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 two (2) spacecraft, Sherpa-FX2 and Sherpa-LTE1 launching on a SpaceX Falcon 9 for a period not to exceed six (6) months, with such period to commence from their launch and deployment that is scheduled to occur between June 1, 2021 and July 31, 2021. Sherpa-FX2 will operate for or less than 24 hours from launch and deployment and Sherpa-LTE1 will operate for up to six (6) months following launch and deployment.

Overview

Both Sherpa-FX2 and Sherpa LTE1 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[2] will initiate a timed sequence of procedures to begin the deployment of its spacecraft on Sherpa-FX2 and Sherpa-LTE1. Following customer deployment, Sherpa-LTE1 will move on to a demonstration phase, as further detailed below.

Spaceflight will be coordinating with SpaceX relative to the deployments made by Spaceflight from both Sherpa-FX2 and Sherpa-LTE1 and the other deployments to be made by SpaceX or its customers, which could result in some adjustments relative to the timing at which Spaceflight begins its deployment. Spaceflight will supplement its application with any adjustments in the information that is provided herein to reflect that anticipate coordination activity.

Sherpa-FX2

Sherpa-FX2 will be functionally the same as Sherpa-FX1, approved by the Commission under license number SES-STA-20200728-00089. Sherpa-FX2 is a non-propulsive, free-flying spacecraft that will deploy auxiliary spacecraft after Sherpa-FX2

[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-FX2 and Sherpa LTE1; (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 for approval 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.

[2] Spaceflight would like to clarify that in previous submission it referenced the sequencer generically as "R2A". R2A is the name for the (eventual) family of components that Spaceflight is building. R2A-Core is the proper name. R2A-Core is the same system flown on Spaceflight's Sherpa-FX1 Mission.

itself separates from the Falcon 9 launch vehicle. Sherpa-FX2 will deploy approximately 25 spacecraft. Of the 25 spacecraft on the manifest and to be deployed from Sherpa-FX2, 12 have propulsion.[3] None of the Sherpa-FX2 deployed spacecraft will deploy further payloads or spacecraft. The total launch mass of the Sherpa-FX2 will be approximately 300 kg, of which approximately 180 kg will be made up of customer spacecraft to be deployed. The customer spacecraft manifest is included as Exhibit D-1. Sherpa-FX2 will also carry up to three (3) approximately 1U-sized, hosted payloads, subject to the providers of those payloads securing their own separate authority for their missions from the Commission or the Federal Aviation Administration ("FAA"), as applicable Further detail on Sherpa-FX2, the spacecraft on the manifest and the hosted payloads is included in Exhibit A.

Like Sherpa-FX1, Sherpa-FX2 will utilize Spaceflight's R2A-Core sequencer that communicates over L-band with the Globalstar network. R2A-Core will utilize the EyeStar S3 Black Box Radio (provided by NearSpace Launch)[4] and L-Band transmitter to send deployment confirmation telemetry to the Globalstar constellation for relay by commercial Globalstar and NearSpace Launch data services to Spaceflight.

The Sherpa-FX2 mission is anticipated to last less than six (6) hours and all communications from R2A-Core will stop at or less than 24 hours after launch. Sherpa-FX2 is equipped with an S-band receiver, also contained within the EyeStar S3 Black Box Radio, to allow a kill-command to be sent from a ground station operated by NearSpace Launch 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 24 hours into the mission. Sherpa-FX2 will naturally deorbit over time.

Sherpa-LTE1

Spaceflight's Sherpa-LTE1 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 Sherpa-FX1 and the above referenced Sherpa-FX2. This primary phase is anticipated to last for less than six (6) hours During this phase, the Sherpa-LTE1 vehicle deploys customer spacecraft in the same way as the Sherpa-FX1[5]. Like Sherpa-FX2, the primary mission phase of Sherpa-LTE1 also uses the Spaceflight R2A-Core sequencer that communicates over L-band

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[3] Spaceflight is in the process of confirming with its customers for deployment on FX2 and LTE1 whether the propulsion capabilities are sufficient to enable them to perform collision avoidance.

[4] Spaceflight would like to clarify that in previous submissions, it referenced the NearSpace Launch EyeStar S3 Radio generically, but the proper name for if is "EyeStar S3 Black Box Radio). The EyeStar S3 Black Box Radio is the same version that was flown on the Sherpa-FX1 Mission.

[5] IBFS File No. SAT-STA-20200728-00089

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.

Sherpa-LTE1 will deploy up to 14 spacecraft, 9 of which have propulsion.. The customer spacecraft manifest is included as Exhibit D-2. None of the Sherpa-LTE1 deployed spacecraft will deploy further payloads or spacecraft. The total launch mass of the Sherpa-LTE1 will be approximately 415 kg, of which approximately 212 kg will be made up of customer spacecraft to be deployed. Sherpa-LTE1 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. Further detail on Sherpa-LTE1, spacecraft and the manifest can be found in the attached Exhibit A.

What is materially different about the Sherpa-LTE1 mission is that, instead of concluding the mission after completing the primary phase of customer deployments (the same 6 hours or less like Sherpa-FX2), a secondary mission initiates for a controlled deorbit phase lasting no longer than 6 months. During this time, two new modular systems will be enabled and tested. Further detail on the secondary deorbit phase demonstration mission can found in the attached Exhibit A.

Radio Frequencies To Be Employed

Spaceflight seeks authority to permit it to establish one-way telemetry link from both Sherpa-FX2 and Sherpa-LTE1 to the Globalstar constellation for an up to 24-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-LTE1.[6] 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 both Sherpa-FX2 Sherpa-LTE1 to enable it to receive signals from a NearSpace Launch owned and operated S-band transmit station.[7] 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 the L-band antenna is not shut off within 24 hours by operation of its on board timer or loss of battery life. Both Sherpa-FX2 and Sherpa-LTE1 are equipped with a GPS receive unit to enable it to be more easily tracked. Authority for that unit is also hereby requested.

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[6] R2A-Core does not transmit signals to the ground, except through the Globalstar constellation network.
[7] This is the same facility for which NearSpace Launch was authorized to use to support Spaceflight's FX1 mission.

After the 24-hour period, R2A-Core and communication to or from the EyeStar S3 Black Box Radio will shut down completely. Sherpa-FX2 will no longer receive or send communication, Sherpa-LTE1 will move on to its secondary mission phase.

For Sherpa-LTE1's secondary mission phase, Spaceflight seeks authority for UHF Uplink, S-Band Uplink and UHF downlink to ground.[8] Use of the frequencies below will enable a secondary mission to demonstrate control and propulsive elements, rapidly deorbit the vehicle, and collect data for future missions. During the controlled deorbit phase, an onboard computer with spacecraft sensors and effectors will provide command and control over the Sherpa-LTE1 vehicle. This system will make use of traditional, flight-proven, small satellite control systems (reaction wheels, star trackers, magnetic torque rods, etc.) to detumble and stabilize the Sherpa vehicle in a known attitude, then 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.

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

	Sherpa R2A-Core Comms (Sherpa-FX2 Mission and Primary Mission Phase of Sherpa-LTE1 Mission)	Sherpa-LTE1 Communication System (Secondary Mission Phase)		
Parameter	**L-band Uplink to Globalstar**	**UHF Uplink to Sherpa**	**S-Band Uplink to Sherpa**	**UHF Downlink to GND**
Data Rate	100 bps	38.4 Kbps	38.4 Kbps	38.4 Kbps
Modulation	BPSK	2-GFSK	2-GFSK	2-GFSK
Center Frequency	1616.25 MHz	402.9 MHz	2075 MHz	400.5 MHz
Bandwidth	2.5 MHz	40 KHz	300 KHz	40 KHz
Transmit Power	0.10 W (max)	95 W (max)	10 W (max)	36 dBm (max)
Transmit Antenna	Patch			Monopole
Receive Antennas	Patch (S-band, GPS)	Monopole	Patch (S-band, GPS)	
EIRP	-8 dBW			6 dBW (max)
Encryption	AES-256	AES-256	AES-256	AES-256
Duty Cycle (max)	50%	50%	50%	50%

[8] The ground facilities to be employed are further described in the attached Technical Annex. As noted therein, all ground facilities to be employed are already licensed on the frequencies to be employed, but will require modifications by the ground station licensees of these facilities to permit communication with Sherpa-LTE1.

With regard to these frequencies, Spaceflight understands that it will need a waiver to use 402.9 MHz. as a non-conforming use. Pre-filing coordination activities are underway with federal agencies as to this and other proposed frequencies. 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.

Spaceflight has completed pre-coordination with the Air Force and included the above provision for 400.15-403MHz following discussions with NOAA. Spaceflight has also reached out and is waiting for responses from the following U.S Government agencies: NTIA, NASA and the Navy. Spaceflight has also reached out to pre-coordinate with Part 25 licensees that are authorized in the 400.5 MHz range.

Responsibilities of Owners/Operators of Spacecraft to be Deployed and Hosted Payloads

The spacecraft to be deployed on both the Sherpa-FX2 and Sherpa-LTE1 and each of the up to three (3) hosted payloads on Sherpa-FX2 are owned and to be operated by Spaceflight's customers or, in some cases, their customer operator. Each customer is 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 or hosted payload. Further detail on the hosted payloads to be flown on Sherpa-FX2 is included in Exhibit A, the Technical Annex, attached hereto. A list of those customers or, if different, operators, and authorizing administrations is attached as Exhibit D-1 and D-2 hereto. If any customer/operator is unable to provide its spacecraft for launch, a non-separating mass module will be substituted.

Comparison to Spaceflight's SSO-A and Sherpa-FX1 Mission

While substantially similar to Spaceflight's previously approved and successful SSO-A mission and Sherpa-FX1 mission, the Sherpa-FX2 and Sherpa-LTE1 mission also include several key similarities and advancements from the SSO-A and Sherpa-FX1 mission that improve upon design, including as related to mitigation of the risks of orbital debris. Key similarities and advancements are summarized below:

- Each Sherpa is designed to deploy multiple customer spacecraft to be separately licensed by customers at the FCC or other applicable national administrations.

- The Sherpa-FX2 and primary mission phase of the Sherpa-LTE1 series of Spacecraft transmits an L-band signal from its deployer to the Globalstar constellation. This same system was utilized on the Sherpa-FX1 mission.
- Both Sherpa-FX2 and Sherpa-LTE1 will separate from the Falcon 9 launch vehicle just as the SSO-A Free-flyers and Sherpa-FX1.
- The probability of recontact between all spacecraft to deployed by Spaceflight on both Sherpa-FX2 and Sherpa-LTE1 was determined by Spaceflight using the same high-fidelity simulation that was used for the SSO-A and FX1 missions and with comparable risk results.
- Like Sherpa-FX1, there will be a means to cut off transmission of Sherpa-FX2 and Sherpa-LTE1 RF transmissions by command from a terrestrial ground station will allow a positive means of stopping RF transmissions in the event of electromagnetic interference. Like Sherpa-FX1, no titanium isolation system will be used on either system. This change improves the reentry casualty risk assessment.
- Like Sherpa-FX1, Sherpa-FX2 and Sherpa-LTE-1 are compliant with orbit lifetime requirements without the use of a deorbit device.

Exhibits

A more detailed technical showing is attached as Exhibit A.

An Orbital Debris Assessment Report (“ODAR”) for the Sherpa-FX2 is attached hereto as Exhibit B-1.

An Orbital Debris Assessment Report (“ODAR”) for the Sherpa-LTE1 is attached hereto as Exhibit B-2.

A Recontact Probability Analysis relative to the customer spacecraft to be deployed by Sherpa-FX2 is attached hereto as Exhibit C-1.

A Recontact Probability Analysis relative to the customer spacecraft to be deployed by Sherpa-LTE1 is attached hereto as Exhibit C-2.

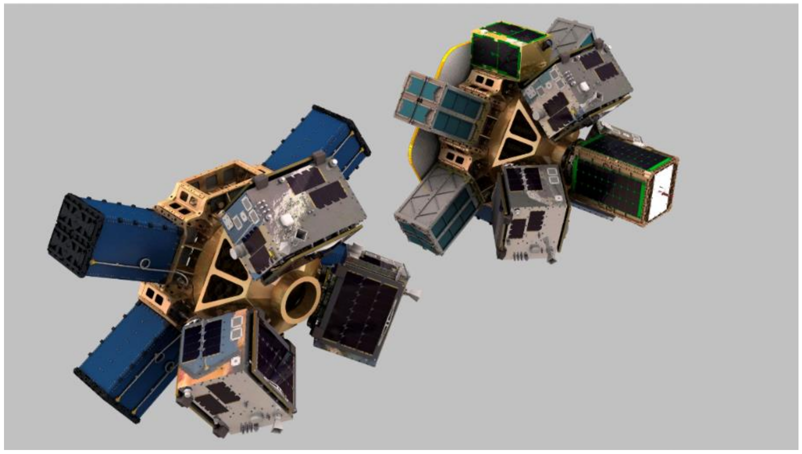
Lists of customers/operators for the spacecraft to be deployed and hosted payloads are attached hereto as Exhibit D-1 and Exhibit D-2.

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

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.

Technical Annex to STA



Spaceflight's Sherpa-FX2 and Sherpa-LTE1 Mission

Spaceflight, Inc, ("Spaceflight") is planning to launch and deploy two (2) free flyers on a Space Exploration Technologies Corporation ("SpaceX") Falcon 9, Sherpa-FX2 and Sherpa-LTE1 (the "Mission"). Sherpa-FX2 has **one (1) primary mission** ("FX2 Mission"): deploy customer spacecraft and host up to three (3) hosted payloads. Sherpa-LTE1 consists of **two (2) distinct missions**: (i) deploy customer spacecraft ("LTE1 Primary Mission"), and (ii) a secondary demonstration mission ("LTE1 Demonstration Mission"), as further detailed below.

Sherpa-FX2 and Sherpa-LTE1 are scheduled to be launched by Space Exploration Technologies Corporation (SpaceX) on a Falcon 9 launch vehicle between 1 June 2021 and 31 July 2021. While on separate ports, both the Sherpa-FX2 and Sherpa-LTE1 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 margin of ± 25km. In addition to the two Sherpas, the Falcon 9 will have multiple rings with SpaceX's own customers stacked above and/or below the ring to which Spaceflight's Sherpa-FX2 and Sherpa-LTE1 are attached.

Sherpa-FX2

Sherpa-FX2 will be functionally the same as Sherpa-FX1, previously approved by the Commission under license number SES-STA-20200728-00089. Sherpa-FX2 is a non-propulsive, free flying spacecraft that is designed to deploy auxiliary spacecraft. Like previous missions, SSO-A[1] and Sherpa-FX1[2], Sherpa-FX2 consists of several structural elements to mount both microsatellites and CubeSat dispensers. Spaceflight provides the launch capacity, structure, separation systems, and integration services for the customer spacecraft. Like Sherpa-FX1, Sherpa-FX2 contains a Rapidly Reconfigurable Avionics Core ("R2A-Core")[3] system to command the deployment of approximately 25 customer spacecraft into Sun Synchronous Orbit ("SSO"). As indicated on Spaceflight's customer manifest for FX2 (Exhibit D-1), Spaceflight has provided for one (1) standby spacecraft that could replace a microsatellite on the forward port of Sherpa-FX2 in the event a currently manifested spacecraft does not make the FX2 Mission. If this swap is not viable for any reason, a non-separating mass model will fill the empty port. In

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[1] SAT-STA-20180523-00042

[2] SAT-STA-20200728-00089

[3] Spaceflight would like to clarify that in previous submission it referenced the sequencer generically as "R2A". R2A is the name for the (eventual) family of components that Spaceflight is building. R2A-Core is the proper name. R2A-Core is the same system flown on Spaceflight's Sherpa-FX1 Mission.

all cases, the Mission analyses will be rerun with the final spacecraft configuration and we expect it to show improved results compared to those presented in the application. Sherpa-FX2 will be attached to a single port on a SpaceX-provided payload ring. Once a separation signal is received by Sherpa-FX2's separation system from Falcon 9 avionics, Sherpa-FX2 will separate. After Sherpa-FX2's separation from Falcon 9 and a subsequent delay in accordance with SpaceX requirements, the R2A-Core will initiate its own separation sequence to deploy approximately 25 Spaceflight customer spacecraft from Sherpa-FX2 and send telemetry back to Spaceflight. The R2A-Core also activates the EyeStar S3 Black Box Radio (provided by NearSpace Launch and more fully described below); 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.

Spaceflight provides the launch capacity, structure, separation systems, and integration services for the customer spacecraft. The Sherpa-FX2 Mission is anticipated to last less than six hours, and all communications will stop at or less than 24 hours after launch. The R2A-Core is equipped with an S-band receiver, also 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 24 hours into the FX2 Mission.

The internal volume of Sherpa-FX2 will contain R2A-Core sequencer and batteries.

Sherpa-FX2 will also carry up to three non-separating customer hosted payloads on its structure, as further detailed below.

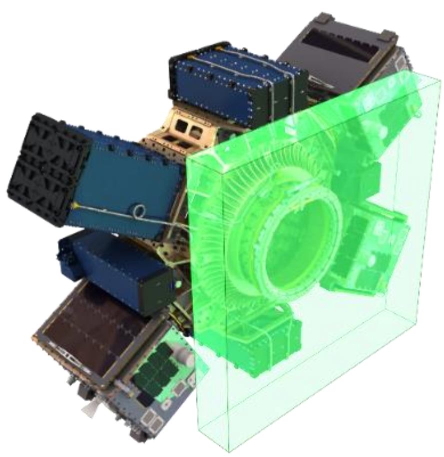


Figure 1: Physical architecture of Spaceflight's Sherpa-FX2 with customers on a Falcon 9 Rideshare Mission.

Hosted Payloads

Spaceflight will host three (3) payloads on Sherpa-FX2. Two (2) of the three (3) hosted payloads that are permanently affixed to the Sherpa-FX2 spacecraft (SOARS and TagSat-2) have radio transmitters. The TagSat-2 payload is owned and operated by NearSpace Launch. TagSat-2 has two independent mechanical switches that are connected to the Sherpa FX2 separation systems. Other than the mechanical interface of the payload to Sherpa-FX2, these switches are the only interface to Sherpa-FX2, and all power and radios are electrically independent from those belonging the Sherpa-FX2. These are payload inhibit switches that prevent inadvertent activation of the payload with single fault tolerance. When the Sherpa separates, the two switches will close, activating an onboard timer on the TagSat-2 payload. Thereafter, these switches have no further function. TagSat-2 will automatically begin beaconing after 24 hours from the activation of the timer. Any RF transmissions from the payload or from the ground will be licensed by NearSpace Launch and are prerequisite to integration on Sherpa-FX2.

SOARS by Keplerian Technologies, and manufactured by Tiger Innovations Inc, is an active beacon for space object identification and tracking. SOARS is electrically independent from Sherpa-FX2.The only direct interface with SOARS is the mechanical mate of the payload to the Sherpa-FX2 structure. SOARS will operate over UHF to collect space environment data (plasma, temperature, radiation, etc.) and Sherpa-FX2 position data. The payload is activated by uplink of a UHF command. The payload can be terminated via a kill command uplink. Keplerian Technologies uses their own ground stations. Keplerian Technologies is responsible to secure required licenses for any RF transmissions from the payload or from the ground and a valid license is a prerequisite to integration on Sherpa-FX2.

Finally, for Sherpa-FX2, Stellar Exploration will provide a semi-passive radar retro-reflector as a technology demonstration for CubeSat identification and tracking. The only interface the hosted payload has with the Sherpa-FX2 vehicle is a mechanical mate to the structure. There are no radio frequency transmissions from the hosted payload. The hosted payload is entirely self-sufficient with power being provided by a solar cell on the radar reflector. The radar reflector turns on with no stored energy and begins charging when exposed to sunlight. The hosted payload will use ground-based radar to capture modulated reflections from Sherpa-FX2, which will only be operated once Sherpa-FX2 satellite deployments are complete. As with the other hosted payloads, proper licensing, such as FAA Payload Review, obtained by the owner of the hosted payload is prerequisite to integration to Sherpa-FX2.

Sherpa-LTE1

Spaceflight's Sherpa-LTE1 mission consists of two mission phases using the same base Sherpa vehicle. Like previous missions, SSO-A[4], Sherpa-FX1[5], and Sherpa-FX2 as described above, Sherpa-LTE1 consists of several structural elements to mount both microsatellites and CubeSat dispensers. The LTE1 Primary Mission phase is the deployment of customer spacecraft, the same as Sherpa-FX2. This phase is anticipated to last for less than six (6) hours. During this phase, the Sherpa-LTE1 vehicle will deploy customer spacecraft in the same way as the Sherpa-FX1 and Sherpa-FX2 as described above.

Like Sherpa-FX2, Sherpa-LTE1 utilizes the R2A-Core system for its primary mission to command the deployment of approximately 14 customer spacecraft into SSO. Sherpa-LTE1 will also have two (2) cameras onboard for the purposes of mission assurance and to confirm customer deployments. As is the case for FX2, as indicated on Spaceflight's customer manifest for LTE1 (Exhibit D-2), Spaceflight has provided for one (1) standby spacecraft that could replace a microsatellite on the forward port of Sherpa-LTE1 Mission in the event a currently manifested spacecraft does not make the mission. If this swap is not viable for any reason, a non-separating mass model would fill the empty port. In all cases, the Mission analyses will be rerun with the final spacecraft configuration and we expect it to show improved results compared to those presented in the application. Spaceflight provides the launch capacity, structure, separation systems, and integration services for the customer spacecraft. Sherpa-LTE1 will be attached to a single port on a SpaceX-provided payload ring. Once a separation signal is

[4] SAT-STA-20180523-00042
[5] SAT-STA-20200728-00089

received by Sherpa-LTE's separation system from Falcon 9 avionics, Sherpa-LTE1 will separate. After Sherpa-LTE1's separation from Falcon 9 and a subsequent delay in accordance with SpaceX requirements, once activated, the R2A-Core executes an onboard mission sequence to deploy all spacecraft. The internal volume of Sherpa-LTE1 will contain R2A-Core sequencer and batteries. 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 LTE1 Primary Mission is anticipated to last less than six (6) hours, and all communications will stop at or less than 24 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 24 hours into the mission.

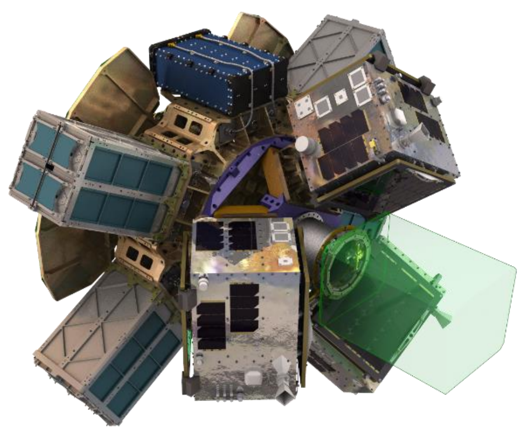
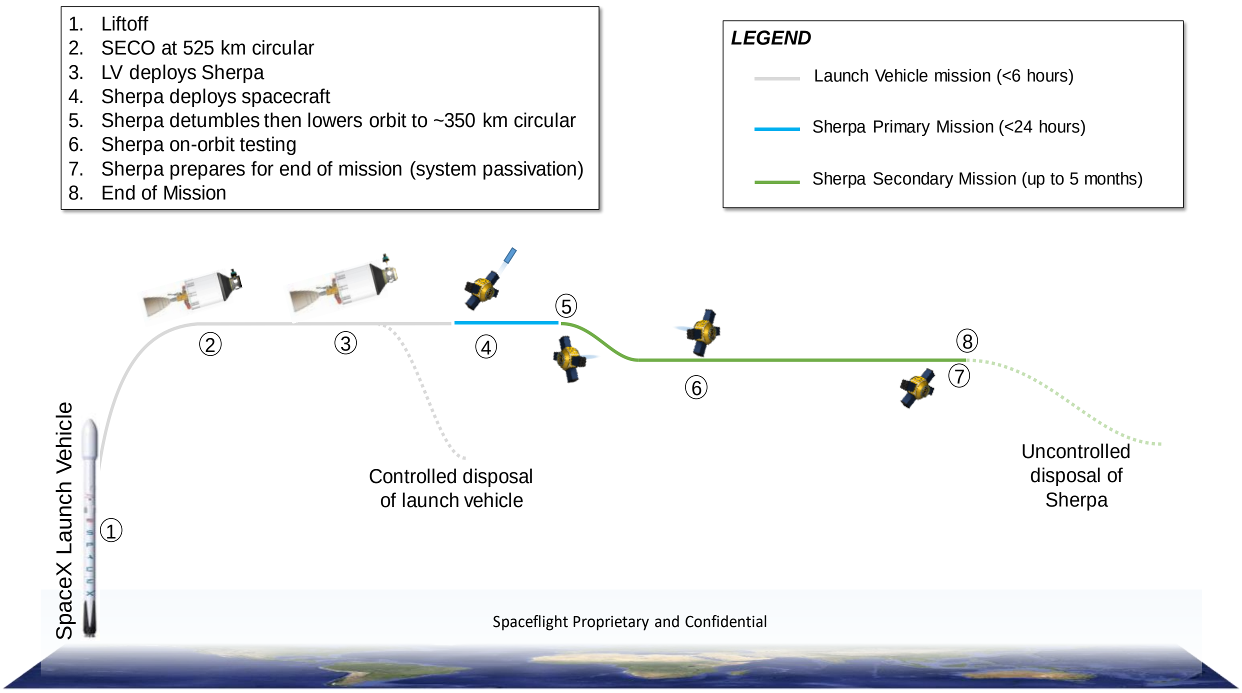


Figure 2: Physical architecture of Spaceflight's Sherpa-LTE1 with customers on a Falcon 9 Rideshare Mission.

Sherpa-LTE1 Deorbit Demonstration Mission

Sherpa-LTE1 includes additional hardware to enable a secondary mission 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 same 6 hours or less like Sherpa-FX2), a secondary mission initiates for a controlled deorbit phase lasting no longer than 6 months. During the controlled deorbit phase, two new modular systems will be enabled and tested. The first is an onboard computer with spacecraft sensors and effectors to provide command and control over the Sherpa vehicle. This system will make use of traditional, flight-proven, small satellite control systems (reaction wheels, star trackers, magnetic torque rods, etc.) to detumble and stabilize the Sherpa vehicle in a known attitude, then point the vehicle to sun-normal for solar panel charging. Also, during this time, the second modular system, an electric propulsion assembly from Apollo Fusion, will be commissioned to lower the Sherpa vehicle altitude from 525 km to approximately 350 km. Orbit lowering will be accomplished through a series of ~20-minute retrograde impulsive maneuvers using xenon gas as the propellant. This set of maneuvers will demonstrate rapid deorbit of the Sherpa system, while providing key performance data for the Apollo Fusion propulsion, and greater Sherpa system. From that altitude, Spaceflight will decommission Sherpa for an uncontrolled reentry, which at this lower altitude, will take a matter of weeks. 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 secondary mission phase, 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. A graphic, on the following page, provides an overview of the LTE1 Primary Mission and LTE1 Demonstration Mission.



Sherpa-FX2 and Sherpa-LTE1 Primary Mission Communication System

RF System Design – R2A-Core

For both the FX2 Mission and LTE-1 Primary Mission, 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 mission. 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.

Other radio property details are shown in the following table:

Sherpa R2A-Core Communication System (for Sherpa-FX2 Mission and Sherpa-LTE1 Primary Mission)	
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-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);
- Kill command from S-band ground transmitter; or
- Battery depleted (less than 24 hours after starting).

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

Sherpa-LTE1 Secondary Demonstration Mission Communication System

Communication details for the secondary mission phase of the Sherpa-LTE1 mission are provided in the following table:

Sherpa-LTE1 Communication System (Secondary Demonstration Mission Phase)			
Parameter	**UHF Uplink to Sherpa (Primary)**	**S-Band Uplink to Sherpa (Backup)**	**UHF Downlink to GND**
Data Rate	38.4 Kbps	38.4 Kbps	38.4 Kbps
Modulation	2-GFSK	2-GFSK	2-GFSK
Center Frequency	402.9 MHz	2075 MHz	400.5 MHz
Bandwidth	40 KHz	300 KHz	40 KHz
Transmit Power	95 W (max)	10 W (max)	36 dBm (max)
Transmit Antenna			Monopole
Receive Antennas	Monopole	Patch	
EIRP			6 dBW (max)
Encryption	AES-256	AES-256	AES-256
Duty Cycle (max)	50%	50%	50%

Spaceflight is planning to use operational ground stations from two (2) providers, Astro Digital 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 (the Tromso station is leased from KSAT by Astro Digital). These two ground stations are already in use with the same Astro Digital flight hardware that Spaceflight has purchased for this secondary mission. Spaceflight is also planning on using two UHF receive stations operated by RBC at Windham, New York and Fairbanks, Alaska. In addition, an S-band uplink is planned to be deployed through Tromso, Norway and Deadhorse, Alaska, the latter operated by RBC. 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.

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-LTE1.

Sherpa-LTE1 Ground Stations (Secondary Demonstration Mission Phase)					
Ground Station	**Provider**	**Location**	**UHF**	**S-band**	**Status**
Tromso, Norway (Primary)	Astro Digital/KSAT	69.66 N, 18.94 E	Up + Down	None	Operational, License Mod
Santa Clara, CA	Astro Digital	37.38 N, 121.96 W	Up + Down	Up	Operational, License Mod
Deadhorse, AK (Primary)	RBC	70.21 N, 148.41 W	Down	Up	Operational, License Mod
Windham, NY	RBC	42.34 N, 74.26 W	Down	None	Operational, License Mod
Fairbanks, AK	RBC	64.86 N, 147.84 W	Down	None	Operational, License Mod

Sherpa-FX2 Orbital Debris Assessment Report (ODAR)

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

Report Version 1
February 4, 2021

Document Data is Not Restricted.

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

DAS Software Version Used In Analysis: v3.1.0
Report prepared by Mike Coletti, Mission Manager
Analysis prepared by Eric Lund, Lead Systems Engineer

VERSION APPROVAL and/or FINAL APPROVAL*:

Mike Coletti
Mission Manager
Spaceflight, Inc.

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

Table Contents

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

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

Orbital Debris Self-Assessment Report Evaluation: Sherpa-FX2 on June 2021 SpaceX Falcon 9 Rideshare Mission

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

Assessment Report Format:

ODAR Technical Sections Format Requirements:

As Spaceflight, Inc. is based in the US, and governed by the rules and regulation of the US; this ODAR follows the format recommended in NASA- STD-8719.14b, Appendix A.1 and includes the content indicated at a minimum in each section 2 through 8 below for the June 2021 SpaceX Rideshare Mission. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Project Manager: Mike Coletti

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

Schedule of upcoming mission milestones:
Launch: June 2021 – July 2021

Mission Overview:
The June 2021 SpaceX Rideshare Mission (“Transporter-2”) is a commercial rideshare mission, for which the primary objective of Spaceflight Inc., is deploying around 25 customer spacecraft into a planned sun-synchronous circular orbit of 525 km ± 25 km. The launch vehicle will deploy a free flyer spacecraft, called “Sherpa-Flex2” or “Sherpa-FX2”, which deploys additional customer spacecraft within several hours of liftoff and will carry up to three hosted payloads through de-orbit. (*Each of these satellite customers are responsible for obtaining an FCC or other agency or administration authorization as appropriate and do not constitute debris*). Sherpa-FX2 will rely on atmospheric drag to fully de-orbit. Sherpa-FX2 has no solar panels, attitude control, propulsion, or pressure vessels.

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

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

- *Nominal Mission*: All customer deployments successful
- *Failed Mission*[1]*:* All spacecraft deployments unsuccessful

ODAR Summary:

- No debris released in normal operations;

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

- No credible scenario for breakups;
- The collision probability with other objects is compliant with NASA standards;
- The estimated decay lifetime due to atmospheric drag is under 25 years, through the possible range altitudes and mission cases presented herein, as predicted by DAS 3.1.0.

	525 km	**550 km**
Sherpa-FX2 Nominal Mission	8 years	13.5 years
Sherpa-FX2 Failed Mission	16 years	23.9 years

Launch vehicle and launch site: Falcon 9**,** Vandenberg Air Force Base, California

Proposed launch date: June 2021 – July 2021

Mission duration:

Maximum Sherpa-FX2 Nominal Operations:

- < 24 hours after launch.

Post-Mission Orbit lifetime:

- For a Nominal Mission at 525 km, Sherpa-FX2 has a predicted post-mission orbit lifetime 8 years, and 13.5 years at 550 km.

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

Sherpa-FX2

	Apogee Altitude	**Perigee Altitude**	**Inclination**	**Mission Duration**
Mission	525 ± 25 km	525 ± 25 km	97.384 ± 0.1 deg	<1 day (all cases)
End-of-Life Orbit	525 ± 25 km	525 ± 25 km	97.384 ± 0.1 deg	8 years (nominal, 525 km mission) - 23.9 years (failed, 550 km mission)

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:

Sherpa-FX2 is a non-propulsive, free flying spacecraft that is designed to deploy auxiliary spacecraft. Sherpa-FX2 will also carry up to 3 hosted payloads that will remain on the spacecraft through deorbit. It is structurally alike, to the previously licensed Sherpa-FX1[2]. The separation system and customer payload layout on Sherpa-FX2 can be variable, depending on the number of microsatellites and CubeSats manifested to the mission. CubeSat and Microsatellite separation systems are interchangeable and can be affixed radially on the body of either Sherpa vehicle. A microsatellite, CubeSat dispenser, or other adapter for separation system mounting can be affixed on the outboard end of Sherpa-FX2. Thus, Sherpa-FX2 will deploy customers in the same fashion as the previously licensed Sherpa-FX1. For this Mission, the planned configuration has a microsatellite on the outboard end of Sherpa-FX2, with three microsatellites, two 6U equivalent CubeSat dispensers, two 3U dispensers, and one 12U equivalent CubeSat dispenser, attached radially on the body of Sherpa-FX2.[3] The Sherpa-FX2 Mission configuration also includes an S-band receive antenna and an L-band transmitter as part of its avionics.

Sherpa-FX2 will be attached to a single port on a SpaceX-provided payload ring. The Falcon 9 will have multiple rings with SpaceX's other customers stacked above and/or below the ring to which Spaceflight's Sherpa FX2 is attached. Once a separation signal is received by Sherpa-FX2's separation system from Falcon 9 avionics, Sherpa-FX2 will separate.

In a case where any combination of spacecraft are unable to make the mission, a non-separating mass dummy will be either inserted into a locked dispenser door or affixed directly to the Sherpa-FX2 structure, depending on the missing spacecraft's form factor. These mass dummies are not included in Spaceflight's casualty risk analysis for this submission, because they would be materially and physically the same as those evaluated in Spaceflight's Sherpa-FX1 submission[1]. In that STA, examples for a microsat mass model, entire 12U and 6U dispenser mass models, or a single CubeSat mass model within a flight dispenser were all shown to fully demise and not contribute to any human casualty risk. Some customers are responsible for providing their own mass model. If a case arises that a customer mass model will need to be integrated for flight, Spaceflight will re-run DAS analysis incorporating that specific mass model and its corresponding material properties to ensure demise and no worse risk of casualty than what is presented here, before integration onto the Sherpa-FX2 structure.

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

Sherpa-FX2 without separating customer spacecraft	128 kg
Sherpa-FX2 with separating customer spacecraft	295 kg

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

Sherpa-FX2 without separating customer spacecraft	128 kg
Sherpa-FX2 with separating customer spacecraft	295 kg

[2] SAT-STA-20200728-00089 Spaceflight, Inc. Sherpa-FX1 STA
[3] None of the spacecraft to be deployed will themselves deploy additional spacecraft.

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

Sherpa-FX2 without separating customer spacecraft	128 kg

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

Sherpa-FX2 has no propulsion.

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

Fluids in Pressurized Batteries: None. Sherpa-FX2 uses two of the same NiMH battery packs previously used on the Sherpa-FX1 mission.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector: Sherpa-FX2 does not have attitude control.

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

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

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

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

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

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

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

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

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

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

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

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

Mission Related Debris Passing Through LEO: COMPLIANT

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

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

Potential causes of spacecraft breakup during deployment and mission operations:

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

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

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

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

There are no planned breakups.

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

No components require passivation at EOM.

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

N/A

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

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

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

Compliance statement:

Required Probability: 0.001.

Expected probability: 0.000.

Supporting Rationale and FMEA details:

Battery explosion:

Effect: All failure modes below might theoretically result in battery explosion with the possibility of orbital debris generation. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of the selected space-rated COTS battery cells is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the battery housing / containment device due to the lack of penetration energy.

Probability: Extremely Low. It is believed to be a much less than 0.1% probability that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

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

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

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

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

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

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

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

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

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

Compliance statement:
Sherpa-FX2 is designed such that when mission operations begin, all energy from the secondary batteries will dissipate within 24 hours. The primary batteries will dissipate all energy within 24 hours. Additionally, Sherpa-FX2 battery charge circuits include overcharge protection and active thermal monitoring to limit the risk of battery failure. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

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

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

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

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

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

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

Requirement 4.5-1:
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-FX2	0.00001690	0.00003760	COMPLIANT

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

Probability of Damage from Small Debris:
Not applicable – there are no subsystems vital to completing post mission disposal and the spacecraft is fully compliant with orbit lifetime requirements in all cases.

Identification of all systems or components required to accomplish any post-mission disposal operation, including passivation and maneuvering:
Sherpa-FX2 batteries will deplete in less than 24 hours after separation. Sherpa-FX2 will deorbit naturally and rely on atmospheric drag. Sherpa-FX2 does not have propellants or pressure vessels.

Recontact Analysis. Although beyond the scope of a standard orbital debris analysis, Spaceflight has conducted extensive testing and modeling 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-FX2 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-FX2 will deorbit naturally by atmospheric re-entry.

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

Sherpa-FX2 does not have propulsion or attitude control. There is no plan for post-mission disposal maneuvers.

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

Spacecraft Mass:

	Nominal Mission	Failed Mission
Sherpa-FX2	128 kg	295 kg

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

	Nominal Mission	Failed Mission
Sherpa-FX2	0.9942 m^2	1.0668 m^2

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

	Nominal Mission	Failed Mission
Sherpa-FX2	0.0078 m^2/kg	0.00361 m^2/kg

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

Requirement 4.6-1: Disposal for space structures passing through LEO:
A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods:
(Requirement 56557)
a. Atmospheric reentry option:

- *Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or*
- *Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.*

b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.
c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

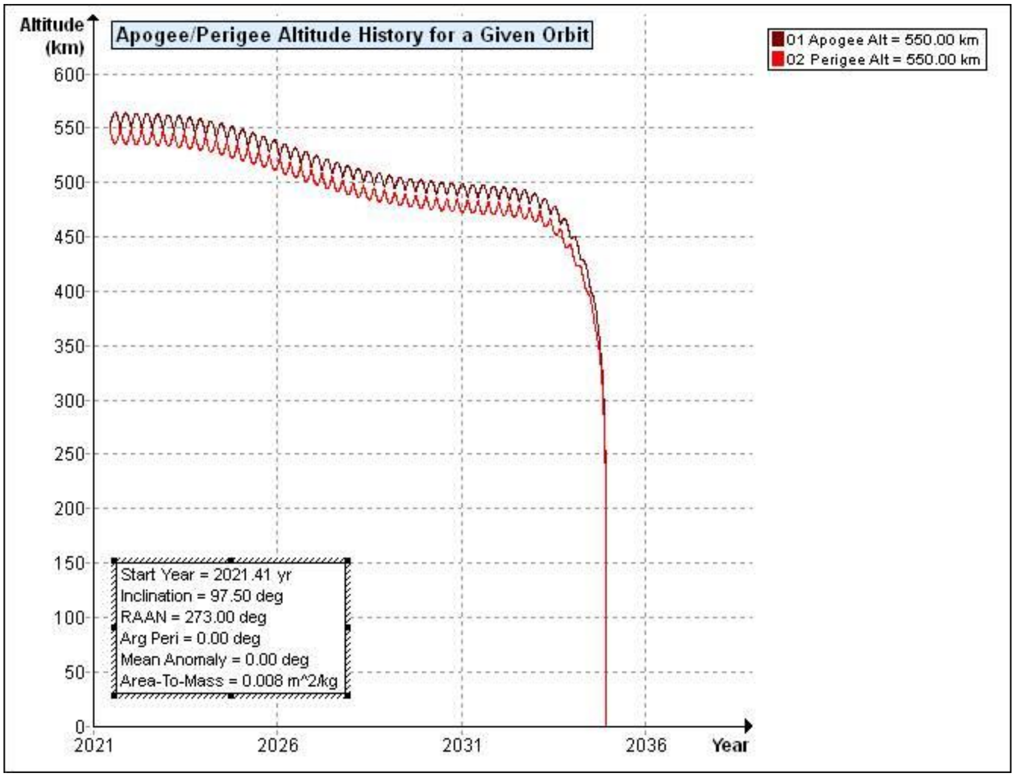


Figure 1 - Sherpa-FX2 (Nominal Mission at 550 km) orbit history

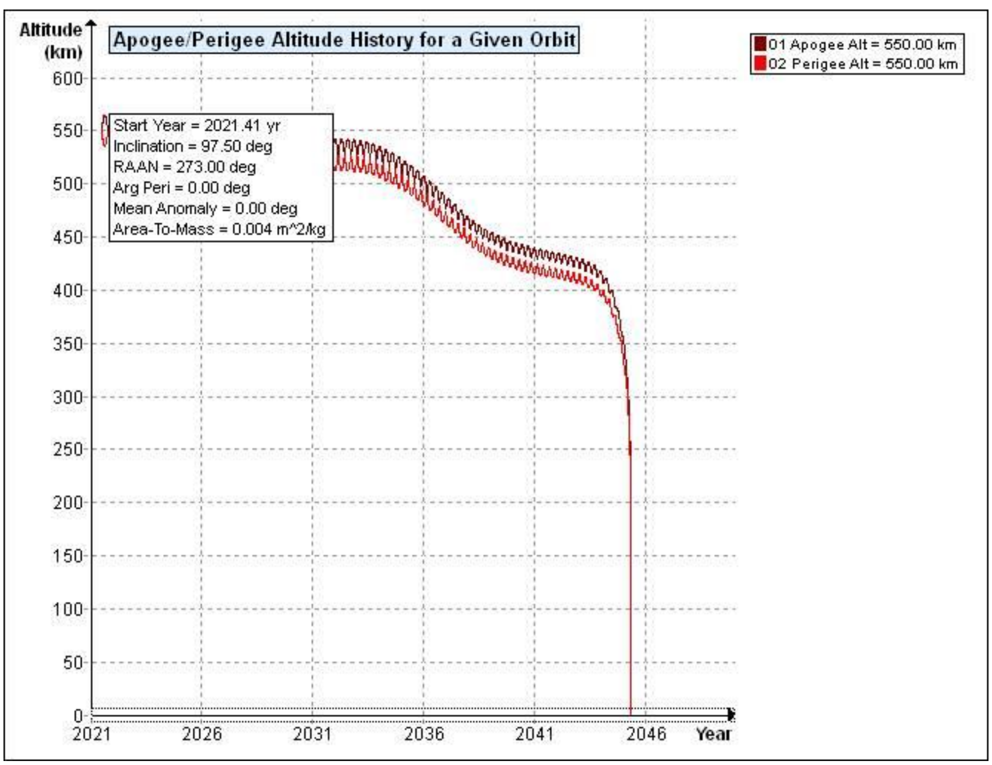


Figure 2 - Sherpa-FX2 (Failed Mission at 550 km) orbit history.

Analysis: Sherpa-FX2 reentry is COMPLIANT using method “a”.

Satellite Name	Sherpa-FX2	Sherpa-FX2
BOL Orbit (Drop off)	525 x 525 km	550 x 550 km
Operational Orbit	525 x 525 km	550 x 550 km
EOM Orbit	525 x 525 km	550 x 550 km
Total Lifetime for Nominal Mission	8 years	13.5 years
Total Lifetime if Mission Failure	16 years	23.9 years

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

Analysis: Not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO. **Analysis:** Not applicable.

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

Reliability: Sherpa-FX2 will rely on atmospheric drag to fully de-orbit. Spaceflight shows DAS analysis cases here for: (i) its planned or Nominal Mission (successful deployment of all spacecraft planned to be deployed); and (ii) were there to be an off-nominal case, the most likely failure scenario, a Total Mission Failure where no spacecraft are deployed. In both cases DAS returns a total mission lifetime less than 25 years.

As with SSO-A and Sherpa-FX1, Spaceflight has a team of highly qualified engineers, and a well-established process for rideshare missions such as this. Spaceflight finds that an avionics failure in the middle of the separation sequence is highly unlikely and has previously demonstrated flight heritage on the Sherpa-FX1 mission. If the primary avionics systems were to fail, it will most likely succumb to the launch environment, which occurs prior to any deployments from Sherpa-FX2, resulting in an orbit lifetime less than 25 years. Finally, Spaceflight believes a successful mission, the “Nominal Mission” case, is most probable. In either case, the analysis contained above shows compliance with FCC regulation and guidelines.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Assessment of spacecraft compliance with Requirement 4.7-1:

Requirement 4.7-1: Limit the risk of human casualty:
The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules:

a) For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

Summary Analysis Results:
DAS calculates Sherpa-FX2 and its separation systems and subcomponents listed in further detail in the full DAS results appended to this report, has a 1:100,000,000 risk of human casualty and thus that spacecraft meets the requirement. No components of the spacecraft are expected to survive reentry.

Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because the Sherpa-FX2 Mission does not use controlled reentry.

4.7-1, b) **NOT APPLICABLE.** For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627).
4.7-1 c) **NOT APPLICABLE.** For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628).

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers in the mission.

Raw DAS Output – Nominal Mission at 525 km (all customers separated)

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

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

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

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

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

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

INPUT

Space Structure Name = Sherpa-FX2
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.384 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0078 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 295.000 (kg)
Final Mass = 128.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 1.6905E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

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

INPUT

Space Structure Name = Sherpa-FX2

Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.384300 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.007771 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 295.000000 (kg)
Final Mass = 128.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 523.358271 (km)
PMD Apogee Altitude = 526.633916 (km)
PMD Inclination = 97.385395 (deg)
PMD RAAN = 3.532465 (deg)
PMD Argument of Perigee = 173.801136 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 523.358271 (km)
Suggested Apogee Altitude = 526.633916 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2029 (yr)
Requirement = 61
Compliance Status = Pass

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

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

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

name = Sherpa-FX2
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 128.000000
Thermal Mass = 128.000000
Diameter/Width = 0.813000

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

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

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

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

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

name = MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.170000
Thermal Mass = 2.170000
Diameter/Width = 0.283660
Length = 0.311150

Height = 0.031750

name = ISIPod L-bracket
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.300000
Length = 0.400000
Height = 0.150000

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

name = FX 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 = FX 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 = FX EyeStar Black Box
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 ISIPod
quantity = 2
parent = 1
materialID = 5

type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.180000
Length = 0.414000
Height = 0.130000

name = FX empty DuoPack
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 4.600000
Thermal Mass = 4.600000
Diameter/Width = 0.250000
Length = 0.402000
Height = 0.152400

name = empty 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 = PRA
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 11.998000
Thermal Mass = 11.998000
Diameter/Width = 0.626000
Length = 0.626000
Height = 0.070000

name = 15-3 Spacer Ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 6.350000
Thermal Mass = 6.350000
Diameter/Width = 0.198000
Length = 0.198000
Height = 0.076200

name = FX lower 8-in separation system
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 1.191000
Thermal Mass = 1.191000
Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

name = lower 15-in separation system
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.057000
Thermal Mass = 2.057000
Diameter/Width = 0.206154
Length = 0.206154
Height = 0.045466

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

name = Sherpa-FX2
Demise Altitude = 77.999092
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX upper 24-in separation sytem
Demise Altitude = 75.541252
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Hex Plate
Demise Altitude = 60.130455
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Interior Wall
Demise Altitude = 72.844116
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Corner Brace
Demise Altitude = 72.654305
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX DuoPack adapter plate
Demise Altitude = 73.088615
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX QuadPack adapter plate
Demise Altitude = 72.968544
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = MLB adapter plate
Demise Altitude = 72.472847
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ISIPod L-bracket
Demise Altitude = 75.473404
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX avionics deck plate
Demise Altitude = 71.815086
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX R2A-Core
Demise Altitude = 70.333923
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX battery module
Demise Altitude = 67.150024
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX EyeStar Black Box
Demise Altitude = 74.773804
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty ISIPod
Demise Altitude = 74.938217
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX empty DuoPack
Demise Altitude = 71.671951
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty QuadPack
Demise Altitude = 70.730232
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PRA
Demise Altitude = 62.091202
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = 15-3 Spacer Ring
Demise Altitude = 59.087605
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX lower 8-in separation system
Demise Altitude = 69.305084
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = lower 15-in separation system
Demise Altitude = 69.622650
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

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

Raw DAS Output –Mission Failure at 525 km (no customers separated)

01 21 2021; 10:41:55AM Activity Log Started
01 21 2021; 10:41:56AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA DoA\
01 21 2021; 10:42:07AM Processing Requirement 4.3-1: Return Status : Not Run

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

=============== End of Requirement 4.3-1 ===============
01 21 2021; 10:42:10AM Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
01 21 2021; 11:28:49AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-FX2
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.384 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0036 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 295.000 (kg)
Final Mass = 295.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 3.7596E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

01 21 2021; 11:28:51AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-FX2

Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.384300 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003610 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 295.000000 (kg)
Final Mass = 295.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 523.358192 (km)
PMD Apogee Altitude = 526.633443 (km)
PMD Inclination = 97.385395 (deg)
PMD RAAN = 3.532465 (deg)
PMD Argument of Perigee = 174.025861 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 523.358192 (km)
Suggested Apogee Altitude = 526.633443 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

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

Raw DAS Output – Nominal Mission at 550 km (all customers separated)

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

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

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

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

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

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

INPUT

Space Structure Name = Sherpa-FX2
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.500 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0078 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 295.000 (kg)
Final Mass = 128.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 3.4436E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

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

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

INPUT

Space Structure Name = Sherpa-FX2
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.007771 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 295.000000 (kg)
Final Mass = 128.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.385245 (km)
PMD Apogee Altitude = 551.609703 (km)
PMD Inclination = 97.501102 (deg)
PMD RAAN = 3.542512 (deg)
PMD Argument of Perigee = 173.951631 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.385245 (km)
Suggested Apogee Altitude = 551.609703 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

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

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

name = Sherpa-FX2
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 128.000000
Thermal Mass = 128.000000
Diameter/Width = 0.813000

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

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

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

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

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

name = MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.170000

Thermal Mass = 2.170000
Diameter/Width = 0.283660
Length = 0.311150
Height = 0.031750

name = ISIPod L-bracket
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.300000
Length = 0.400000
Height = 0.150000

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

name = FX 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 = FX 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 = FX EyeStar Black Box
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 ISIPod

quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.180000
Length = 0.414000
Height = 0.130000

name = FX empty DuoPack
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 4.600000
Thermal Mass = 4.600000
Diameter/Width = 0.250000
Length = 0.402000
Height = 0.152400

name = empty 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 = PRA
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 11.998000
Thermal Mass = 11.998000
Diameter/Width = 0.626000
Length = 0.626000
Height = 0.070000

name = 15-3 Spacer Ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 6.350000
Thermal Mass = 6.350000
Diameter/Width = 0.198000
Length = 0.198000
Height = 0.076200

name = FX lower 8-in separation system
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 1.191000
Thermal Mass = 1.191000

Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

name = lower 15-in separation system
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.057000
Thermal Mass = 2.057000
Diameter/Width = 0.206154
Length = 0.206154
Height = 0.045466

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

name = Sherpa-FX2
Demise Altitude = 77.999817
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX upper 24-in separation sytem
Demise Altitude = 75.533455
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Hex Plate
Demise Altitude = 60.231030
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Interior Wall
Demise Altitude = 72.850060
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Corner Brace
Demise Altitude = 72.668243
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX DuoPack adapter plate
Demise Altitude = 73.091049
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX QuadPack adapter plate
Demise Altitude = 72.969254
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = MLB adapter plate

Demise Altitude = 72.467041
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ISIPod L-bracket
Demise Altitude = 75.476692
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX avionics deck plate
Demise Altitude = 71.831902
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX R2A-Core
Demise Altitude = 70.341408
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX battery module
Demise Altitude = 67.148643
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX EyeStar Black Box
Demise Altitude = 74.773628
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty ISIPod
Demise Altitude = 74.942795
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX empty DuoPack
Demise Altitude = 71.661888
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty QuadPack
Demise Altitude = 70.731926
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PRA
Demise Altitude = 62.102901
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = 15-3 Spacer Ring
Demise Altitude = 59.115799

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX lower 8-in separation system
Demise Altitude = 69.313759
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = lower 15-in separation system
Demise Altitude = 69.642227
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

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

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

01 29 2021; 09:59:22AM Activity Log Started
01 29 2021; 09:59:22AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA DoA\
01 29 2021; 09:59:35AM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ==============
01 29 2021; 09:59:36AM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ==============
01 29 2021; 11:15:26AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-FX2
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.500 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0036 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 295.000 (kg)
Final Mass = 295.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 5.8447E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

01 29 2021; 11:15:30AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-FX2
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003610 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 295.000000 (kg)
Final Mass = 295.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.385268 (km)
PMD Apogee Altitude = 551.609323 (km)
PMD Inclination = 97.501102 (deg)
PMD RAAN = 3.542512 (deg)
PMD Argument of Perigee = 174.176703 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.385268 (km)
Suggested Apogee Altitude = 551.609323 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

=============== End of Requirement 4.6 ===============
01 29 2021; 11:15:35AM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = Sherpa-FX2
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 295.000000
Thermal Mass = 295.000000
Diameter/Width = 0.813000

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

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

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

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

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

name = MLB adapter plate
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 2.170000
Thermal Mass = 2.170000

Diameter/Width = 0.283660
Length = 0.311150
Height = 0.031750

name = ISIPod L-bracket
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.300000
Length = 0.400000
Height = 0.150000

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

name = FX 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 = FX 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 = FX EyeStar Black Box
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 ISIPod
quantity = 2

parent = 1
materialID = 5
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.180000
Length = 0.414000
Height = 0.130000

name = FX empty DuoPack
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 4.600000
Thermal Mass = 4.600000
Diameter/Width = 0.250000
Length = 0.402000
Height = 0.152400

name = empty 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 = PRA
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 11.998000
Thermal Mass = 11.998000
Diameter/Width = 0.626000
Length = 0.626000
Height = 0.070000

name = 15-3 Spacer Ring
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 6.350000
Thermal Mass = 6.350000
Diameter/Width = 0.198000
Length = 0.198000
Height = 0.076200

name = FX lower 8-in separation system
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 1.191000
Thermal Mass = 1.191000
Diameter/Width = 0.117508

Length = 0.117508
Height = 0.045466

name = lower 15-in separation system
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.057000
Thermal Mass = 2.057000
Diameter/Width = 0.206154
Length = 0.206154
Height = 0.045466

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

name = Sherpa-FX2
Demise Altitude = 77.998375
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX upper 24-in separation sytem
Demise Altitude = 76.346458
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Hex Plate
Demise Altitude = 67.388969
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Interior Wall
Demise Altitude = 74.356865
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX Corner Brace
Demise Altitude = 74.215584
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX DuoPack adapter plate
Demise Altitude = 74.542831
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX QuadPack adapter plate
Demise Altitude = 74.451355
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = MLB adapter plate
Demise Altitude = 74.040718

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ISIPod L-bracket
Demise Altitude = 76.278023
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX avionics deck plate
Demise Altitude = 73.605568
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX R2A-Core
Demise Altitude = 72.383125
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX battery module
Demise Altitude = 69.828629
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX EyeStar Black Box
Demise Altitude = 75.775063
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty ISIPod
Demise Altitude = 75.907417
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FX empty DuoPack
Demise Altitude = 73.427376
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty QuadPack
Demise Altitude = 72.719269
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PRA
Demise Altitude = 66.339401
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = 15-3 Spacer Ring
Demise Altitude = 63.084335
Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = FX lower 8-in separation system
Demise Altitude = 71.547256
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = lower 15-in separation system
Demise Altitude = 71.794197
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

=============== End of Requirement 4.7-1 ===============
01 29 2021; 11:15:35AM Project Data Saved To File
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END of Sherpa-FX2 Orbital Debris Assessment Report (ODAR)

Sherpa-LTE1 Orbital Debris Assessment Report (ODAR)

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

Report Version 1
February 4, 2021

Document Data is Not Restricted.

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

DAS Software Version Used In Analysis: v3.1.0
Report prepared by Mike Coletti, Mission Manager
Analysis prepared by Eric Lund, Lead Systems Engineer

VERSION APPROVAL and/or FINAL APPROVAL*:

Mike Coletti
Mission Manager
Spaceflight, Inc.

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

Table Contents

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

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

Orbital Debris Self-Assessment Report Evaluation: Sherpa-LTE1 on June 2021 SpaceX Falcon 9 Rideshare Mission

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

Assessment Report Format:

ODAR Technical Sections Format Requirements:

As Spaceflight, Inc. is based in the US, and governed by the rules and regulation of the US; this ODAR follows the format recommended in NASA- STD-8719.14b, Appendix A.1 and includes the content indicated at a minimum in each section 2 through 8 below for the June 2021 SpaceX Rideshare Mission. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Project Manager: Mike Coletti

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

Schedule of upcoming mission milestones:
Launch: June 2021 – July 2021

Mission Overview:
The June 2021 SpaceX Rideshare Mission ("Transporter-2") is a commercial rideshare mission, for which the primary objective of Spaceflight Inc., is deploying around 14 customer spacecraft into a planned sun-synchronous circular orbit of 525 km ± 25 km, from a free flyer Sherpa vehicle. The launch vehicle will deploy a free flyer spacecraft called "Sherpa-LTE1", which will deploy additional customer spacecraft within several hours of liftoff through de-orbit. (*Each of these satellite customers are responsible for obtaining an FCC or other agency or administration authorization as appropriate and do not constitute debris*).

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

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

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

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

ODAR Summary:

- No debris released in normal operations;
- No credible scenario for breakups;
- The collision probability with other objects is compliant with NASA standards;
- The estimated decay lifetime due to atmospheric drag is under 25 years, through the possible range altitudes and mission cases presented herein, as predicted by DAS 3.1.0.

	525 km	**550 km**
Sherpa-LTE1 Nominal Mission	1.2 year	1.2 year
Sherpa-LTE1 Nominal Mission without PMD	13 years	14.9 years
Sherpa-LTE1 Failed Mission	16 years	24.4 years

- **Launch vehicle and launch site:** Falcon 9**,** Vandenberg Air Force Base, California

Proposed launch date: June 2021 – July 2021

Mission duration:

Maximum Sherpa-LTE1 Nominal Operations:

- <6 months.

Post-Mission Orbit lifetime:

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

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

Sherpa-LTE1

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

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:
Sherpa-LTE1 base structure or CAB is identical to the previously licensed Sherpa-FX1[2]. It also contains an identical R2A-core separation sequencer, which will provide separation signals to the various separation systems. Sherpa-LTE1 will have an adapter on the forward port which will accommodate four microsatellites. Radially, Sherpa-LTE1 will have the attitude determination and control system, four 12U dispensers, and a 6U dispenser affixed radially on the body of Sherpa-LTE1. The internal volume of Sherpa-LTE1 will contain its R2A-Core sequencer and batteries, in addition to the electronic propulsion subsystem. Like Sherpa-FX1, Sherpa-LTE1 will be attached to a single port on a SpaceX-provided payload ring. The Falcon 9 will have multiple rings with SpaceX's other customers stacked above and/or below the ring to which Spaceflight's Sherpa-LTE1 is attached. Once a separation signal is received by Sherpa-LTE1's separation system from Falcon 9 avionics, Sherpa-LTE1 will separate.

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

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

Sherpa-LTE1 without separating customer spacecraft	203 kg
Sherpa-LTE1 with separating customer spacecraft	415 kg

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

Sherpa-LTE1 without separating customer spacecraft	203 kg
Sherpa-LTE1 with separating customer spacecraft	415 kg

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

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

Sherpa-LTE1 without separating customer spacecraft	203 kg

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

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

Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes: Up to 5 kg of Xenon at 2,700 psi in a DOT approved propellant tank, to be fueled at Spaceflight's Integration Facility.

Fluids in Pressurized Batteries: None.

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

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

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

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

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

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

Description of the electrical generation and storage system:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Mission Related Debris Passing Through LEO: COMPLIANT

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

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

Potential causes of spacecraft breakup during deployment and mission operations:

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

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

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

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

There are no planned breakups.

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

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

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

N/A

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

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

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

Compliance statement:

Required Probability: 0.001.

Expected probability: 0.000.

Supporting Rationale and FMEA details:

Battery explosion:

Effect: All failure modes below might theoretically result in battery explosion with the possibility of orbital debris generation. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of the selected space-rated COTS battery cells is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the battery

housing / containment device due to the lack of penetration energy.
Probability: Extremely Low. It is believed to be a much less than 0.1% probability that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

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

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

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

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

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

orbit at the time the crushing occurs.

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

Failure Mode 7: Excess temperatures due to orbital environment and high discharge combined.
Mitigation 7: The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that batteries do not exceed normal allowable operating temperatures, which are well below temperatures of concern for explosions.

Combined faults required for realized failure: Thermal analysis and thermal design and mission simulations in thermal-vacuum chamber testing and over- current monitoring and control must all fail for this failure mode to occur.

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

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

Compliance statement:
Sherpa-LTE1's primary mission batteries are designed such that when mission operations begin, all energy from the primary and secondary batteries will dissipate within 24 hours. Additionally, Sherpa-LTE1 battery charge circuits include overcharge protection and active thermal monitoring to limit the risk of battery failure. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

The CCS have the ability to fully disconnect the Lithium-Ion cells from the charging current of the solar arrays. At End-Of-Life, this feature will be used to completely passivate the batteries by removing all energy from them. In the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, the debris from the battery rupture should be contained within the spacecraft due to the lack of penetration energy to the multiple enclosures surrounding the batteries.

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

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

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

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

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

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

Requirement 4.5-1:

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

Large Object Impact and Debris Generation Probability:

Spacecraft	Nominal Mission	Nominal Mission w/o PMD	Failed Mission	Status
Sherpa-LTE1	0.00000372	0.0000297	0.00005193	COMPLIANT

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

Probability of Damage from Small Debris:

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

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

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

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

Recontact Analysis. Although beyond the scope of a standard orbital debris analysis, Spaceflight has conducted extensive testing and modeling to limit the risk that individual spacecraft that will be deployed on this mission will re-contact with each other after release. That analysis is presented as attachment titled *Sherpa-LTE1 Long-Term Recontact Probability* to Spaceflight's STA application.

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

6.1 **Description of spacecraft disposal option selected:**

Sherpa-LTE1 will deorbit to a 350 km disposal altitude via an electric propulsion system, and finally naturally decay via atmospheric drag.

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

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

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

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

Spacecraft Mass:

	Nominal Mission	Nominal Mission w/o PMD	Failed Mission
Sherpa-LTE1	203 kg	203 kg	415 kg

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

	Nominal Mission	Nominal Mission w/o PMD	Failed Mission
Sherpa-LTE1	1.1989 m^2	1.1989 m^2	1.45 m^2

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

	Nominal Mission	Nominal Mission w/o PMD	Failed Mission
Sherpa-LTE1	0.0059 m^2/kg	0.0059 m^2/kg	0.0035 m^2/kg

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

Requirement 4.6-1: Disposal for space structures passing through LEO:
A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods:
(Requirement 56557)
a. Atmospheric reentry option:

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

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

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

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

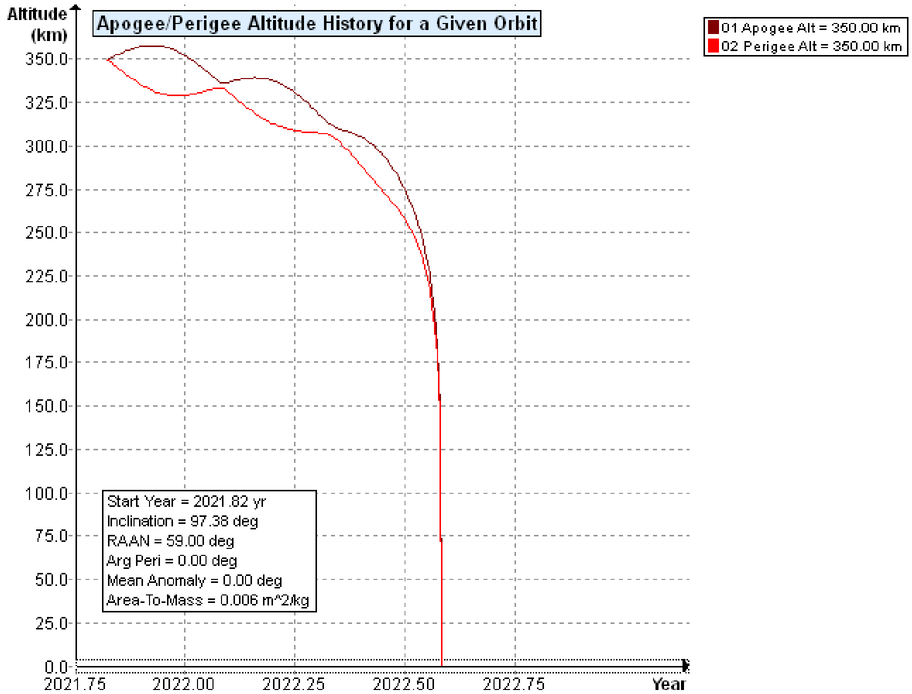

Figure 1 - Sherpa-LTE1 orbit history (Nominal Mission at 550 km) once it has reached its final disposal altitude (350 km). Due to the limitations of DAS the initial primary mission (<1 day at 550 km), and the deorbit maneuvering (<6 months, from 550 km – 350 km) could not be depicted. That portion of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

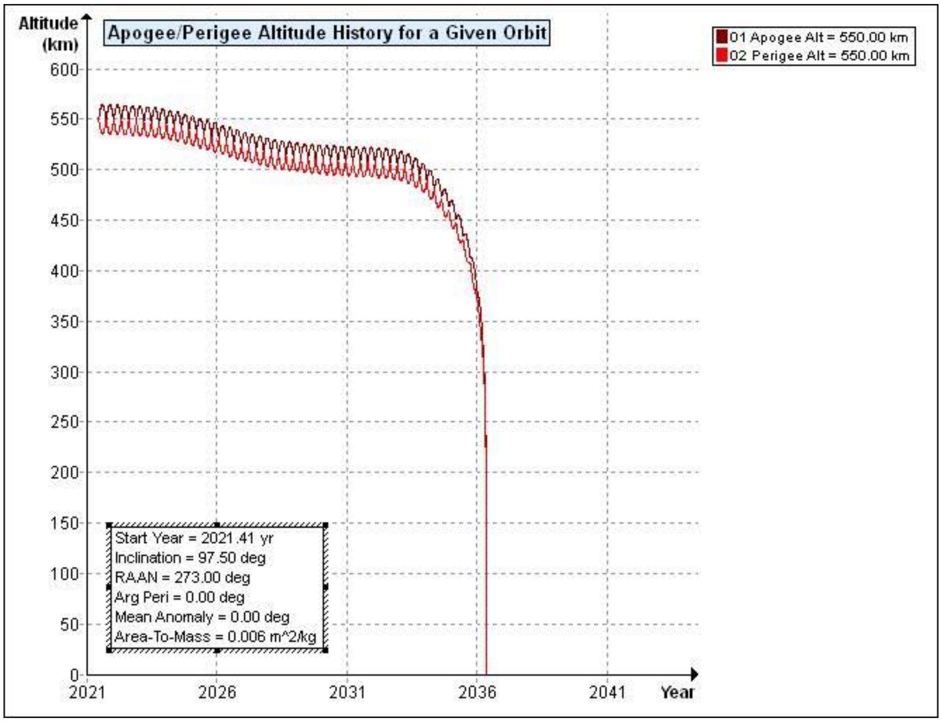

Figure 2 - Sherpa-LTE1 orbit history (Nominal Mission without PMD at 550 km). In this case the propulsion and/or attitude control system could not be commissioned and Sherpa-LTE1 altitude would decay naturally over time.

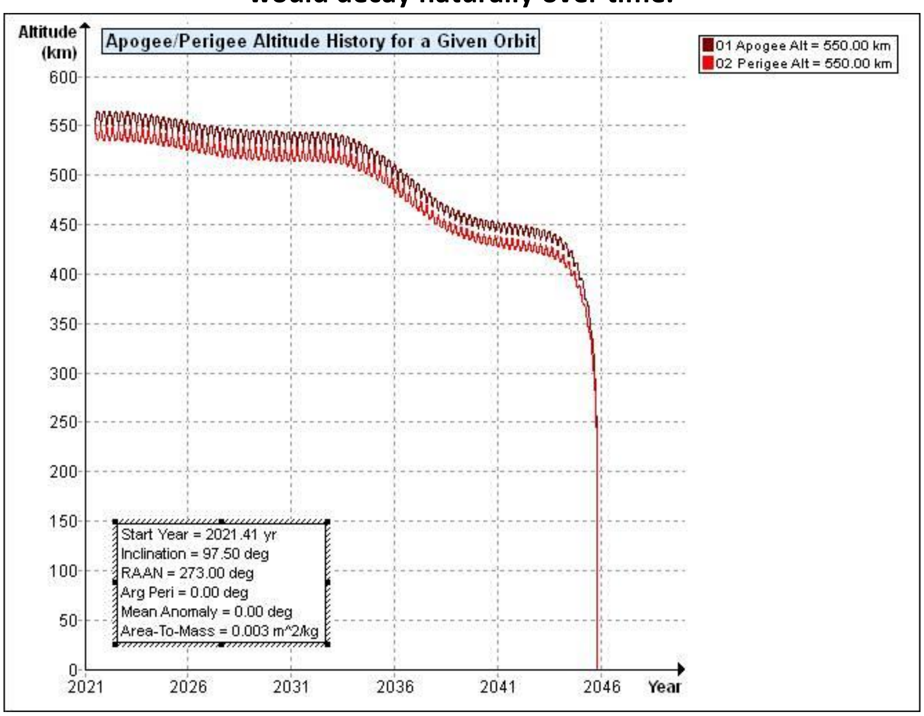

Figure 3 - Sherpa-LTE1 orbit history (Failed Mission at 550 km). In this case the propulsion and/or attitude control system could not be commissioned, no customer deployments were successful, and Sherpa-LTE1 altitude would decay naturally over time.

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

Satellite Name	**Sherpa-LTE1**	**Sherpa-LTE1**
BOL Orbit (Drop off)	525 x 525 km	550 x 550 km
Operational Orbit	525 x 525 km	550 x 550 km
EOM Orbit	350 x 350 km	350 x 350 km
Total Lifetime for Nominal Mission	1.2 years	1.2 year
Total Lifetime if Nominal Mission without PMD (EOM Orbit remains at Operational Orbit)	13 years	14.9 years
Total Lifetime if Total Mission Failure	16 years	24.4 years

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

Analysis: Not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO **Analysis:** Not applicable.

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

Reliability: Spaceflight’s plan is to drastically reduce post-mission orbit lifetime by reducing Sherpa-LTE1 altitude with electric propulsion. The ADCS on Sherpa-LTE1 is a flight proven system operating with a highly flexible flight software package. In addition, the electric propulsion system has accumulated many thousands of seconds of integrated test time, in vacuum. In order to perform the disposal acceleration burn, the spacecraft requires the proper functioning of its attitude determination and control subsystem (ADCS) as well as its Apollo Fusion propulsion system in order to successfully execute the planned deorbit maneuver. Accordingly, redundancy and reliability have been carefully considered in these disposal-critical areas.

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

Attitude control is accomplished with the reaction wheels. Three wheels, one oriented along each axis, are used for precision pointing. The magnetic torquers provide momentum desaturation for the reaction wheels. The spacecraft requires the ability to fire magnetic torquers along a minimum of two independent axes to maintain attitude control. A total of six torque coils are included in the spacecraft in two groups with different reliability chains to prevent a systematic failure. In the unlikely case of a reaction wheel failure, the magnetic torquers can be used for primary attitude control to continue the deorbit maneuver. Once Sherpa-LTE1 arrives at 350 km, its EOM orbit, it will rely on atmospheric drag to fully de-orbit.

Spaceflight shows DAS analysis cases here for: (i) its planned or Nominal Mission (successful deployment of all spacecraft planned to be deployed and successful orbit reduction); (ii) were there to be an off-nominal case, the most likely failure scenario, a Mission Failure where no spacecraft are deployed and the electric propulsion system is not commissioned; and (iii) a Nominal Mission without PMD, in which customers are successfully deployed, but the secondary mission to commission attitude control and electric propulsion systems is unsuccessful, and thus naturally decays from its 525 km or 550 km altitude via atmospheric drag. In each case DAS returns a total on-orbit lifetime of 25 years or less. In an entirely separate case, where spacecraft deployments are unsuccessful, but the secondary mission of altitude reduction is still viable, orbit lifetime would only be improved compared to this Failed Mission case where both primary and secondary mission are unsuccessful. Thus, the Failed Mission case presented here is the worst-case scenario. Since this scenario is bounded by the others, it is not discussed further.

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

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Assessment of spacecraft compliance with Requirement 4.7-1:

Requirement 4.7-1: Limit the risk of human casualty:
The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules:
a) For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

Summary Analysis Results:

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

Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

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

Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because the Sherpa-LTE1 Mission does not use controlled reentry.

4.7-1, b) **NOT APPLICABLE.** For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627).
4.7-1 c) **NOT APPLICABLE.** For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628).

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers in the mission.

Raw DAS Output – Nominal Mission at 525 km (all customers separated; Sherpa-LTE orbit lowered to 350 km)

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

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

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

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

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

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

INPUT

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

PMD Mean Anomaly = 0.000 (deg)

OUTPUT

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

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

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

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

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

INPUT

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

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

OUTPUT

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

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

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

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

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

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

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

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

Height = 0.082550

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

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

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

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

name = LT DuoPack adapter plate
quantity = 2

parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000
Diameter/Width = 0.311000
Length = 0.350000

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

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

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

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

Diameter/Width = 0.100000
Length = 0.139000
Height = 0.100000

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

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

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

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

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

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

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

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

name = RPG plinth
quantity = 1

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

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

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

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

name = RWA enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.570000
Thermal Mass = 0.570000

Diameter/Width = 0.140000
Length = 0.150000
Height = 0.042000

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****
name = torque rod
Demise Altitude = 69.685234

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****
name = Apollo Fusion thruster

Demise Altitude = 67.657211
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

****

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

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

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

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

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

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

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

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

INPUT

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

OUTPUT

Collision Probability = 2.9740E-05

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

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

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

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

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

INPUT

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

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

OUTPUT

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

Released Year = 2034 (yr)
Requirement = 61

Compliance Status = Pass

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

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

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

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

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

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

name = solar panel wing
quantity = 6
parent = 1
materialID = 8

type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

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

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

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

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

Length = 0.350000

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

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

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

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

name = LT EyeStar Black Box
quantity = 6

parent = 1
materialID = 5
type = Box
Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000
Length = 0.089000
Height = 0.047000

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

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

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

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

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

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

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

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

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

Length = 0.220000

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

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

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

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

name = RWA rotor
quantity = 3

parent = 1
materialID = 62
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

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

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

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

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000

Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****
name = AD avionics
Demise Altitude = 68.472267

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****
name = camera bracket

Demise Altitude = 74.523315
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

****

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

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

01 21 2021; 10:41:55AM Activity Log Started
01 21 2021; 10:41:56AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA DoA\
01 21 2021; 10:42:07AM Processing Requirement 4.3-1: Return Status : Not Run

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

============== End of Requirement 4.3-1 ===============
01 21 2021; 10:42:10AM Processing Requirement 4.3-2: Return Status : Passed

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

============== End of Requirement 4.3-2 ===============
01 21 2021; 11:28:49AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.384 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0035 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 415.000 (kg)
Final Mass = 415.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 5.1925E-05

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

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

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

01 21 2021; 11:28:51AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

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

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.384300 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003478 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 415.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 523.358233 (km)
PMD Apogee Altitude = 526.633708 (km)
PMD Inclination = 97.385395 (deg)
PMD RAAN = 3.532465 (deg)
PMD Argument of Perigee = 173.901307 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 523.358233 (km)
Suggested Apogee Altitude = 526.633708 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2037 (yr)
Requirement = 61

Compliance Status = Pass

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

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

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

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

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

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

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

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

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

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

PMD Mean Anomaly = 0.000 (deg)

OUTPUT

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

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

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

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

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

INPUT

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

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005906 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = False
PMD Perigee Altitude = 350.000000 (km)
PMD Apogee Altitude = 350.000000 (km)
PMD Inclination = 97.450000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 350.000000 (km)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Height = 0.100000

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

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

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

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

name = LT lower 8-in separation system

quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 1.190681
Thermal Mass = 1.190681
Diameter/Width = 0.117508
Length = 0.117508
Height = 0.045466

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

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

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

name = RPG plinth
quantity = 1
parent = 1
materialID = 8

type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.220000
Length = 0.220000

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

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

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

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

Height = 0.042000

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

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

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

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

name = Apollo Fusion PPU
quantity = 1

parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

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

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

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

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

Length = 0.047000

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

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

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

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

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

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

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

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

****

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Impact Kinetic Energy = 0.000000

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

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

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

****

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

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

01 29 2021; 08:53:57AM Activity Log Started
01 29 2021; 08:53:57AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA post-deploy no PMD\
01 29 2021; 08:54:29AM Mission Editor Changes Applied
01 29 2021; 08:54:29AM Project Data Saved To File
01 29 2021; 08:54:32AM Processing Requirement 4.3-1: Return Status : Not Run

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

=============== End of Requirement 4.3-1 ===============
01 29 2021; 08:54:34AM Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
01 29 2021; 09:42:06AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

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

OUTPUT

Collision Probability = 4.7694E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

01 29 2021; 09:42:08AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

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

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005906 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 203.000000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 538.515984 (km)
PMD Apogee Altitude = 561.239650 (km)
PMD Inclination = 97.509297 (deg)
PMD RAAN = 177.301636 (deg)
PMD Argument of Perigee = 46.034152 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 538.515984 (km)
Suggested Apogee Altitude = 561.239650 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

============== End of Requirement 4.6 ===============
01 29 2021; 09:42:20AM *********Processing Requirement 4.7-1
Return Status : Passed

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

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

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

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

name = solar panel wing
quantity = 6
parent = 1

materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000
Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

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

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

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

name = LT DuoPack adapter plate
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.920000
Thermal Mass = 1.920000

Diameter/Width = 0.311000
Length = 0.350000

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

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

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

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

name = LT EyeStar Black Box

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

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

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

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

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

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

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

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

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

name = RPG plinth
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.350000
Thermal Mass = 2.350000

Diameter/Width = 0.220000
Length = 0.220000

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

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

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

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

name = RWA rotor

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

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

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

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

name = Apollo Fusion PPU
quantity = 1
parent = 1
materialID = 8
type = Flat Plate

Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.148000
Length = 0.432000

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

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

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

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

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

Item Number = 2

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

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

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

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

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

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

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

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

Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****
name = empty 1-way PSL12U
Demise Altitude = 72.386795

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****
name = AD avionics

Demise Altitude = 68.499886
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

****

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

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

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

****

============== End of Requirement 4.7-1 ===============
01 29 2021; 09:42:20AM Project Data Saved To File

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

01 29 2021; 09:59:22AM Activity Log Started
01 29 2021; 09:59:22AM Opened Project C:\Users\elund\Box\Eric Lund\Missions and Programs\SXRS-5\DAS RevA DoA\
01 29 2021; 09:59:35AM Processing Requirement 4.3-1: Return Status : Not Run

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

=============== End of Requirement 4.3-1 ===============
01 29 2021; 09:59:36AM Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
01 29 2021; 11:15:26AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Sherpa-LTE1
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 97.500 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0035 (m^2/kg)
Start Year = 2021.000 (yr)
Initial Mass = 415.000 (kg)
Final Mass = 415.000 (kg)
Duration = 0.010 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 8.2167E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range

Status = Pass

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

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

01 29 2021; 11:15:30AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

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

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.003478 (m^2/kg)
Start Year = 2021.000000 (yr)
Initial Mass = 415.000000 (kg)
Final Mass = 415.000000 (kg)
Duration = 0.010000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 548.385252 (km)
PMD Apogee Altitude = 551.609537 (km)
PMD Inclination = 97.501102 (deg)
PMD RAAN = 3.542512 (deg)
PMD Argument of Perigee = 174.051957 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 548.385252 (km)
Suggested Apogee Altitude = 551.609537 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

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

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

=============== End of Requirement 4.6 ===============
01 29 2021; 11:15:35AM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = Sherpa-LTE1
quantity = 1
parent = 0
materialID = 5
type = Cylinder
Aero Mass = 415.000000
Thermal Mass = 415.000000
Diameter/Width = 0.813000

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

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

name = solar panel wing
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 2.350000
Thermal Mass = 2.350000

Diameter/Width = 0.546350
Length = 0.548500
Height = 0.060000

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

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

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

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

name = LT QuadPack adapter plate

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

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

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

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

name = LT EyeStar Black Box
quantity = 6
parent = 1
materialID = 5
type = Box

Aero Mass = 0.290000
Thermal Mass = 0.290000
Diameter/Width = 0.054000
Length = 0.089000
Height = 0.047000

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

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

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

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

Length = 0.117508
Height = 0.045466

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

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

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

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

name = RPG MLB adapter plate

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

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

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

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

name = RWA rotor
quantity = 3
parent = 1
materialID = 62
type = Box

Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.135000
Length = 0.135000
Height = 0.037000

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

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

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

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

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

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

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

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

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

name = Sherpa-LTE1
Demise Altitude = 77.998383

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT upper 24-in separation sytem
Demise Altitude = 76.371803
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = 24inch Jchannel spacer ring
Demise Altitude = 73.933426
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = solar panel wing
Demise Altitude = 76.000191
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Hex Plate
Demise Altitude = 67.772034
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Interior Wall
Demise Altitude = 74.396339
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT Corner Brace
Demise Altitude = 74.262268
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT DuoPack adapter plate
Demise Altitude = 74.592979
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT QuadPack adapter plate

Demise Altitude = 74.502579
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT avionics deck plate
Demise Altitude = 73.677467
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT R2A-Core
Demise Altitude = 72.479553
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT battery module
Demise Altitude = 69.982864
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT EyeStar Black Box
Demise Altitude = 75.789139
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LT empty DuoPack
Demise Altitude = 73.459198
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty 2-way PSL12U
Demise Altitude = 72.799706
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = empty 1-way PSL12U
Demise Altitude = 73.468880
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = LT lower 8-in separation system
Demise Altitude = 71.661430
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG base ring
Demise Altitude = 73.387184
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG leg
Demise Altitude = 75.648262
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG triangle plate
Demise Altitude = 72.768440
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG plinth
Demise Altitude = 74.584702
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RPG MLB adapter plate
Demise Altitude = 74.193092
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = torque rod
Demise Altitude = 70.423592
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = AD avionics
Demise Altitude = 70.135857
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = RWA enclosure
Demise Altitude = 75.655006
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 = 128.065353

****
name = propulsion deck plate
Demise Altitude = 73.677467
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Apollo Fusion tank
Demise Altitude = 75.479988
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Apollo Fusion feed system
Demise Altitude = 70.230850
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Apollo Fusion PPU
Demise Altitude = 72.503487
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Apollo Fusion thruster
Demise Altitude = 68.467690
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = camera bracket
Demise Altitude = 75.262093
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = IMPERX camera
Demise Altitude = 76.677689
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = camera lens assembly
Demise Altitude = 72.738541
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

============== End of Requirement 4.7-1 ===============
01 29 2021; 11:15:35AM Project Data Saved To File
01 29 2021; 11:16:50AM Project Data Saved To File

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

Sherpa-FX2 Long-Term Recontact Probability

REVISION / DATE

A / 28 January 2021

SPACEFLIGHT, INC.
1505 WESTLAKE AVENUE NORTHSUITE 600
SEATTLE, WASHINGTON 98109

REV	DATE	PREPARED BY	ANALYSIS BY	CHANGES
A	2021-01-21	M. Coletti	E. Lund	Initial Release

1. Introduction

The Sherpa-FX2 Mission (hereinafter "Sherpa-FX2 Mission", or "Mission") on a SpaceX Rideshare launch, currently planned for June – July 2021, is a commercial rideshare mission with the primary Spaceflight, Inc. ("Spaceflight") objective of hosting 3 customer payloads which will remain attached to the Sherpa-FX2, and deploying 25 customer spacecraft into a planned sun-synchronous circular orbit of 525 ± 25 km. SpaceX's Falcon 9 launch vehicle will deploy the free flyer spacecraft, called Sherpa-FX2, which subsequently deploys the additional customer spacecraft within several hours of liftoff.[1]

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

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

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

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

2. Methodology

Spaceflight has performed a high-fidelity analysis set forth below, using the same analytic techniques that Spaceflight described for its previously successful SSO-A and Sherpa-FX1 mission. As a general matter, spacecraft with propulsion or differential drag capabilities should be able to avoid conjunction with other spacecraft. Spaceflight is still in the process of confirming with its customers with propulsion on their spacecraft (12 spacecraft in all) whether that propulsion will enable them to do so. Therefore, we present analyses here with and without this assumption factored in. There is also some risk of conjunction in the period immediately following launch which is mitigated through the use of collision avoidance analysis between the launch vehicle and the Combined Space Operations Center (CSpOC). Additionally, the nature of that risk, and more generally of conjunctions involving spacecraft deployed as part of the Sherpa-FX2 Mission, is one better described as recontact rather than collision because of the low-speed nature of any possible conjunction. Contact at this low speed may cause minor damage to a spacecraft, but little or no debris.

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

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

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

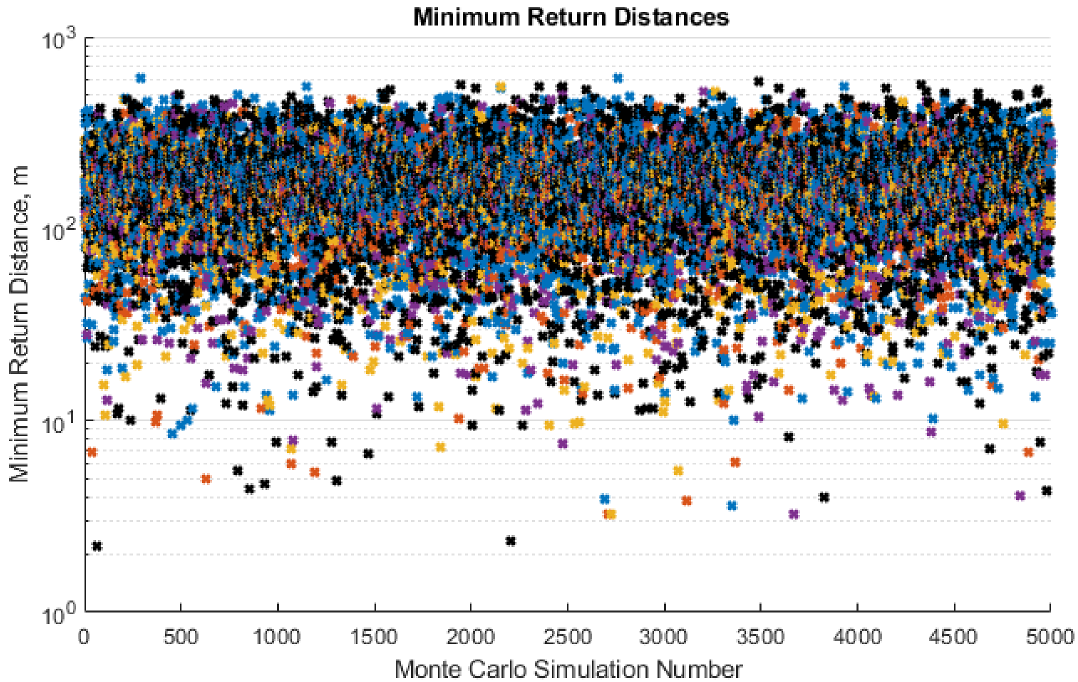

Figure 1: 5000 simulation Monte Carlo analysis over five orbits. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-FX2-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach.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

A 5,000-run Monte Carlo analysis was performed using this approach over a period that lasted five orbits after the last spacecraft is deployed from Sherpa-FX2 (a duration of approximately 8 hours) (Figure 1). The analysis was based on a deployment sequence that was chosen to reduce the probability of recontact. Any final modifications to deployment sequence order or timing from that which was used as inputs to the analysis here, shall have an equal or reduced probability of recontact than those presented herein. The five-orbit time period was chosen for detailed analysis because of the divergence of spacecraft that naturally occurs over this period, as further analyzed below. During this time (five orbits), no recontact events were observed. In order to provide a probability of recontact more significant than 0%, we can conservatively expand the definition from strictly the sum of hard body radii, to the smallest miss distance observed during the simulation, 2.2 m. In this case, a single recontact event was observed over these 5,000 full deployment sequence simulations (Pr(recontact) = $2x10^{-4}$). There was a 99.0% probability that all relative miss distances remained above 10.7 m, a 95% probability of all miss distances being greater than 23.9 m, and a 90.0% probability of all miss distances being greater than 35.3 m. Further, this estimate encompasses the period of highest spacecraft density where recontact events are most probable.

2000 further full deployment sequence simulations were run over a longer seven-day duration to substantiate this claim. In previous recontact analysis[3] we showed through binning of the relative miss distances, that the period immediately following separation through the first few orbits is the period of highest congestion, and the spacecraft diverge over time. With that in mind, we can conservatively assume this 2000 sequence, 7-day simulation's probability of recontact is fixed through two years, after the initial five orbit time period. Therefore, Spaceflight calculates the probability of recontact between the all spacecraft on the Sherpa-FX2 Mission over a two-year period, even if none of the spacecraft to be deployed are capable of performing propulsive maneuvers, is $1.70x10^{-3}$. Considering the assumption that propulsive spacecraft will be able to perform debris avoidance maneuvers, the probability of recontact would be reduced to $1.24x10^{-3}$.

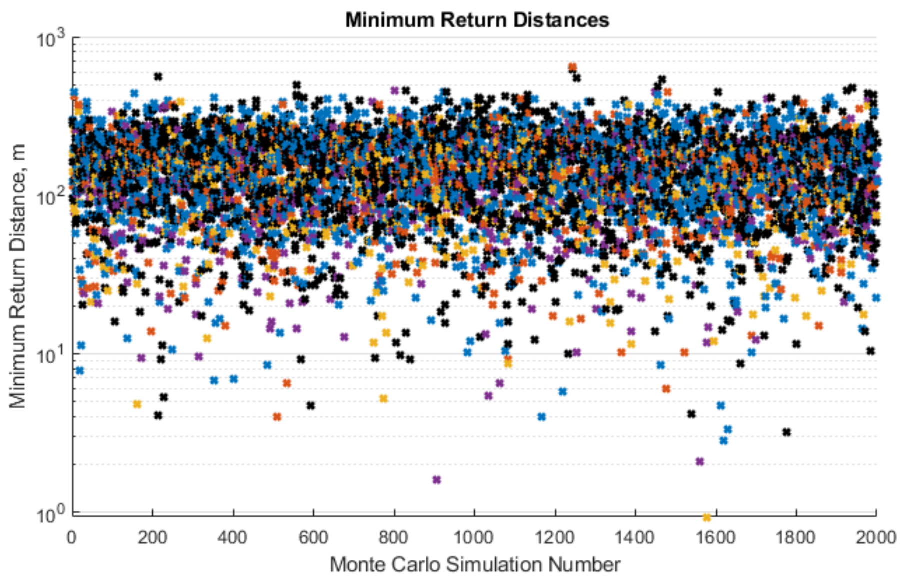

Figure 2: 2000 simulation Monte Carlo analysis over seven days. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-FX2-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach.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

2.1 Conjunction with Resident Space Objects

The analyses above addresses recontact between spacecraft on the Sherpa-FX2 Mission, which would be low velocity events. Another concern is the probability of a conjunction with a Resident Space Object (RSO) that is not part of the Sherpa-FX2 Mission. Each spacecraft is responsible for performing this analysis as part of their Orbit Debris Assessment Report (ODAR). Overall probability of conjunction with an RSO for all spacecraft can be estimated based on the individual spacecraft size and mass as an input into the Debris Assessment Software (DAS v3.1.0) RSO collision analysis. DAS predicts that Sherpa-FX2 and its deployed spacecraft, , even if none of the spacecraft to be deployed are capable of performing propulsive maneuvers, have a probability of collision with RSOs of $4.33x10^{-5}$ over the entire orbit lifetime of the spacecraft. Assuming that the spacecraft to be deployed with propulsion systems would

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

be able to avoid RSO collisions, given advance warning, including the FX2 vehicle itself, the probability of collision for non-propulsive objects with RSOs would be 2.91×10^{-5}.

3. Conclusions

Spaceflight estimates that the combined probability of recontact for all objects on the Sherpa-FX2 mission is between 1.24×10^{-3} (assuming debris avoidance capability of propulsive spacecraft) and 1.7×10^{-3} (assuming none of those spacecraft have such capability), in each case using the approach described in Section 2. Adding the probability of deployed spacecraft and Sherpa-FX2 conjunction with a non-Sherpa-FX2 Resident Space Object provides a probability of recontact or conjunction with RSO of between 1.268×10^{-3} and 1.743×10^{-3} , depending on whether propulsive spacecraft have debris avoidance capability.

Parent Free Flyer	Spacecraft Name	Spacecraft Type	Operator	Country Of Operator	Quantity	Comment	Propulsion	Deploys Other Spacecraft
Sherpa-FX2	Astrocast	CubeSat	Astrocast	Switzerland	5		Y	N
Sherpa-FX2	LEMUR	CubeSat	Spire Global	USA	4		N	N
Sherpa-FX2	Hawk	Microsatellite	Hawkeye 360	USA	3		Y	N
Sherpa-FX2	Lynk-06	Microsatellite	Lynk	USA	1		N	N
Sherpa-FX2	SpaceBEE	CubeSat	Swarm Technologies	USA	12	Four (4) s/c have prop	Four (4) have prop	N
Sherpa-FX2	*SOARS*	*Hosted Payload*	*KeplarianTech, Tiger Innovations Inc.*	*USA*	*1*	*No separation*	*N*	*N*
Sherpa-FX2	*TagSat-2*	*Hosted Payload*	*NearSpace Launch*	*USA*	*1*	*No separation*	*N*	*N*
Sherpa-FX2	*NFB-4*	*Hosted Payload*	*Stellar Exploration*	*USA*	*1*	*No Separation, no RF transmission*	*N*	*N*
Sherpa-FX2	Tenzing	Microsatellite	Orbit Fab	USA	1	Standby: could fill a spot on Sherpa-FX2 in case a spacecraft above cannot make the mission	Y	N

Sherpa-LTE1 Long-Term Recontact Probability

REVISION / DATE

A / 1 February 2021

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SPACEFLIGHT, INC.
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REV	DATE	PREPARED BY	ANALYSIS BY	CHANGES
A	2021-02-21	M. Coletti	E. Lund	Initial Release

1. Introduction

The Sherpa-LTE1 Mission (hereinafter "Sherpa-LTE1 Mission" or "Mission") on a SpaceX Rideshare launch, currently planned for June – July 2021, is a commercial rideshare mission with the primary objective of deploying 14 customer spacecraft into a planned sun-synchronous circular orbit of 525 ± 25 km. SpaceX's Falcon 9 launch vehicle will deploy the free flyer spacecraft, Sherpa-LTE1, which subsequently deploys the additional customer spacecraft within several hours of liftoff.[1] Once the primary mission is complete, a secondary mission to reduce the altitude of the empty Sherpa-LTE1 vehicle to 350 km via electric propulsion will be performed. Mission operations for this secondary mission will be performed in coordination with NASA and other interagency partners.

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

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

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[1] Spaceflight notes that, as with any rideshare mission, there is a possibility that one or more customers will either not be ready, not be able to meet one or more of Spaceflight and/or SpaceX's readiness criteria for flight or, choose to remove their spacecraft from the mission. Removed customers will be replaced by a non-separating mass model to keep the various launch and mission analyses valid. Since Sherpa-LTE1 will only have an attitude control system to be demonstrated after the primary mission of customer deployment the separation is complete, dispersion is dependent on the momentum change after each deployment. This momentum change is based on the specific mass of each spacecraft and the spring energy in their separation system. Therefore, replacing a separating customer spacecraft with a non-separating mass model will change the momentum of the Sherpa-LTE1, and thus the deployment vector for subsequent spacecraft. In such event, a new recontact analysis will be run to verify that the mission cumulative recontact probability is 9.56×10^{-4} or less. If the probability of recontact would be greater than this threshold, a new sequence will be developed and tested to ensure that this threshold is met. Equally, there would be no material impact on the recontact analysis if the attitude control and electronic system to be demonstrated were replaced by mass model. In any such event, a new recontact analysis will be run to verify that the mission cumulative recontact probability is 9.56×10^{-4} or less. If the probability of recontact would be greater than this threshold, a new sequence will be developed and tested to ensure that this threshold is met.

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

2. Methodology

Spaceflight has performed a high-fidelity analysis set forth below, using the same analytic techniques that Spaceflight described for its previously successful SSO-A and Sherpa-FX1 missions. As a general matter, spacecraft with propulsion or differential drag capabilities should be able to avoid conjunction with other spacecraft. Spaceflight is still in the process of confirming with its customers with propulsion on their spacecraft (9 spacecraft in all) whether that propulsion will enable them to do so. Therefore, we present analyses here with and without this assumption factored in. There is some risk of conjunction in the period immediately following launch which is mitigated using collision avoidance analysis between the launch vehicle and the Combined Space Operations Center (CSpOC). Additionally, the nature of that risk, and more generally of conjunctions involving spacecraft deployed as part of the Sherpa-LTE1 Mission, is one better described as recontact rather than collision because of the low-speed nature of any possible conjunction. Contact at this low speed may cause minor damage to a spacecraft, but little or no debris.

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

A 5,000-run Monte Carlo analysis was performed using this approach over a period that lasted five orbits after the last spacecraft is deployed from Sherpa-LTE1 (a duration of approximately 8 hours. The analysis was based on a deployment sequence that was chosen to reduce the probability of recontact. Any final modifications to deployment sequence order or timing from that which was used as inputs to the analysis here, shall have an equal or reduced probability of recontact than those presented herein. The five-orbit time period was chosen for detailed analysis because of the divergence of spacecraft that occurs naturally over this period, as further analyzed below. During this time (five orbits), two recontact events were observed over these 5,000 full deployment sequence simulations, Pr(recontact) = 4×10^{-4}, each with a $\Delta v < 1.0$ m/s. There was a 99.0% probability that all relative miss distances remained above 9.8 m, a 95% probability of all miss distances being greater than 26.8 m, and a 90.0% probability of all miss distances being greater than 40.3 m. Further, this estimate encompasses the period of highest spacecraft density where recontact events are most probable.

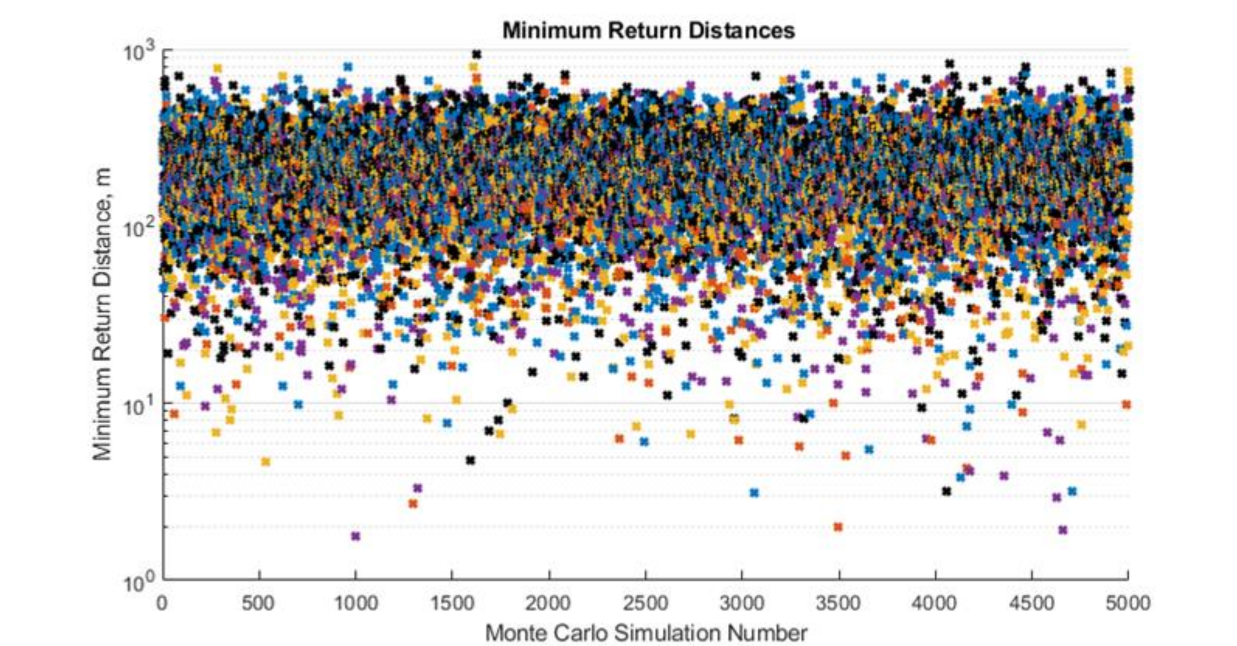

Figure 1: 5,000 simulation Monte Carlo analysis over five orbits. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-LTE1-Cubesat close approach. Blue data points indicate Cubesat-Microsat close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

2000 further full deployment sequence simulations were run over a longer seven-day duration to substantiate this claim (Figure 2). In previous recontact analysis[3] we showed through binning of the relative miss distances, that the period immediately following separation through the first few orbits is the period of highest congestion, and the spacecraft diverge over time. With that in mind, we can conservatively assume this 2000 sequence, 7-day simulation's probability of recontact is fixed through two years, after the initial five orbit time period. Therefore, Spaceflight calculates the probability of recontact between all spacecraft on the Sherpa-LTE1 Mission over a two-year period, even if none of the spacecraft to be deployed are capable of performing propulsive maneuvers, is is 9.00×10^{-4}. Considering the assumption that propulsive spacecraft will be able to perform debris avoidance maneuvers, the probability of recontact would be reduced to 7.46×10^{-4}.

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

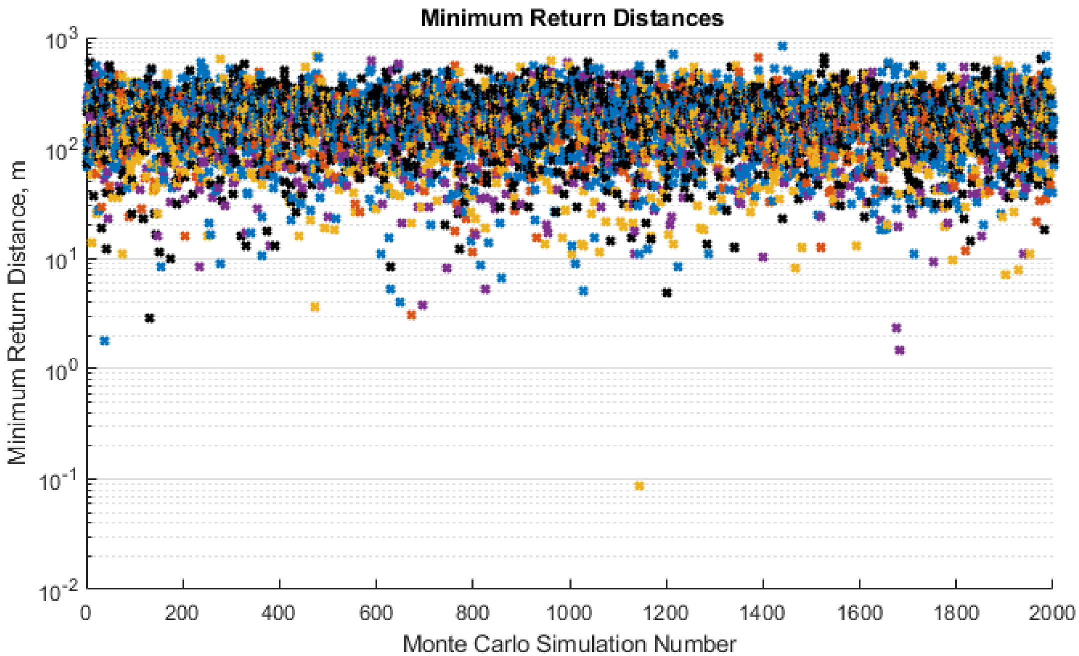

Figure 2: 2,000 simulation Monte Carlo analysis over seven days. Black data points indicate CubeSat- CubeSat close approach. Yellow data points indicate Microsat-Microsat close approach. Orange data points indicate Sherpa-LTE1-Cubesat close approach. Blue data points indicate Cubesat-Microsat close approach.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

2.1 Conjunction with Resident Space Objects

The analyses above addresses recontact between spacecraft on the Sherpa-LTE1 Mission, which would be low velocity events. Another concern is the probability of a conjunction with a Resident Space Object (RSO) that is not part of the Sherpa-LTE1 Mission. Each spacecraft is responsible for performing this analysis as part of their Orbit Debris Assessment Report (ODAR). Overall probability of conjunction with an RSO for all spacecraft can be estimated based on the individual spacecraft size and mass as an input into the Debris Assessment Software (DAS v3.1.0) RSO collision analysis. DAS predicts the sum of all objects on the mission have a probability of collision with RSOs , even if none of the spacecraft to be deployed are capable of performing propulsive maneuvers, is of 5.63×10^{-5} over the entire orbit lifetime of the spacecraft. Assuming that the spacecraft to be deployed with propulsion systems would be able to avoid RSO collisions with advance notice of such a possible collision, including the Sherpa-LTE1 spacecraft itself, the probability of collision for non-propulsive objects with RSOs would be 6.85×10^{-6}.

3. Conclusions

Spaceflight estimates that the probability of recontact for all objects on the Sherpa-LTE1 Mission is between 7.46×10^{-4} (assuming debris avoidance capability for all propulsive spacecraft) and 9.0×10^{-4} (assuming none of those spacecraft have such capability), in each case using the approach described in Section 2. Adding the probability of conjunction with a non-Sherpa-LTE1 Resident Space Object provides a probability of recontact or conjunction with RSO of between 7.53×10^{-4} and 9.56×10^{-4} , depending on whether propulsive spacecraft have debris avoidance capability.

Parent Free Flyer	Spacecraft Name	Spacecraft Type	Operator	Country Of Operator	Quantity	Comment	Propulsion	Deploys Other Spacecraft
Sherpa-LTE1	Shasta	Microsatellite	AstroDigital	USA	1		N	N
Sherpa-LTE1	KSM-2	CubeSat	Kleos Space	Luxembourg	5		Y	N
Sherpa-LTE1	Faraday Phoenix	CubeSat	InSpace	UK	1		N	N
Sherpa-LTE1	Tiger-2	CubeSat	OQTech	Rwanda	1		N	N
Sherpa-LTE1	HERON MkII	CubeSat	University of Toronto	Canada	1		N	N
Sherpa-LTE1	PAINANI-II	CubeSat	CISESE	Mexico	1		N	N
Sherpa-LTE1	ARTHUR-1	CubeSat	Aerospacelab	Belgium	1		Y	N
Sherpa-LTE1	Hawk	Microsatellite	Hawkeye 360	USA	3		Y	N
Sherpa-LTE1	Tenzing	Microsatellite	Orbit Fab	USA	1	Could fill a spot on Sherpa-LTE1 in case a spacecraft above cannot make the mission	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