment of customer spacecraft ("Demonstration Mission").

Sherpa-LTC1 is scheduled to be launched by Space Exploration Technologies Corporation (SpaceX) on a Falcon 9 launch vehicle between 1 December 2021 and 31 January 2022. The Sherpa-LTC1 will separate from the Falcon 9 upon receipt of a separation commands from the launch vehicle once the launch vehicle reaches the destination orbit, targeted at 525 km, with a tolerance of ± 25km. In addition to the Sherpa-LTC1 , the Falcon 9 will have multiple rings with SpaceX's own customers stacked above and/or below the ring to which Spaceflight's Sherpa-LTC1 is attached.

Sherpa-LTC1

Like previous missions, SSO-A[1], Sherpa-FX1[2], and Sherpa-FX2, Sherpa-LTC1 consists of several structural elements to mount both microsatellites and CubeSat dispensers. The Sherpa-LTC1 Primary Mission phase is the deployment of eight of the customer spacecraft being carried by the vehicle. This Primary Mission phase is anticipated to last for less than six (6) hours. During this phase, the Sherpa-LTC1 vehicle will deploy customer spacecraft in the same way as the Sherpa-FX1 and Sherpa-FX2.

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[1] SAT-STA-20180523-00042.

[2] SAT-STA-20200728-00089.

Sherpa-LTC1 utilizes the R2A-Core system for its primary mission to command the deployment of approximately 8 customer spacecraft into SSO.[3] Sherpa-LTC1 will also have two (2) cameras onboard for the purposes of mission assurance and to confirm customer deployments. Spaceflight provides the launch capacity, structure, separation systems, and integration services for the customer spacecraft. Sherpa-LTC1 will be attached to a single port on a SpaceX-provided payload ring. Once a separation signal is received by Sherpa-LTC's separation system from SpaceX's Falcon 9 avionics, Sherpa-LTC1 will separate. The internal volume of Sherpa-LTC1 will contain R2A-Core sequencer and batteries. After Sherpa-LTC1's separation from Falcon 9 (and a subsequent delay in accordance with SpaceX requirements), once activated, the R2A-Core will initiate its own separation sequence to deploy customer spacecraft

The R2A-Core also activates the EyeStar S3 Black Box Radio (provided by NearSpace Launch, and more fully described below) and, specifically, the L-band transmitter that sends deployment confirmation telemetry to the Globalstar constellation for relay by commercial Globalstar and NearSpace Launch data services to Spaceflight.

The Sherpa-LTC1 Primary Mission is anticipated to last less than six (6) hours, and all communications from R2A-Core will stop at or less than 36 hours after launch. The R2A-Core is equipped with an S-band receiver contained within the EyeStar Radio to allow a kill-command to be sent from a ground station operated by NearSpace to deactivate the transmitter in the event of radio frequency interference. The R2A-Core will also have an on-board timer to cut off its transmissions several hours after the end of the planned deployment cycle. If all else fails, battery life is expected to be exhausted by 36 hours into the mission.

[3] Spaceflight notes that while the Sherpa-LTC1 manifest may change before launch, Sherpa-LTC1 will carry no more than thirteen (13) spacecraft on this launch and all risk assessments and analyses of the Sherpa-LTC1 spacecraft factor in the maximum number of spacecraft and highest possible launch mass. The Mission analyses will be rerun with the final spacecraft configuration and Spaceflight expects the analyses to show improved results compared to those presented in this application.

Figure 2: Physical architecture of Spaceflight's Sherpa-LTC1 with customers on a Falcon 9 Rideshare Mission.

Sherpa-LTC1 Demonstration Mission

Sherpa-LTC1 includes additional hardware to demonstrate control and propulsive elements, rapidly deorbit the vehicle, and collect data for future missions. Instead of concluding the mission after completing the primary phase of customer deployments, the Demonstration Mission will reduce the initial orbit, and after the deployment of five (5) sub-3U cubesats, proceed to remain active in that final orbit to collect performance data and execute demonstration maneuvers. This mission will demonstrate the capabilities and effectiveness of two primary subsystems. The first is the same onboard computer that flew on Sherpa-LTE1, with spacecraft sensors and effectors to provide command and control over the Sherpa vehicle. This system makes 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 point the vehicle to sun-normal for solar panel charging. Also, during this time, the second modular system, a chemical propulsion assembly from Benchmark Space Systems, will be commissioned to lower the Sherpa vehicle altitude to 500km. Orbit lowering will be accomplished through a series of retrograde impulsive maneuvers. Upon completion of the Demonstration Mission and performance monitoring objectives, Spaceflight will decommission Sherpa for an uncontrolled reentry. Spaceflight will work with the 18th Space Control Squadron for planned propulsive maneuvers to screen for any close approaches to other space objects.

For the Demonstration Mission phase, Spaceflight will use flight-proven space-to-ground communications over UHF and S-band for command and health data TT&C. In addition, Sherpa will include a new dual X-band[4] and S-band transceiver to test capabilities for greater situational awareness and higher data rates, as well as greater levels of encryption. The higher data rates will allow Spaceflight to deliver in-demand images and video of customer spacecraft separating from the Sherpa-LTC1.

RF System Design – R2A-Core

The R2A-Core has an L-band transmitter, an S-band receiver, and a GPS L-band receiver. The L-band transmitter broadcasts through one simplex patch antenna to the Globalstar constellation using a NearSpace Launch the EyeStar S3 Black Box Radio, the same system that flew on the Sherpa-FX1 and Sherpa- FX2 missions. The EyeStar S3 Black Box Radio has an absolute temperature operating range between -40°C and 60°C. If found to be outside of that range for too long, the transmitter will stop working. The EyeStar S3 Black Box Radio unit transmits 99.00% of its radiated power within 1.8817 MHz of the specified 2.5 MHz bandwidth. The EyeStar S3 Black Box Radio also includes an integrated Novatel GPS receiver module that works in conjunction with a GPS patch antenna.

[4] Because the unit is designed to include both X-band and S-band elements, it would not be practical physically to prevent the X-band from being capable of transmitting while keeping the S-band transmitter active. Nevertheless, Spaceflight will not seek authority to transmit in X-band and will not transmit for any purpose in X-band during the Mission.

Other radio property details are shown in the following table:

Sherpa R2A-Core Communication System (for Sherpa-LTC1 Primary Mission)[5]	
Parameter	**L-band Uplink to Globalstar**
Data Rate	100 bps
Modulation	BPSK
Center Frequency	1616.25 MHz
Bandwidth	2.5 MHz
Transmit Power	0.10 W (max)
Transmit Antenna	Patch
Receive Antennas	Patch (S-band, GPS)
EIRP	-8 dBW
Encryption	AES-128 and AES-256
Duty Cycle (max)	50%

RF Concept of Operations

The L-band avionics systems are set to beacon data to the Globalstar constellation from activation until cut off by a timer set to shut off transmissions once the deployments of all customer spacecraft are complete. The duty cycle for the L-band system is a transmission up to 10 seconds every 20 seconds (30 seconds of broadcast time per minute; a 50% duty cycle). The EyeStar S3 Radio has an S-band uplink that can receive a kill command from the NearSpace Launch ground station.

The L-band transmitter will continue to broadcast until the earliest of the following:

- Programmed stop (via R2A-Core's onboard mission sequence); or
- Kill command from S-band ground transmitter; or
- Battery depleted (No more than 36 hours after starting).

The S-band receive antenna's purpose is solely to receive a kill command from the ground.

[5] The R2A-Core will not be used for the demonstration mission.

Sherpa-LTC1 Demonstration Mission Communication System

Communication details for the Primary Mission and Demonstration Mission phase of the Sherpa-LTC1 mission are provided in the following table:

Sherpa-LTC1 Transmissions							
Parameter	L-band Uplink to Globalstar	UHF Uplink to Sherpa	S-Band Uplink to Sherpa (Primary Mission)	UHF Downlink to GND	S-Band uplink to Sherpa (Demonstration Mission)	S-Band Downlink to GND	S-Band uplink to Sherpa (Demonstration Mission)
Data Rate	100 bps	38.4 Kbps	38.4 Kbps	38.4 Kbps	250 kbps	250 kbps	20.3 Mbps
Modulation	BPSK	2-GFSK	2-GFSK	2-GFSK	2-GFSK	2-GFSK	DVB-S2(X)
Center Frequency or Frequency Range	1616.25 MHz	402.9 MHz	2075 MHz	400.5 MHz	2025-2120 MHz	2200-2290 MHz	2025-2120 MHz
Bandwidth	2.5 MHz	40 KHz	300 KHz	40 KHz	300 KHz	500 KHz	5.0 MHz
Transmit Power	0.10 W (max)			36 dBm (max)	16.5 dBW	3 dBW	13 dBW
Transmit Antenna/Gain	Patch			Monopole/2.0 dBi	5.4m Dish	Patch/+5.5 dBi	5.4m Dish/42.3 dBi
EIRP	-8 dBW			6 dBW (max)	+53.0 dBW	+9 dBW	+53.0 dBW
Polarization	RHCP			Linear	RHCP	RHCP	RHCP
Receive Antennas	Patch (S-band, GPS)/ 4.5 dBi	Monopole/1.9 dBi	Active Patch/5.5 dBi		Active Patch/5.5 dBi	5.4m Dish	Single Patch/5.5 dBi
Receive Noise Temp.	250 K					225 K	330 K
Receive System Figure of Merit (G/T)	-19.5 dB/K					16 dB/K	-20.7 dB/K
Encryption	AES-256	AES-256	AES-256	AES-256	AES-256	AES-256	AES-256
Duty Cycle (max)	50%	50%	50%	50%	50%	50%	50%

Spaceflight is planning to use operational ground stations from three (3) providers: Astro Digital, Amazon, and RBC. The system architecture has a primary radio set that operates using UHF for full duplex operation, and is flight proven through two ground stations in Tromso, Norway and Santa Clara, California. These two ground stations are already in use with the same flight hardware that will be used for the Demonstration Mission. Spaceflight is also planning on using two UHF receive stations at Windham, New York and Fairbanks, Alaska. In addition, an S-band uplink (at 2075 MHz) is planned to be deployed through Tromso, Norway and Deadhorse, Alaska. The S-band receiver is planned to be used as a backup for this mission, also with the objective of evaluating its use as a future primary uplink for Sherpa communications. All space-to-ground data is downlinked over UHF, or S-band (2200-2290 MHz).

Ground station information is provided in the following table. All ground stations listed are currently operational on the frequencies shown. The providers listed in the table below are responsible for obtaining license modifications to allow for communication to and from Sherpa-LTC1.

Sherpa-LTC1 Ground Stations (Demonstration Mission Phase)			
Ground Station Location	**UHF**	**S-band**	**Status**
Tromso, Norway (Primary)	Up + Down	None	Operational, License Mod
Santa Clara, CA	Up + Down	Up	Operational, License Mod
Deadhorse, AK (Primary)	Down	Up	Operational, License Mod
Windham, NY	Down	None	Operational, License Mod
Fairbanks, AK	Down	None	Operational, License Mod
Dublin, Ireland	None	Down	Operational
Sydney, Australia	None	Down	Operational
Vasteras, Sweden	None	Down	Operational
Puntas Arenas, Chile	None	Down	Operational
Capetown, South Africa	None	Down	Operational
Zallaq, Bahrain	None	Down	Operational
Seoul, South Korea	None	Down	Operational

UHF Operations

With regard to these frequencies, Spaceflight understands that it will need a waiver to use 402.9 MHz. as a non-conforming use. Spaceflight will coordinate with federal agencies as to this and other proposed frequencies, the use of which is consistent with past Spaceflight missions. With regard to use of 400.5 MHz, Spaceflight understands that its use would be permitted only on a secondary, non-interference basis. Lastly, operations in the 400.15-403 MHz frequency band shall not exceed the long-term interference criteria limits specified in Table 2 (Type C) of Recommendation ITU-R RS.1263-2 to protect NOAA radiosondes operations in the United States and Possessions.

S-Band Operations

2025-2120 MHz

This band is allocated to the Space Operation service on a primary basis subject to conditions as may be applied on a case-by-case basis and the limitation that any use may not cause harmful interference to Federal and non-Federal stations operating consistent with the Table of Frequency Allocations. Spaceflight seeks to use this band on a non-interference basis with regard to higher status users of this band and will coordinate with those users to ensure that Spaceflight's operations will not cause harmful interference. Spaceflight's limited, short-term operations, coupled with the use of software-defined radios, should facilitate coordination in any available segment of the band.

2200-2290 MHz

Spaceflight seeks to use one 500-kilohertz channel anywhere in the 2200-2290 MHz band to land imaging and video data. Spaceflight's operations will only require the use of this band when in line of sight over one of seven earth stations (Dublin, Ireland; Sydney, Australia; Stockholm, Sweden;

Capetown, South Africa, Zallaq, Bahrain, Seoul, South Korea and Puntas Arenas, Chile). Spaceflight will not use this band to communicate with an earth station inside the United States or its territories. Each transmission pass over one of the potential earth stations will take approximately 5-10 minutes and will occur 2-5 times per day. The duty cycle will not exceed 50% throughout the mission.

In the 2200-2290 MHz band, Spaceflight's transmissions shall not cause harmful interference to Federal stations operating consistent with the Table of Frequency Allocations. Subject to coordination, Spaceflight can operate its carrier in the portion of the 2200-2290 MHz band where traffic is lowest and Spaceflight's use is most compatible with incumbent government and commercial operators. Initial research suggests one of the following center frequencies could support Spaceflight's mission: 2207.5 MHz, 2212.5 MHz, 2217.5 MHz, 2272.5 MHz, or 2287.5 MHz. Spaceflight's limited, short-term operations, coupled with the use of software-defined radios, should facilitate coordination in the identified center frequencies or any other segment of the 2200-2290 MHz band.

The Commission's rules do not specify a PFD limit in the 2200–2290 MHz band; however, there are PFD limits specified in rule No. 21.16 of the International Telecommunication Union (ITU) Radio Regulations. The maximum PFD levels for the LTC-1 transmissions were calculated for the 2200-2290 MHz band. Figure 1 below illustrates the S-band downlink PFD values in comparison with the ITU PFD limits in No. 21.16. This figure represents the maximum transmitted EIRP when the satellite is at the orbital altitudes of 500 km and 525 km. Spaceflight will not transmit at elevation angles where it cannot meet the PFD limits, as shown below, or will attenuate the transmitted RF power accordingly to meet the PFD limits.

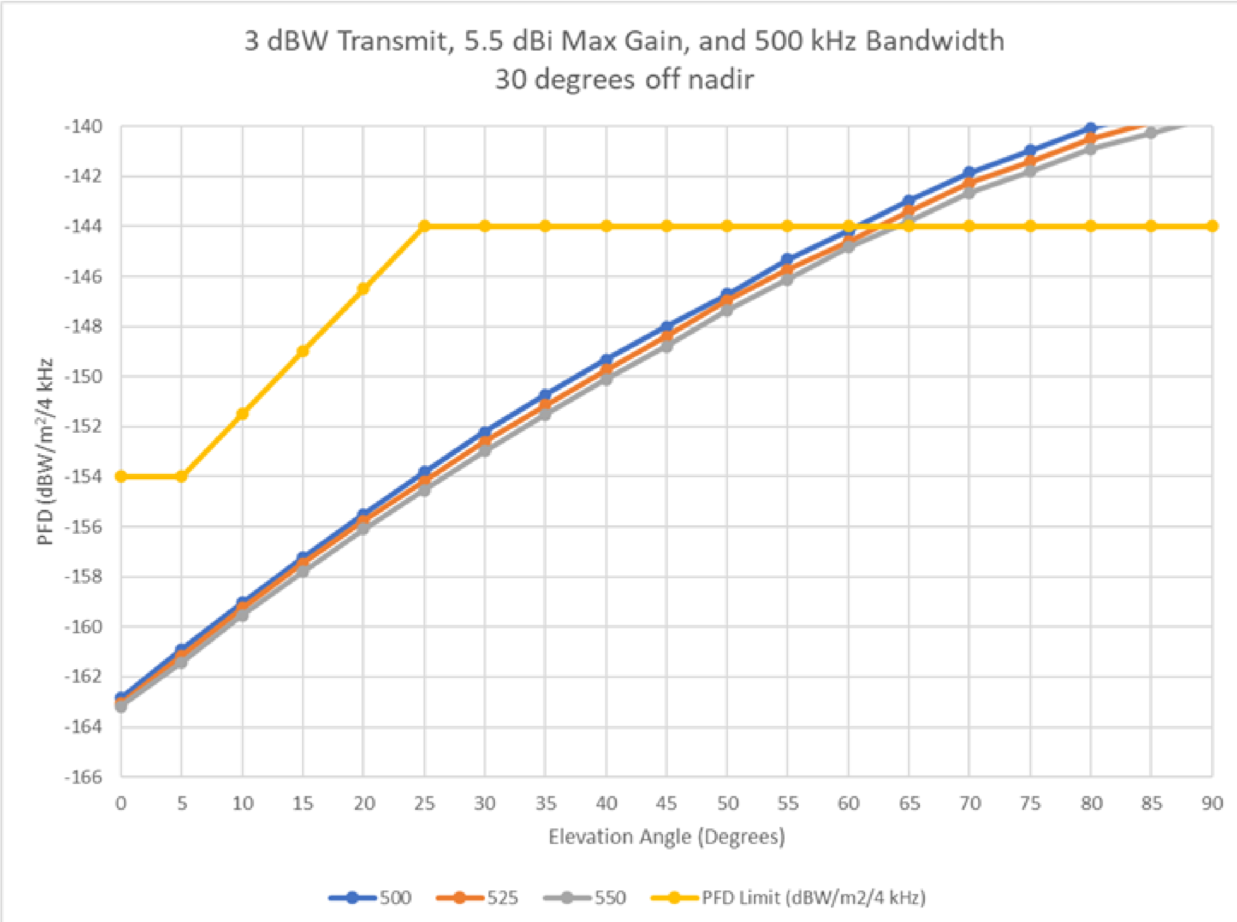

Figure 1: PFD Demonstration for the 2200-2290 MHz Band

Figure 2 shows the simulated radiation pattern of the antenna for phi (azimuth) angles 0, 45, 90, 135, and 180.

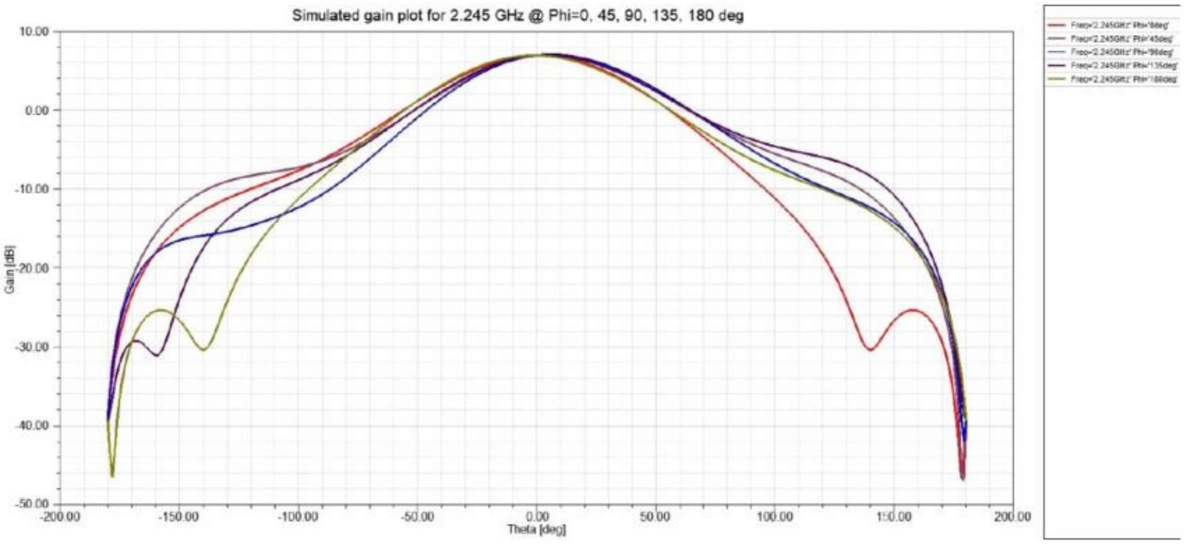

Figure 2: Simulated Radiation Pattern for 2200-2290 MHz Band

Sherpa-LTC1 Orbital Debris Assessment Report (ODAR)

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

Report Version 1
August 11, 2021

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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-8719.14B.

Orbital Debris Self-Assessment Report Evaluation: Sherpa-LTC1 on December 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 U.S., and governed by the rules and regulation of the U.S.; this ODAR follows the format recommended in NASA- STD-8719.14b, Appendix A.1 and includes the content indicated at a minimum in each Section 2 through 8 below for the December 2021-January 2022 SpaceX Rideshare Mission. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Project Manager: Mike Coletti

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

Schedule of upcoming mission milestones:
Launch: December 2021-January 2022

Mission Overview:
The December 2021-January 2022 SpaceX Rideshare Mission ("Transporter-3") is a commercial rideshare mission, for which the primary objective of Spaceflight Inc. is deploying approximately 13 customer spacecraft into a planned sun-synchronous circular orbit of 525 km with a tolerance of ± 25 km. The launch vehicle will deploy an orbital transfer vehicle called "Sherpa-LTC1", which deploys the majority of its additional customer spacecraft within several hours of launch and launch separation. (*Each of these satellite customers are responsible for obtaining an FCC or other agency or administration authorization as appropriate and does not constitute debris*). This represents a worst-case scenario and ensures that any changes to the Sherpa-LTC1 manifest will be bounded by our ODAR analysis here.

Spaceflight's Sherpa-LTC1 is an upgraded version of the Sherpa vehicle variant, similar to the previously licensed Sherpa-LTE1. Sherpa-LTC1 will have attitude control, chemical propulsion, and the same forward port adapter to accommodate additional microsatellites as Sherpa-LTE1. The Sherpa-LTC1 demonstration mission consists of two mission phases. The first (primary) mission phase is the deployment of eight (8) customer spacecraft. This phase is anticipated to last for less than six (6) hours after launch. During this phase, the Sherpa-LTC1 vehicle deploys customer spacecraft in the same way as the previously licensed Sherpa vehicles. The material difference between the Sherpa-LTC1 mission and previous Sherpa-FX missions is that instead of concluding the mission after finishing all deployments at the orbital altitude in which the vehicle was first inserted by the launch vehicle, Sherpa-LTC1 will undertake a demonstration mission phase to reduce the altitude of the spacecraft to a 500 km altitude. The remaining five (5) customers will be deployed from Sherpa-LTC1 at this new orbit, and then Sherpa-LTC1 will rely on atmospheric drag to deorbit. This demonstration mission should take approximately three (3) weeks, but Spaceflight will continue to gather valuable flight data from LTC-1 through the term of its Special Temporary Authority.

During the demonstration mission, a new modular system will be enabled and tested, in addition to the previously-flown onboard computer with sensors and effectors to provide command and control over the Sherpa vehicle. This command and control 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 toward the sun for solar panel charging. The new modular system is a chemical propulsion deck from Benchmark Space Systems, which will be commissioned to be used to lower the Sherpa vehicle altitude from 525 km to approximately 500 km and perform inclination adjustments. Orbit lowering will be accomplished through a series of retrograde thruster firings. This set of maneuvers will demonstrate propulsive capability of the Sherpa system, while providing key performance data for the Benchmark Space Systems propulsion system. From that altitude, Spaceflight will decommission Sherpa for reentry by atmospheric drag, which at this lower altitude will take about 6.9 years.

ODAR Configuration:
ODAR analysis was run for two (2) potential scenarios (Nominal Mission and Failed Mission). The results presented here for the Failed Mission envelope the worst-case scenario and our final mission analyses shall be no worse than these initial baselined numbers. Since the physical architecture layout of the Sherpa vehicles is often not finalized until approximately Launch – three (3) months, due to customer remanifest, vehicle optimization, etc., Spaceflight seeks to initially present these worst-case, generalized results for the Sherpa-LTC1 vehicle now. Once the physical architecture has been finalized, Spaceflight shall rerun our ODAR analysis and provide an updated ODAR report to the Commission demonstrating that the finalized ODAR shows equal or improved results compared to those baselined in this submission. This approach seeks to demonstrate what the Commission can expect as a worst-case scenario initially and will also mitigate the potential for the Commission's review of the results of this analysis to become outdated as physical architecture changes during the course of mission preparation.

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

- *Nominal Mission*: All customer deployments successful, demonstration mission successful.
- *Failed Mission:* All spacecraft deployments unsuccessful, demonstration mission unsuccessful, which represents a worst-case. In an entirely separate case, where spacecraft deployments are unsuccessful or partially unsuccessful, but the demonstration mission of altitude reduction is still viable, orbit lifetime would only be improved compared to this *Failed Mission* case where both primary and demonstration mission are unsuccessful. Thus, the *Failed Mission* case presented here is the worst-case scenario.[1]

In order to most accurately perform analysis within the constraints of the DAS tool, ODAR analyses contained in this report were run for the scenarios in the following table, showing comparison to the intended mission.

Scenario	DAS Analysis	Mission	Delta between DAS and Mission
Sherpa-LTC1 Nominal Mission	500 km operational orbit	550 km deployment, reduction to 500 km operational orbit	Initial time to commission subsystems (~ 3 weeks) at the initial 550 km is not captured in DAS due to DAS program constraints[2]
Sherpa-LTC1 Failed Mission	550 km, no PMD	550 km, no PMD	None

[1] In addition to assuming the highest possible mass, Spaceflight has also assumed the highest target orbit and highest ballistic coefficient throughout the orbit lifetime of the vehicles.
[2] The orbit lifetime of the Sherpa-LTC1 *Nominal Mission* is under the 25-year orbit lifetime requirement with the initial 3-week phase considered.

ODAR Summary:

- No debris released in normal operations;
- No credible scenario for breakups;
- The collision probability with other objects is compliant with NASA standards; and
- The estimated worst-case 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.

	Nominal Mission	Failed Mission
Sherpa-LTC1	9.2 years	23.2 years

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

Proposed launch date: December 2021

Mission duration:

Maximum Sherpa-LTC1 Nominal Transmitting Operations:

- < 6 months

Post-Mission Orbit lifetime:

- For a Nominal Mission at 500 km, Sherpa-LTC1 has a predicted post-mission orbit lifetime of 9.2 years.

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

Sherpa-LTC1

	Apogee Altitude	Perigee Altitude	Inclination	Duration
Deployment Orbit	525 ± 25 km	525 ± 25 km	97.384 ± 0.1 deg	Mission Duration: ~3 weeks
Demonstration Mission Orbit	500 ± 25 km	500 ± 25 km	96.5 deg	Transit: ~3 weeks Mission Duration: 3 weeks with post-mission checkups occurring for the remaining 4 months
End-of-Life Orbit	500 ± 25 km	500 ± 25 km	96.5 deg	9.2 years (nominal) 23.2 years (failed, 550 km mission)

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:

Sherpa-LTC1 is a propulsive orbital transfer vehicle that is designed to deploy auxiliary spacecraft and transit to different orbits. It is structurally alike to the previously licensed Sherpa-FX1[3] and Sherpa-FX2.[4] The separation system and customer payload layout on Sherpa-LTC1 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 vehicle. A microsatellite, CubeSat dispenser, or other adapter for separation system mounting can be affixed on the outboard end of Sherpa-LTC1. Thus, Sherpa-LTC1 will deploy customers in the same fashion as the previously licensed Sherpa-FX1 and FX2. For this Mission, the currently planned configuration has three (3) microsatellites on the outboard end of Sherpa-LTC1, with ten CubeSats integrated in various dispensers attached radially on the body of Sherpa-LTC1.[5] The Sherpa-LTC1 Mission configuration also includes an S-band receive antenna and an L-band transmitter as part of its avionics.

Sherpa-LTC1 will be attached to a single port on a SpaceX-provided payload ring. The SpaceX Falcon 9 launch vehicle will have multiple rings with SpaceX's other customers stacked above and/or below the ring on which Spaceflight's Sherpa-LTC1 is attached. Once a separation signal is received by Sherpa-LTC1's separation system from SpaceX's Falcon 9 avionics, the Sherpa-LTC1 will separate. After Sherpa-LTC1's separation from SpaceX's Falcon 9 launch vehicle and a subsequent delay in accordance with SpaceX requirements, once activated, the R2A-Core will execute an onboard mission sequence to deploy the majority of the customer spacecraft. The internal volume of Sherpa-LTC1 will contain R2A-Core sequencer and batteries. Sherpa-LTC1 utilizes the R2A-Core system for its primary mission to command the deployment of approximately 8 customer spacecraft into SSO.

The R2A-Core also activates the EyeStar S3 Black Box Radio (provided by NearSpace Launch) and, specifically, the L-band transmitter which sends deployment confirmation telemetry to the Globalstar constellation for relay by commercial Globalstar and NearSpace Launch data services to Spaceflight.

Sherpa-LTC1 will also have two (2) cameras onboard for the purposes of mission assurance and to confirm customer deployments.

Spaceflight's Sherpa-LTC1 mission consists of two (2) mission phases. The Sherpa-LTC1 Primary Mission phase is the deployment of customer spacecraft at the initial 525 km altitude. This phase is anticipated to last for less than six (6) hours. During this phase, the Sherpa-LTC1 vehicle will deploy customer spacecraft in the same way as the Sherpa-FX1, Sherpa-FX2 and Sherpa-LTE1 missions.

The material difference between the Sherpa-LTC1 mission is that instead of concluding the mission after finishing its deployments at the orbital altitude in which the Sherpa-LTC vehicle is first inserted by the launch vehicle, it will undertake a demonstration mission phase to reduce the altitude of the spacecraft to a 500 km altitude. The remaining customers' spacecraft will be deployed from Sherpa-LTC1 at this new orbit, and then Sherpa-LTC1 will rely on atmospheric drag to deorbit.

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

[4] SAT-STA-20210205-00017 Spaceflight, Inc. Sherpa-FX2 and Sherpa-LTE1 STA.

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

In a case where any combination of spacecraft are unable to make the mission, a non-separating mass model will either be inserted into a locked dispenser door or affixed directly to the Sherpa structure, depending on the missing spacecraft's form factor. These mass models are materially and physically the same as those evaluated in Spaceflight's previous Sherpa-FX2 license submission and therefore have not been included in this new risk analysis. In the Sherpa-FX2 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-LTC1 structure.

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

Sherpa-LTC1	362 kg[6]

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

Sherpa-LTC1	360.4 kg

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

Sherpa-LTC1	258 kg

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

Sherpa-LTC1 has a chemical propulsion assembly from Benchmark Space Systems.

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

Fluids in Pressurized Batteries: None.

Power System #1: Sherpa-LTC1 uses two of the same NiMH battery packs previously used on the Sherpa-FX1 mission.

Power System #2: Sherpa-LTC1 batteries contained in the attitude and control system, called Command and Control System (CCS), are four unpressurized Commercial off-the-shelf (COTS) Lithium-ion battery cells.

Power System #3: Sherpa-LTC1 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: Sherpa-LTC1 has attitude control.

Fifteen minutes after activation, the reaction wheels on Sherpa-LTC1 will be used, if necessary, 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. Sherpa-LTC1 also includes the following:

[6] Satellite mass at launch is based on current manifest. Spaceflight's mass at launch will not exceed 362 kg for Sherpa-LTC1.

- A *<u>sun pointing safe mode</u>* 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 *<u>sun pointing link mode</u>* that is optimized for solar power generation and allows the satellite to maintain an intersatellite link with the OISL. The Sherpa-LTC1'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 *<u>velocity tracking mode,</u>* 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 Sherpa-LTC1'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:

Sherpa-LTC1 contains Power Systems #1-3, described below.

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-LTC1 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 demonstration 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-LTC1 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 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 Failure Mode and Effects Analysis (FMEA) (see requirement 4.4-1 below) describe the combined faults that must occur for any of seven (7) independent, mutually exclusive failure modes to lead to explosion.

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

There are no planned breakups.

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

No components require passivation at EOM.

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

N/A

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

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

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

Compliance statement:

Required Probability: 0.001.

Expected Probability: 0.000.

Supporting Rationale and FMEA details:

Battery explosion:

Effect: All failure modes below might theoretically result in battery explosion with the possibility of orbital debris generation. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of the selected space-rated COTS battery cells is such that while the Sherpa-LTC1 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 the 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 cell's 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 Sherpa-LTC1 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-LTC1 is designed such that when mission operations begin, all energy from the secondary batteries will dissipate within 36 hours. The primary batteries will dissipate all energy within 36 hours. Additionally, Sherpa-LTC1 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.

On Sherpa-LTC1, the CCS has 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	Failed Mission	Status
Sherpa-LTC1	0.00001578	0.00007485	PASS

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

Spacecraft	Status
Sherpa-LTC1	COMPLIANT

Probability of Damage from Small Debris
While there are subsystems onboard the Sherpa-LTC1 vehicle which provide the ability to perform a post mission disposal maneuver, the vehicle is compliant with all orbit lifetime requirements without the use of a post mission disposal maneuver. However, altitude reduction and orbit adjustment will be employed as a part of the primary mission concept of operations (CONOPS) to deploy a customer at a lower altitude. We demonstrate in this report that the *Failed Mission* cases are still compliant with orbit lifetime requirements. The *Failed Mission* case shows that, akin to a Micrometeoroid orbital debris strike that incapacitates the attitude control or chemical propulsion system, Sherpa-LTC1 is still compliant with orbit lifetime requirements in the case that that attitude control or chemical propulsion system fails.

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

Sherpa-LTC1 will conduct controlled altitude reduction by means of enabling and testing new attitude control and chemical propulsion systems. The controlled descent of Sherpa-LTC1 for its Demonstration Mission will last no longer than three weeks. During this time, the previously demonstrated CCS and a new chemical propulsion system will be enabled and tested. The first system is an onboard computer with sensors and effectors to provide command and control over the Sherpa-LTC1 vehicle. This system will make use of traditional, flown, small satellite control systems (reaction wheels, star trackers, magnetic torque rods, etc.) to detumble and stabilize the Sherpa vehicle in a known attitude (if necessary), then pointing the vehicle to sun-normal for solar panel charging. Also, during this time, the second modular system, a chemical propulsion assembly from Benchmark Space Systems, will be commissioned to be used to lower the Sherpa-LTC1 vehicle altitude from the initial altitude to approximately 500 km. Orbit lowering will be accomplished through a series retrograde thruster firings. This set of maneuvers will demonstrate rapid deorbit of the Sherpa-LTC1 system, while providing key performance data for the Benchmark Space Systems propulsion system. From that altitude, Spaceflight will decommission Sherpa-LTC1 for reentry and will 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-LTC1 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-LTC1 will descend to a 500 km altitude for the deployment of the final payload and finally naturally decay via atmospheric drag.

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

Sherpa-LTC1 orbit lowering will be accomplished through a series of retrograde impulsive maneuvers. These maneuvers are not required to maintain compliance with ODAR requirements (see Figure 4) but will diminish the post-mission orbit lifetime of Sherpa-LTC1.

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

Spacecraft Mass:

	Nominal Mission	Failed Mission
Sherpa-LTC1	258 kg	362 kg

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

	Nominal Mission	Failed Mission
Sherpa-LTC1	1.2461 m^2	1.4714 m^2

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

	Nominal Mission	Failed Mission
Sherpa-LTC1	0.004830 m^2/kg	0.003684 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-8719.14B 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.

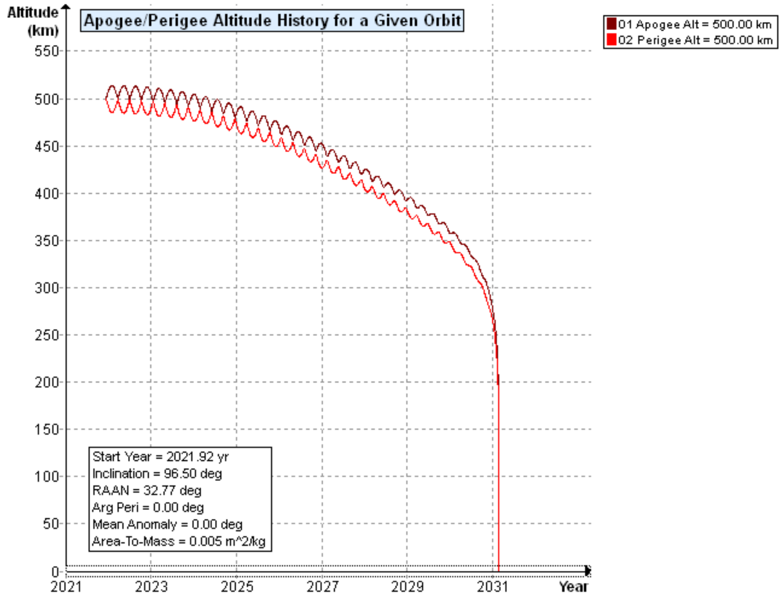

Figure 1 - Sherpa-LTC1 orbit history (Nominal Mission at 525 km) once it has reached its final secondary altitude of 500 km. Due to the limitations of DAS the initial primary mission (<1 day at 550 km), commissioning of subsystems and transit to secondary drop off at 500 km (~3 weeks) could not be depicted. That additional 3-week portion of the mission would be appended to the beginning of this graph.

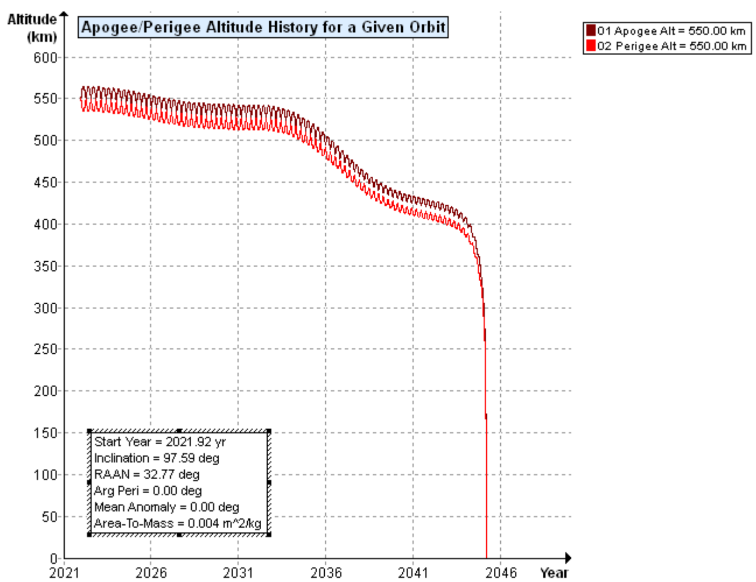

Figure 2 - Sherpa-LTC1 (Failed Mission at 550 km) orbit history.

Analysis: Sherpa-LTC1 reentry is COMPLIANT using method "a".

Satellite Name	**Sherpa-LTC1**
BOL Orbit (Drop off)	550 x 550 km
Operational Orbit	500 x 500 km
EOM Orbit	500 x 500 km
Total Lifetime for Nominal Mission	9.2 years
Total Lifetime if Mission Failure	23.2 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:

The attitude determination and control system (ADCS) on Sherpa-LTC1 is a flown heritage system operating with a highly flexible flight software package. In addition, the chemical 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 ADCS subsystem as well as its Benchmark Space Systems 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 Sherpa-LTC1 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 Sherpa-LTC1 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-LTC1 arrives at 500 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, inclusive of the Demonstration mission deployment, and successful orbit reduction); (ii) an off-nominal Mission Failure case where no spacecraft are deployed and the chemical propulsion system is not commissioned and altitude decays naturally via atmospheric drag. In each case DAS returns a total on-orbit lifetime of 25 years or less.

In an entirely separate case not shown here, where Sherpa-LTC1 deployments are unsuccessful, but the demonstration mission of altitude reduction is still viable, orbit lifetime would only be improved compared to this Failed Mission. Thus, the Failed Mission case presented here is the worst-case scenario. Since this hybrid scenario is bounded by the others, it is not discussed further.

As with SSO-A, Sherpa-FX1, Sherpa-FX2 and Sherpa-LTE1, 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, Sherpa-FX2, and Sherpa-LTE1 missions. If the primary avionics systems were to fail, it will most likely succumb to the launch environment, which occurs prior to any deployments from the Sherpa-LTC1 vehicle resulting in the Mission Failure cases. Furthermore, in case the ability to reduce the Sherpa-LTC1 orbit to 500km is unsuccessful, 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 regulations 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-LTC1 and its separation systems and subcomponents (listed in further detail in the full DAS results appended to this report) have a 1:11,200 risk of human casualty and thus the Sherpa-LTC1 meets the requirement. Components which may survive reentry are the following:

Input	Output
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 = RWA rotor Demise Altitude = 0.000000 Debris Casualty Area = 1.502729 Impact Kinetic Energy = 128.080551
name = PropSysItem002 (OX Tank Assembly) quantity = 1 parent = 1 materialID = 54 type = Box Aero Mass = 20.000000 Thermal Mass = 20.000000 Diameter/Width = 0.457000 Length = 0.490000 Height = 0.360000	name = PropSysItem002 (OX Tank Assembly) Demise Altitude = 0.000000 Debris Casualty Area = 1.097043 Impact Kinetic Energy = 16557.078125
name = PropSysItem003 (Fuel Tank) quantity = 1 parent = 1 materialID = 54 type = Cylinder Aero Mass = 6.099000 Thermal Mass = 6.099000 Diameter/Width = 0.237600 Length = 0.357390	name = PropSysItem003 (Fuel Tank) Demise Altitude = 0.000000 Debris Casualty Area = 0.794600 Impact Kinetic Energy = 4270.816895
name = PropSysItem004 (pressurant tanks) quantity = 2 parent = 1 materialID = 65 type = Cylinder Aero Mass = 1.010380 Thermal Mass = 1.010380 Diameter/Width = 0.085000 Length = 0.300000	name = PropSysItem004 (pressurant tanks) Demise Altitude = 0.000000 Debris Casualty Area = 1.154249 Impact Kinetic Energy = 420.786102

name = PropSysItem012 (thruster assembly) quantity = 4 parent = 1 materialID = 47 type = Cylinder Aero Mass = 0.245000 Thermal Mass = 0.245000 Diameter/Width = 0.076000 Length = 0.166000	name = PropSysItem012 (thruster assembly) Demise Altitude = 0.000000 Debris Casualty Area = 2.029605 Impact Kinetic Energy = 48.213413

For the "Mission Failed" case, as the Sherpa vehicle begins to demise, customer payloads will break free and should demise as described in the ODAR assessments they would have provided during their own licensing efforts. Consistent with Spaceflight's prior missions, Spaceflight relies upon its customers' own authorizations for reentry hazards each for their own spacecraft.

Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because the Sherpa-LTC1 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

08 08 2021; 16:35:53PM Activity Log Started
08 08 2021; 16:35:54PM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-6\DAS ODAR Rev B Nominal\
08 08 2021; 16:36:09PM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ==============
08 08 2021; 16:36:11PM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ==============
08 08 2021; 17:24:14PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-LTC1
Space Structure Type = Payload
Perigee Altitude = 500.000 (km)
Apogee Altitude = 500.000 (km)
Inclination = 96.500 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0048 (m^2/kg)
Start Year = 2021.918 (yr)
Initial Mass = 400.000 (kg)
Final Mass = 258.000 (kg)
Duration = 0.300 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 1.5777E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

08 08 2021; 17:24:17PM Project Data Saved To File
08 08 2021; 17:24:23PM Requirement 4.5-2: Compliant

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

08 08 2021; 17:24:25PM   Processing Requirement 4.6   Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-LTC1
Space Structure Type = Payload

Perigee Altitude = 500.000000 (km)
Apogee Altitude = 500.000000 (km)
Inclination = 96.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004830 (m^2/kg)
Start Year = 2021.918000 (yr)
Initial Mass = 400.000000 (kg)
Final Mass = 258.000000 (kg)
Duration = 0.300000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 495.677957 (km)
PMD Apogee Altitude = 503.622182 (km)
PMD Inclination = 96.495321 (deg)
PMD RAAN = 94.493480 (deg)
PMD Argument of Perigee = 159.440978 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 495.677957 (km)
Suggested Apogee Altitude = 503.622182 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2031 (yr)
Requirement = 61
Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
08 08 2021; 17:24:29PM   *********Processing Requirement 4.7-1
Return Status : Passed

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

name = Sherpa-LTC1
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 258.000000
Thermal Mass = 258.000000

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 = 10.000000
Thermal Mass = 10.000000
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 = 0.830000
Thermal Mass = 0.830000
Diameter/Width = 0.118000
Length = 0.318000

name = LT Corner Brace

quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 1.100000
Thermal Mass = 1.100000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT QuadPack adapter plate
quantity = 5
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

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 NSL Black Box Std
quantity = 1
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 = empty 2-way QuadPack
quantity = 2
parent = 1
materialID = 5

type = Box
Aero Mass = 6.300000
Thermal Mass = 6.300000
Diameter/Width = 0.250000
Length = 0.440000
Height = 0.250000

name = empty 4-way QuadPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 7.500000
Thermal Mass = 7.500000
Diameter/Width = 0.250000
Length = 0.440000
Height = 0.250000

name = LT QuadPack Mass Model
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 26.299999
Thermal Mass = 26.299999
Diameter/Width = 0.250000
Length = 0.528000
Height = 0.250000

name = LT lower 8-in separation system
quantity = 3
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 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 = 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 = LTC J-channel
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 4.640000
Thermal Mass = 4.640000
Diameter/Width = 0.628650
Length = 0.628650

name = PropSysItem001
quantity = 1
parent = 1

materialID = 8
type = Flat Plate
Aero Mass = 4.648000
Thermal Mass = 4.648000
Diameter/Width = 0.572000
Length = 0.572000

name = PropSysItem002
quantity = 1
parent = 1
materialID = 54
type = Box
Aero Mass = 20.000000
Thermal Mass = 20.000000
Diameter/Width = 0.457000
Length = 0.490000
Height = 0.360000

name = PropSysItem003
quantity = 1
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 6.099000
Thermal Mass = 6.099000
Diameter/Width = 0.237600
Length = 0.357390

name = PropSysItem004
quantity = 2
parent = 1
materialID = 65
type = Cylinder
Aero Mass = 1.010380
Thermal Mass = 1.010380
Diameter/Width = 0.085000
Length = 0.300000

name = PropSysItem005
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.928000
Thermal Mass = 0.928000
Diameter/Width = 0.250000
Length = 0.250000
Height = 0.013000

name = PropSysItem006
quantity = 3
parent = 1
materialID = 59
type = Box
Aero Mass = 0.151667
Thermal Mass = 0.151667
Diameter/Width = 0.051000

Length = 0.105000
Height = 0.020000

name = PropSysItem007
quantity = 4
parent = 1
materialID = 64
type = Cylinder
Aero Mass = 0.156000
Thermal Mass = 0.156000
Diameter/Width = 0.200000
Length = 0.340000

name = PropSysItem008
quantity = 10
parent = 1
materialID = 37
type = Box
Aero Mass = 0.232000
Thermal Mass = 0.232000
Diameter/Width = 0.025400
Length = 0.076000
Height = 0.025400

name = PropSysItem009
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.078000
Thermal Mass = 0.078000
Diameter/Width = 0.025660
Length = 0.080520
Height = 0.022200

name = PropSysItem011
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 0.152900
Thermal Mass = 0.152900
Diameter/Width = 0.156000
Length = 0.220000
Height = 0.014600

name = PropSysItem012
quantity = 4
parent = 1
materialID = 47
type = Cylinder
Aero Mass = 0.245000
Thermal Mass = 0.245000
Diameter/Width = 0.076000
Length = 0.166000

name = PropSysItem013

quantity = 1
parent = 1
materialID = 54
type = Flat Plate
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.053000
Length = 0.053000

name = PropSysItem014
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.081000
Thermal Mass = 0.081000
Diameter/Width = 0.047300
Length = 0.076000
Height = 0.041600

name = PropSysItem015
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.047000
Length = 0.076000
Height = 0.042000

name = PropSysItem017
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.077000
Thermal Mass = 0.077000
Diameter/Width = 0.047000
Length = 0.076000
Height = 0.042000

name = PropSysItem018
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.087000
Thermal Mass = 0.087000
Diameter/Width = 0.020160
Length = 0.057660
Height = 0.017460

name = PropSysItem019
quantity = 1
parent = 1
materialID = 59

type = Box
Aero Mass = 0.063650
Thermal Mass = 0.063650
Diameter/Width = 0.035140
Length = 0.053800
Height = 0.014300

name = PropSysItem020
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.018300
Length = 0.060000
Height = 0.015880

name = PropSysItem021
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.072150
Thermal Mass = 0.072150
Diameter/Width = 0.041500
Length = 0.067000
Height = 0.031750

name = PropSysItem022
quantity = 4
parent = 1
materialID = 59
type = Box
Aero Mass = 0.064000
Thermal Mass = 0.064000
Diameter/Width = 0.030000
Length = 0.030000
Height = 0.016000

name = PropSysItem023
quantity = 4
parent = 1
materialID = 59
type = Box
Aero Mass = 0.063500
Thermal Mass = 0.063500
Diameter/Width = 0.032500
Length = 0.053000
Height = 0.014300

name = PropSysItem024
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.057400

Thermal Mass = 0.057400
Diameter/Width = 0.085000
Length = 0.085000
Height = 0.015000

name = PropSysItem025
quantity = 6
parent = 1
materialID = 59
type = Box
Aero Mass = 0.087500
Thermal Mass = 0.087500
Diameter/Width = 0.018330
Length = 0.054360
Height = 0.015880

name = PropSysItem026
quantity = 7
parent = 1
materialID = 59
type = Box
Aero Mass = 0.036143
Thermal Mass = 0.036143
Diameter/Width = 0.028800
Length = 0.044700
Height = 0.011180

name = PropSysItem027
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.018675
Thermal Mass = 0.018675
Diameter/Width = 0.073300
Length = 0.073300
Height = 0.016000

name = PropSysItem028
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.054000
Thermal Mass = 0.054000
Diameter/Width = 0.085000
Length = 0.092100
Height = 0.017500

name = PropSysItem029
quantity = 1
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.042160
Thermal Mass = 0.042160
Diameter/Width = 0.006350

Length = 0.350000

name = PropSysItem030
quantity = 1
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.037000
Thermal Mass = 0.037000
Diameter/Width = 0.006350
Length = 0.319000

name = PropSysItem031
quantity = 32
parent = 1
materialID = 54
type = Box
Aero Mass = 0.005094
Thermal Mass = 0.005094
Diameter/Width = 0.011300
Length = 0.013000
Height = 0.011300

name = PropSysItem032
quantity = 32
parent = 1
materialID = 57
type = Box
Aero Mass = 0.007688
Thermal Mass = 0.007688
Diameter/Width = 0.010000
Length = 0.025400
Height = 0.010000

name = PropSysItem033
quantity = 36
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.011444
Thermal Mass = 0.011444
Diameter/Width = 0.003180
Length = 9.652000

name = PropSysItem034
quantity = 9
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.026667
Thermal Mass = 0.026667
Diameter/Width = 0.006350
Length = 2.127000

name = PropSysItem035
quantity = 15
parent = 1

materialID = 59
type = Cylinder
Aero Mass = 0.003037
Thermal Mass = 0.003037
Diameter/Width = 0.001590
Length = 2.947000

name = PropSysItem036
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.034000
Thermal Mass = 0.034000
Diameter/Width = 0.021000
Length = 0.021000
Height = 0.015000

name = PropSysItem037
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.034000
Thermal Mass = 0.034000
Diameter/Width = 0.014000
Length = 0.051000
Height = 0.012000

name = PropSysItem038
quantity = 4
parent = 1
materialID = 64
type = Box
Aero Mass = 0.033000
Thermal Mass = 0.033000
Diameter/Width = 0.215000
Length = 0.215000
Height = 0.012000

name = PropSysItem039
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.030000
Thermal Mass = 0.030000
Diameter/Width = 0.016400
Length = 0.038100
Height = 0.014200

name = PropSysItem041
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.027000

Thermal Mass = 0.027000
Diameter/Width = 0.025000
Length = 0.038000
Height = 0.015300

name = PropSysItem042
quantity = 5
parent = 1
materialID = 59
type = Box
Aero Mass = 0.026000
Thermal Mass = 0.026000
Diameter/Width = 0.020000
Length = 0.030000
Height = 0.010000

name = PropSysItem043
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.025000
Thermal Mass = 0.025000
Diameter/Width = 0.067000
Length = 0.067000

name = PropSysItem045
quantity = 5
parent = 1
materialID = 59
type = Box
Aero Mass = 0.024500
Thermal Mass = 0.024500
Diameter/Width = 0.012000
Length = 0.035560
Height = 0.011600

name = PropSysItem046
quantity = 10
parent = 1
materialID = 59
type = Box
Aero Mass = 0.011500
Thermal Mass = 0.011500
Diameter/Width = 0.012900
Length = 0.019200
Height = 0.011180

name = PropSysItem047
quantity = 12
parent = 1
materialID = 54
type = Box
Aero Mass = 0.007738
Thermal Mass = 0.007738
Diameter/Width = 0.007000
Length = 0.067500

Height = 0.007000

name = PropSysItem049
quantity = 4
parent = 1
materialID = 59
type = Box
Aero Mass = 0.020000
Thermal Mass = 0.020000
Diameter/Width = 0.012900
Length = 0.030500
Height = 0.011280

name = PropSysItem050
quantity = 8
parent = 1
materialID = 59
type = Box
Aero Mass = 0.010000
Thermal Mass = 0.010000
Diameter/Width = 0.009170
Length = 0.031500
Height = 0.007940

name = PropSysItem051
quantity = 24
parent = 1
materialID = 59
type = Box
Aero Mass = 0.002875
Thermal Mass = 0.002875
Diameter/Width = 0.025000
Length = 0.025000
Height = 0.000790

name = PropSysItem052
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.043000
Thermal Mass = 0.043000
Diameter/Width = 0.025000
Length = 0.025000
Height = 0.017600

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

name = Sherpa-LTC1
Demise Altitude = 77.998978
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT upper 24-in separation sytem
Demise Altitude = 76.188004

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = 24inch Jchannel spacer ring
Demise Altitude = 73.445656
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = solar panel wing
Demise Altitude = 75.799995
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Hex Plate
Demise Altitude = 68.468033
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Interior Wall
Demise Altitude = 75.237183
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Corner Brace
Demise Altitude = 75.854698
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT QuadPack adapter plate
Demise Altitude = 74.160103
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT R2A-Core
Demise Altitude = 71.936638
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT battery module
Demise Altitude = 69.201202
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT NSL Black Box Std
Demise Altitude = 75.609253
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty 2-way QuadPack
Demise Altitude = 73.242142
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty 4-way QuadPack
Demise Altitude = 72.291161
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT QuadPack Mass Model
Demise Altitude = 61.118370
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT lower 8-in separation system
Demise Altitude = 71.055695
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG base ring
Demise Altitude = 72.851761
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG leg
Demise Altitude = 75.444023
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG triangle plate
Demise Altitude = 72.226761
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG MLB adapter plate
Demise Altitude = 73.833443
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = torque rod
Demise Altitude = 69.738327
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = AD avionics
Demise Altitude = 69.360519

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RWA enclosure
Demise Altitude = 75.447647
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 = 128.080551

****
name = camera bracket
Demise Altitude = 75.012108
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = IMPERX camera
Demise Altitude = 76.578934
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = camera lens assembly
Demise Altitude = 72.227234
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LTC J-channel
Demise Altitude = 76.928123
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem001
Demise Altitude = 72.311508
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem002
Demise Altitude = 0.000000
Debris Casualty Area = 1.097043
Impact Kinetic Energy = 16557.078125

****
name = PropSysItem003
Demise Altitude = 0.000000
Debris Casualty Area = 0.794600
Impact Kinetic Energy = 4270.816895

****
name = PropSysItem004
Demise Altitude = 0.000000
Debris Casualty Area = 1.154249
Impact Kinetic Energy = 420.786102

****
name = PropSysItem005
Demise Altitude = 75.512947
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem006
Demise Altitude = 74.161377
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem007
Demise Altitude = 77.945427
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem008
Demise Altitude = 73.491180
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem009
Demise Altitude = 75.916977
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem011
Demise Altitude = 77.519775
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem012
Demise Altitude = 0.000000
Debris Casualty Area = 2.029605
Impact Kinetic Energy = 48.213413

****
name = PropSysItem013
Demise Altitude = 71.168671
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem014
Demise Altitude = 77.223404

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem015
Demise Altitude = 77.238899
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem017
Demise Altitude = 77.269852
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem018
Demise Altitude = 74.799881
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem019
Demise Altitude = 75.231300
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem020
Demise Altitude = 74.913017
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem021
Demise Altitude = 77.082314
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem022
Demise Altitude = 73.497902
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem023
Demise Altitude = 75.233528
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem024
Demise Altitude = 77.422356
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem025
Demise Altitude = 74.466499
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem026
Demise Altitude = 75.905281
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem027
Demise Altitude = 77.780357
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem028
Demise Altitude = 77.512894
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem029
Demise Altitude = 77.328407
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem030
Demise Altitude = 77.351463
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem031
Demise Altitude = 76.217918
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem032
Demise Altitude = 77.002747
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem033
Demise Altitude = 77.995399
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem034
Demise Altitude = 77.932335

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem035
Demise Altitude = 77.987823
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem036
Demise Altitude = 74.266541
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem037
Demise Altitude = 76.043137
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem038
Demise Altitude = 77.977638
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem039
Demise Altitude = 76.057541
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem041
Demise Altitude = 76.284966
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem042
Demise Altitude = 75.665382
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem043
Demise Altitude = 77.549454
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem045
Demise Altitude = 76.020737
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem046
Demise Altitude = 76.269348
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem047
Demise Altitude = 77.330879
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem049
Demise Altitude = 76.135849
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem050
Demise Altitude = 76.777267
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem051
Demise Altitude = 77.542488
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PropSysItem052
Demise Altitude = 74.248672
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

============== End of Requirement 4.7-1 ==============

08 08 2021; 17:24:29PM Project Data Saved To File

Raw DAS Output – Failed Mission

08 08 2021; 17:26:21PM Activity Log Started
08 08 2021; 17:26:22PM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-6\DAS ODAR Rev B DoA\
08 08 2021; 17:26:32PM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ==============
08 08 2021; 17:26:34PM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ==============
08 08 2021; 20:34:43PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-LTC1_DoA
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.594 (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 = 2021.918 (yr)
Initial Mass = 400.000 (kg)
Final Mass = 400.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 7.4850E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

08 08 2021; 20:34:46PM Project Data Saved To File
08 08 2021; 20:34:57PM Requirement 4.5-2: Compliant

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

08 08 2021; 20:35:00PM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-LTC1_DoA
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.594000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003684 (m^2/kg)
Start Year = 2021.918000 (yr)
Initial Mass = 400.000000 (kg)
Final Mass = 400.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.410926 (km)
PMD Apogee Altitude = 551.579571 (km)
PMD Inclination = 97.592574 (deg)
PMD RAAN = 3.586400 (deg)
PMD Argument of Perigee = 165.091502 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.410926 (km)
Suggested Apogee Altitude = 551.579571 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

=============== End of Requirement 4.6 ===============
08 08 2021; 20:35:06PM *********Processing Requirement 4.7-1
Return Status : Passed
***********INPUT****
Item Number = 2

name = Sherpa-LTC1_DoA
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 400.000000
Thermal Mass = 400.000000
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 = 10.000000
Thermal Mass = 10.000000
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 = 0.830000
Thermal Mass = 0.830000
Diameter/Width = 0.118000
Length = 0.318000

name = LT Corner Brace
quantity = 6

parent = 1
materialID = 8
type = Box
Aero Mass = 1.100000
Thermal Mass = 1.100000
Diameter/Width = 0.151000
Length = 0.178000
Height = 0.151000

name = LT QuadPack adapter plate
quantity = 5
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.727000
Thermal Mass = 1.727000
Diameter/Width = 0.297000
Length = 0.311000

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 NSL Black Box Std
quantity = 1
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 = empty 2-way QuadPack
quantity = 2
parent = 1
materialID = 5
type = Box

Aero Mass = 6.300000
Thermal Mass = 6.300000
Diameter/Width = 0.250000
Length = 0.440000
Height = 0.250000

name = empty 4-way QuadPack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 7.500000
Thermal Mass = 7.500000
Diameter/Width = 0.250000
Length = 0.440000
Height = 0.250000

name = LT QuadPack Mass Model
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 26.299999
Thermal Mass = 26.299999
Diameter/Width = 0.250000
Length = 0.528000
Height = 0.250000

name = LT lower 8-in separation system
quantity = 3
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 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 = 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 = LTC J-channel
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 4.640000
Thermal Mass = 4.640000
Diameter/Width = 0.628650
Length = 0.628650

name = PropSysItem001
quantity = 1
parent = 1
materialID = 8

type = Flat Plate
Aero Mass = 4.648000
Thermal Mass = 4.648000
Diameter/Width = 0.572000
Length = 0.572000

name = PropSysItem002
quantity = 1
parent = 1
materialID = 54
type = Box
Aero Mass = 20.000000
Thermal Mass = 20.000000
Diameter/Width = 0.457000
Length = 0.490000
Height = 0.360000

name = PropSysItem003
quantity = 1
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 6.099000
Thermal Mass = 6.099000
Diameter/Width = 0.237600
Length = 0.357390

name = PropSysItem004
quantity = 2
parent = 1
materialID = 65
type = Cylinder
Aero Mass = 1.010380
Thermal Mass = 1.010380
Diameter/Width = 0.085000
Length = 0.300000

name = PropSysItem005
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.928000
Thermal Mass = 0.928000
Diameter/Width = 0.250000
Length = 0.250000
Height = 0.013000

name = PropSysItem006
quantity = 3
parent = 1
materialID = 59
type = Box
Aero Mass = 0.151667
Thermal Mass = 0.151667
Diameter/Width = 0.051000
Length = 0.105000

Height = 0.020000

name = PropSysItem007
quantity = 4
parent = 1
materialID = 64
type = Cylinder
Aero Mass = 0.156000
Thermal Mass = 0.156000
Diameter/Width = 0.200000
Length = 0.340000

name = PropSysItem008
quantity = 10
parent = 1
materialID = 37
type = Box
Aero Mass = 0.232000
Thermal Mass = 0.232000
Diameter/Width = 0.025400
Length = 0.076000
Height = 0.025400

name = PropSysItem009
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.078000
Thermal Mass = 0.078000
Diameter/Width = 0.025660
Length = 0.080520
Height = 0.022200

name = PropSysItem011
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 0.152900
Thermal Mass = 0.152900
Diameter/Width = 0.156000
Length = 0.220000
Height = 0.014600

name = PropSysItem012
quantity = 4
parent = 1
materialID = 47
type = Cylinder
Aero Mass = 0.245000
Thermal Mass = 0.245000
Diameter/Width = 0.076000
Length = 0.166000

name = PropSysItem013
quantity = 1

parent = 1
materialID = 54
type = Flat Plate
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.053000
Length = 0.053000

name = PropSysItem014
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.081000
Thermal Mass = 0.081000
Diameter/Width = 0.047300
Length = 0.076000
Height = 0.041600

name = PropSysItem015
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.047000
Length = 0.076000
Height = 0.042000

name = PropSysItem017
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.077000
Thermal Mass = 0.077000
Diameter/Width = 0.047000
Length = 0.076000
Height = 0.042000

name = PropSysItem018
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.087000
Thermal Mass = 0.087000
Diameter/Width = 0.020160
Length = 0.057660
Height = 0.017460

name = PropSysItem019
quantity = 1
parent = 1
materialID = 59
type = Box

Aero Mass = 0.063650
Thermal Mass = 0.063650
Diameter/Width = 0.035140
Length = 0.053800
Height = 0.014300

name = PropSysItem020
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.018300
Length = 0.060000
Height = 0.015880

name = PropSysItem021
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.072150
Thermal Mass = 0.072150
Diameter/Width = 0.041500
Length = 0.067000
Height = 0.031750

name = PropSysItem022
quantity = 4
parent = 1
materialID = 59
type = Box
Aero Mass = 0.064000
Thermal Mass = 0.064000
Diameter/Width = 0.030000
Length = 0.030000
Height = 0.016000

name = PropSysItem023
quantity = 4
parent = 1
materialID = 59
type = Box
Aero Mass = 0.063500
Thermal Mass = 0.063500
Diameter/Width = 0.032500
Length = 0.053000
Height = 0.014300

name = PropSysItem024
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.057400
Thermal Mass = 0.057400

Diameter/Width = 0.085000
Length = 0.085000
Height = 0.015000

name = PropSysItem025
quantity = 6
parent = 1
materialID = 59
type = Box
Aero Mass = 0.087500
Thermal Mass = 0.087500
Diameter/Width = 0.018330
Length = 0.054360
Height = 0.015880

name = PropSysItem026
quantity = 7
parent = 1
materialID = 59
type = Box
Aero Mass = 0.036143
Thermal Mass = 0.036143
Diameter/Width = 0.028800
Length = 0.044700
Height = 0.011180

name = PropSysItem027
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.018675
Thermal Mass = 0.018675
Diameter/Width = 0.073300
Length = 0.073300
Height = 0.016000

name = PropSysItem028
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.054000
Thermal Mass = 0.054000
Diameter/Width = 0.085000
Length = 0.092100
Height = 0.017500

name = PropSysItem029
quantity = 1
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.042160
Thermal Mass = 0.042160
Diameter/Width = 0.006350
Length = 0.350000

name = PropSysItem030
quantity = 1
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.037000
Thermal Mass = 0.037000
Diameter/Width = 0.006350
Length = 0.319000

name = PropSysItem031
quantity = 32
parent = 1
materialID = 54
type = Box
Aero Mass = 0.005094
Thermal Mass = 0.005094
Diameter/Width = 0.011300
Length = 0.013000
Height = 0.011300

name = PropSysItem032
quantity = 32
parent = 1
materialID = 57
type = Box
Aero Mass = 0.007688
Thermal Mass = 0.007688
Diameter/Width = 0.010000
Length = 0.025400
Height = 0.010000

name = PropSysItem033
quantity = 36
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.011444
Thermal Mass = 0.011444
Diameter/Width = 0.003180
Length = 9.652000

name = PropSysItem034
quantity = 9
parent = 1
materialID = 59
type = Cylinder
Aero Mass = 0.026667
Thermal Mass = 0.026667
Diameter/Width = 0.006350
Length = 2.127000

name = PropSysItem035
quantity = 15
parent = 1
materialID = 59

type = Cylinder
Aero Mass = 0.003037
Thermal Mass = 0.003037
Diameter/Width = 0.001590
Length = 2.947000

name = PropSysItem036
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.034000
Thermal Mass = 0.034000
Diameter/Width = 0.021000
Length = 0.021000
Height = 0.015000

name = PropSysItem037
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.034000
Thermal Mass = 0.034000
Diameter/Width = 0.014000
Length = 0.051000
Height = 0.012000

name = PropSysItem038
quantity = 4
parent = 1
materialID = 64
type = Box
Aero Mass = 0.033000
Thermal Mass = 0.033000
Diameter/Width = 0.215000
Length = 0.215000
Height = 0.012000

name = PropSysItem039
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.030000
Thermal Mass = 0.030000
Diameter/Width = 0.016400
Length = 0.038100
Height = 0.014200

name = PropSysItem041
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.027000
Thermal Mass = 0.027000

Diameter/Width = 0.025000
Length = 0.038000
Height = 0.015300

name = PropSysItem042
quantity = 5
parent = 1
materialID = 59
type = Box
Aero Mass = 0.026000
Thermal Mass = 0.026000
Diameter/Width = 0.020000
Length = 0.030000
Height = 0.010000

name = PropSysItem043
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.025000
Thermal Mass = 0.025000
Diameter/Width = 0.067000
Length = 0.067000

name = PropSysItem045
quantity = 5
parent = 1
materialID = 59
type = Box
Aero Mass = 0.024500
Thermal Mass = 0.024500
Diameter/Width = 0.012000
Length = 0.035560
Height = 0.011600

name = PropSysItem046
quantity = 10
parent = 1
materialID = 59
type = Box
Aero Mass = 0.011500
Thermal Mass = 0.011500
Diameter/Width = 0.012900
Length = 0.019200
Height = 0.011180

name = PropSysItem047
quantity = 12
parent = 1
materialID = 54
type = Box
Aero Mass = 0.007738
Thermal Mass = 0.007738
Diameter/Width = 0.007000
Length = 0.067500
Height = 0.007000

name = PropSysItem049
quantity = 4
parent = 1
materialID = 59
type = Box
Aero Mass = 0.020000
Thermal Mass = 0.020000
Diameter/Width = 0.012900
Length = 0.030500
Height = 0.011280

name = PropSysItem050
quantity = 8
parent = 1
materialID = 59
type = Box
Aero Mass = 0.010000
Thermal Mass = 0.010000
Diameter/Width = 0.009170
Length = 0.031500
Height = 0.007940

name = PropSysItem051
quantity = 24
parent = 1
materialID = 59
type = Box
Aero Mass = 0.002875
Thermal Mass = 0.002875
Diameter/Width = 0.025000
Length = 0.025000
Height = 0.000790

name = PropSysItem052
quantity = 2
parent = 1
materialID = 59
type = Box
Aero Mass = 0.043000
Thermal Mass = 0.043000
Diameter/Width = 0.025000
Length = 0.025000
Height = 0.017600

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

name = Sherpa-LTC1_DoA
Demise Altitude = 77.996513
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT upper 24-in separation sytem
Demise Altitude = 76.318939
Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = 24inch Jchannel spacer ring
Demise Altitude = 73.792923
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = solar panel wing
Demise Altitude = 75.956284
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Hex Plate
Demise Altitude = 69.424545
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = LT Interior Wall
Demise Altitude = 75.400909
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Corner Brace
Demise Altitude = 75.976212
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT QuadPack adapter plate
Demise Altitude = 74.407616
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT R2A-Core
Demise Altitude = 72.325943
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT battery module
Demise Altitude = 69.755669
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = LT NSL Black Box Std
Demise Altitude = 75.741936
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = empty 2-way QuadPack
Demise Altitude = 73.537537
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = empty 4-way QuadPack
Demise Altitude = 72.657196
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = LT QuadPack Mass Model
Demise Altitude = 62.178402
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = LT lower 8-in separation system
Demise Altitude = 71.483162
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG base ring
Demise Altitude = 73.251190
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG leg
Demise Altitude = 75.589867
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG triangle plate
Demise Altitude = 72.612366
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Impact Kinetic Energy = 0.000000

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name = RPG MLB adapter plate
Demise Altitude = 74.087334
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = torque rod
Demise Altitude = 70.234673
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = AD avionics
Demise Altitude = 69.904114
Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

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name = RWA enclosure
Demise Altitude = 75.597389
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name = RWA rotor
Demise Altitude = 0.000000
Debris Casualty Area = 1.502729
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name = camera bracket
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name = camera lens assembly
Demise Altitude = 72.596924
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = LTC J-channel
Demise Altitude = 76.983704
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Demise Altitude = 72.740616
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Impact Kinetic Energy = 16556.753906

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Demise Altitude = 0.000000
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Demise Altitude = 0.000000
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Impact Kinetic Energy = 0.000000

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Demise Altitude = 0.000000
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Impact Kinetic Energy = 0.000000

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Impact Kinetic Energy = 0.000000

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Impact Kinetic Energy = 0.000000

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Impact Kinetic Energy = 0.000000

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Impact Kinetic Energy = 0.000000

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****

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Impact Kinetic Energy = 0.000000

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Demise Altitude = 76.252815
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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Demise Altitude = 76.849533
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = PropSysItem051
Demise Altitude = 77.579453
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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name = PropSysItem052
Demise Altitude = 74.510483
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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============== End of Requirement 4.7-1 ===============
08 08 2021; 20:35:06PM Project Data Saved To File

END of Sherpa-LTC1 Orbital Debris Assessment Report (ODAR)

Sherpa-LTC1 Long-Term Recontact Probability

REVISION / DATE

A / 11 August 2021

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

REV	DATE	PREPARED BY	ANALYSIS BY	CHANGES
A	2021-08-11	M. Coletti	E. Lund	Initial Release

1. Introduction

The Sherpa-LTC1 Mission (hereinafter "Mission") on a SpaceX Rideshare launch, currently planned for December 2021-January 2022, is a commercial rideshare mission with Spaceflight, Inc. ("Spaceflight") deploying up to 8 customer spacecraft on Sherpa-LTC1 into a planned sun-synchronous circular orbit of 525 ± 25 km altitude SpaceX's Falcon 9 launch vehicle will deploy Spaceflight's orbital transfer vehicle, which will subsequently deploy the customer spacecraft within several hours of liftoff.[1] Approximately one month later, Sherpa-LTC1 will descend to 500 km and deploy the remaining 5 customer spacecraft.

The separation system and customer payload layout on the Sherpa-LTC1 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 Sherpa-LTC1. A microsatellite, CubeSat dispenser, or other adapter for separation system mounting can be affixed on the outboard end of Sherpa-LTC1. The Sherpa-LTC1 structure upon which the separation systems are affixed is identical to the previously licensed Sherpa-FX1, Sherpa-FX2, and Sherpa-LTE1. Thus, Sherpa-LTC1 will deploy customers in the same fashion as the previously licensed Sherpa missions.

The planned configuration for Sherpa-LTC1 has three microsatellites on the outboard end of Sherpa-LTC1, with ten cubesats integrated in dispensers attached radially on the body of Sherpa-LTC1.[2] Sherpa-LTC1 also contains a chemical propulsion system, which will be commissioned and operated only after the initial batch of customer payload deployments is complete, leaving five (5) sub-3U spacecraft onboard for deployment at a lower altitude. Once the Sherpa-LTC1 is at this lower altitude of 500 km, the final spacecraft onboard will be deployed. The Sherpa-LTC1 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 presents the worst-case probability of recontact for the Mission based on the current manifest and incorporates the worst possible change in manifest subsequent to filing.

[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-LTC1's attitude control system will not be commissioned before all but the last customer deployments at 500 km, the five (5) sub-3U spacecraft, 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-LTC1 vehicle 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 1.743×10^{-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, Sherpa-FX2, and Sherpa-LTE1 missions.

As a general matter, spacecraft with propulsion or differential drag capabilities should be able to avoid conjunction with other spacecraft. As described above there are currently up to 13 spacecraft onboard Sherpa-LTC1. There are seven (7) spacecraft with propulsion on the Mission. The propulsion systems on customer spacecraft identified in the STA filing are sufficient to enable them to perform collision avoidance. There are a number of variables, such as when customer spacecraft can activate propulsion, 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 an avoidance maneuver. Therefore, we present a summary of our analyses here without propulsion 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-LTC1 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 deployment sequence based on the current manifest and is presented as a worst-case scenario. 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-LTC1 Mission are run using a six degree-of-freedom orbit and attitude dynamics model with relative distances tracked between all spacecraft. Final mission analyses with our final configuration will show equal or better recontact analysis results and Spaceflight will provide those results to the Commission.

Sub-3U spacecraft will be grouped together in the same slot of their separation system, and are 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 the Mission, all spacecraft to be deployed at 500 km are sub-3U, and separated in two deployment events). In this configuration, all the spacecraft in a 3U 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 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 will be the only spacecraft deployed by Sherpa-LTC1 at this orbit and will be deployed in the same velocity vector and thus relative velocities between them would be negligible compared to relative velocities between other spacecraft, 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-LTC1 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.

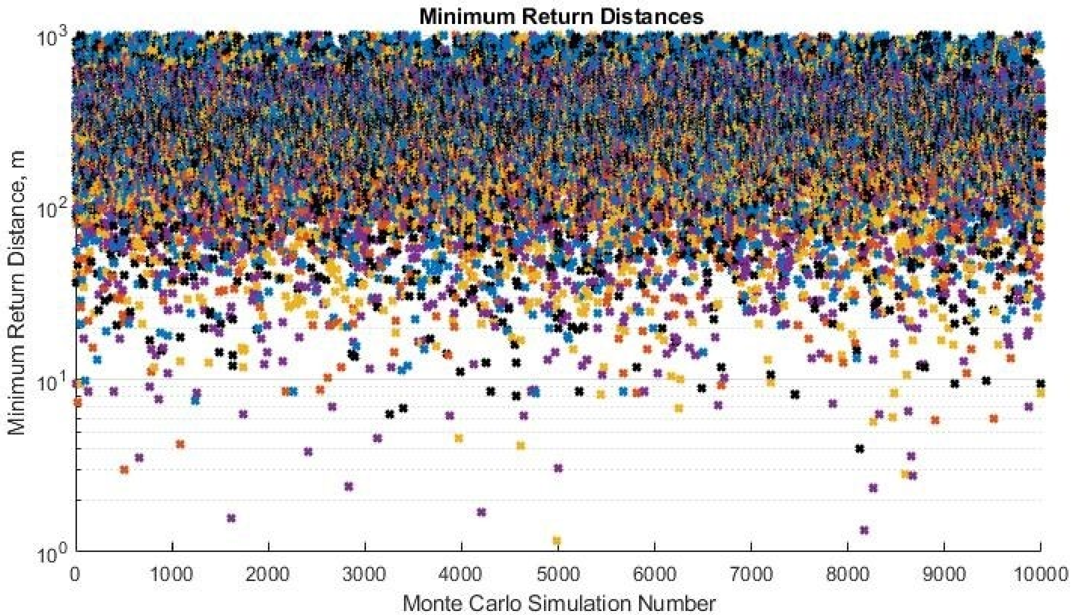

Figure 1: 10,000 simulation Monte Carlo analysis over five orbits. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach. Purple data points indicate Sherpa-Microsat close approach.

A 10,000-run Monte Carlo analysis was performed using this approach over a period that lasted five orbits after the last spacecraft is deployed from Sherpa-LTC1 (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. Further, this time period encompasses the period of highest spacecraft density where recontact events are most probable. 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 (5) orbits), four (4) recontact events were observed (Pr(recontact) = $4x10^{-4}$) with a $\Delta v < 1.0$ m/s. There was a 99.0% probability that all relative miss distances remained above 12.7 m, a 95% probability of all miss distances being greater than 34.7 m, and a 90.0% probability of all miss distances being greater than 54.3 m.

Customer spacecraft are prohibited from performing propulsive maneuvers within the first 45 minutes after separation from Sherpa-LTC1, however once that time period has passed the probability of recontact would further be reduced.

3. Conclusions

Therefore, Spaceflight estimates that the worst-case probability of recontact for all objects on Sherpa-LTC1 is $4x10^{-4}$.

LTC1 Manifest

Spacecraft Name	Spacecraft Type	Operator	Country Of Operator	Quantity	Propulsion	Deploys Other Spacecraft	Comment
Hawk 5A-5C	microsatellite	Hawkeye 360	USA	3	Y	N	
VZLUSat-2	cubesat	SpaceManic	Czech Republic	1	N	N	
LLITED	cubesat	NASA	USA	2	N	N	
OreSat0	cubesat	Portland State University	USA	1	N	N	
MA61C	cubesat	Space Products and Innovation GmbH (SPiN)	Germany	1	N	N	
GT-1	cubesat	Georgia Institute of Technology	USA	1	N	N	
KSF2a-KSF2d	cubesat	Kleos Space	UK	4	Y	N	

Spaceflight Ownership Information

In connection with Spaceflight's previous request for an STA for FX1, the Bureau asked Spaceflight to provide information responsive to the questions contained in Form 312 Main Form, Application for Satellite Space Station Authorizations, Questions 29-34 and 36-40, which would typically be completed by an applicant for deployment and operating authority.

We provide that same information in Attachments 1 and 2. Note regarding responses to questions 30-34: It is Spaceflight's understanding that these questions would be inapplicable even were Spaceflight to seek ordinary license authority, including for deployment and operations, because the space station would not be used for broadcast or common carrier operations and would not be an aeronautical en route or aeronautical fixed station. *See,* Section 310(b) of the Communications Act. Spaceflight nevertheless notes as to foreign ownership, as indicated in its response to question 40, that its capital stock is 100% owned and voted by a Japanese company, M&Y Space Co., Ltd.

Attachment 1

Question	**Response**
29. Is the applicant a foreign government or the representative of any foreign government?	No.
30. Is the applicant an alien or the representative of an alien?	N/A. See note to Exhibit E
31. Is the applicant a corporation organized under the laws of any foreign government?	N/A. See note to Exhibit E
32. Is the applicant a corporation of which more than one-fifth of the capital stock is owned of record or voted by aliens or their representatives or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country?	N/A. See note to Exhibit E
33. Is the applicant a corporation directly or indirectly controlled by any other corporation of which more than one-fourth of the capital stock is owned of record or voted by aliens, their representatives, or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country?	N/A. See note to Exhibit E
34. If any answer to questions 29, 30, 31, 32 and/or 33 is Yes, attach as an exhibit, the identification of the aliens or foreign entities, their nationality, their relationship to the applicant, and the percentage of stock they own or vote.	N/A. See note to Exhibit E.
36. Has the applicant or any party to this application had any FCC station authorization or license revoked or had any application for an initial, modification or renewal of FCC station authorization, license, or construction permit denied by the Commission? If Yes, attach as an exhibit, an explanation of the circumstances.	No.
37. Has the applicant, or any party to this application, or any party directly or indirectly controlling the applicant ever been convicted of a felony by any state or federal court? If Yes, attach as an exhibit, an explanation of the circumstances.	No.
38. Has any court finally adjudged the applicant, or any person directly or indirectly controlling the applicant, guilty of unlawfully monopolizing or attempting unlawfully to monopolize radio communication, directly or indirectly, through control of manufacture or sale of radio apparatus, exclusive traffic arrangement or any other means or unfair methods of competition? If Yes, attach as an exhibit, an explanation of the circumstances.	No.
39. Is the applicant, or any person directly or indirectly controlling the applicant, currently a party in any pending matter referred to in the preceding two items? If Yes, attach as an exhibit, an explanation of the circumstances.	No.
40. If the applicant is a corporation and is applying for a space station license, attach as an exhibit the names, addresses, and citizenship of those stockholders owning of record and/or voting 10 percent or more of the Filer's voting stock and the percentages so held. In the case of fiduciary control, indicate the beneficiary(ies) or class of beneficiaries. Also list the names and addresses of the officers and directors of the Filer.	See Attachment 2.

Attachment 2

Spaceflight, Inc.'s ownership structure and Officers and Directors are listed below:

Ownership
M&Y Space Co., Ltd., a Japanese Private Company
2-1, Otemachi 1-chome
Chiyoda-ku, Tokyo 100-8631,
Japan
Owns 100% of Spaceflight, Inc., stock
Has 100% voting rights

Officers and Directors
c/o Spaceflight, Inc.
1505 Westlake Avenue North, Suite 600
Seattle, WA 98109

Tomohiro Musha
Chairman of the Board of Directors

Ryan Bates
Director

Curtis Dean Blake
Chief Executive Officer and Director

David Ekizian
Director

Norikazu Sano
Director

Yonosuke Miwa
Chief Financial Officer

Sasha Field
General Counsel and Secretary

August 11, 2021

Secretary
Office of the Secretary
Federal Communications Commission
45 L Street, N.E.
Washington, D.C. 20554

Subject: ITU Cost Recovery Fees for Sherpa-LTC1

Reference: FCC File No.

Dear FCC Secretary,

Spaceflight, Inc. ("Spaceflight"), proposed operator of the subject network, is aware that as a result of actions taken at the International Telecommunication Union's 1998 Plenipotentiary Conference, and modified by the ITU Council in 2001, 2002 and 2004, processing fees will now be charged by the ITU for satellite network filings. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU. The applicant hereby states that it is aware of this requirement and accepts responsibility to pay any cost recovery fees associated with these applications. Invoices for such fees should be sent to the point of contact specified below:

(1) Point of Contact Name: Alexandra Field

(2) Applicant: Spaceflight, Inc.

(3) Applicant Address: 1505 Westlake Avenue North, Suite 600
Seattle, WA 98109, U.S.A.

(4) Email address: legal@spaceflight.com

(5) Telephone number: 206-348-3582

Sincerely,

/s/ Alexandra Field
Alexandra Field
General Counsel