Sidus Space

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ORBITAL DEBRIS ASSESSMENT REPORT (ODAR)

For

LizzieSat-3

LizzieSat-4

LizzieSat-5

LizzieSat-6

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REVISIONS

Rev	Change Description	Change No	Date	Approval
1	Initial Release	N/A	06/13/2023	S. Chandler

APPROVALS

All applicable Approvers for the LizzieSat program, and their responsibilities regarding this project, are listed below.

Approver's Name	Signature	Date	Responsibilities
Chief Mission Operations Officer			
John Curry	*/s/ John Curry*	6/13/2023	Direct all satellite mission operations and mission operations team, Author and reviewer of Mission Operations Plan, Procedures, and Training. Final decision authority on Mission Operations.
Systems Engineer			
Lindsey Waitt	*/s/ Lindsey Waitt*	6/13/2023	Design, integrate, and test the satellite system over the course of its life cycle. Author/manage requirements document, verification matrix, test plan

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SELF ASSESSMENT OF THE ODAR

This LizzieSat-3, LizzieSat-4, LizzieSat-5 and LizzieSat-6 ODAR follows the format recommended in NASA-STD-8719.14, Appendix A.1, sections 1 through 8 for the LS satellites. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here. Data analysis was performed using NASA DAS 3.2.4 software per the December 2021 version of the Debris Assessment Software User's Guide (NASA/TP-20210025946)

Orbital Debris Self-Assessment Report Evaluation: LS Mission

(Based upon DAS version 3.2.4)

Table 1: LS - ODAR Review Check Sheet

Section	Status	Comments
4.3-1, Mission-Related Debris Passing Through LEO	COMPLIANT	
4.3-2, Mission-Related Debris Passing Near GEO	N/A	
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	COMPLIANT	
4.4-2, Design for passivation after completion of mission operations while in orbit about Earth or the Moon	COMPLIANT	
4.4-3, Limiting the long-term risk to other space systems from planned breakups	N/A	
4.4-4, Limiting the short-term risk to other space systems from planned breakups	N/A	
4.5-1, Probability of Collision with Large Objects	COMPLIANT	
4.5-2, Probability of Damage from Small Objects	COMPLIANT	System will passively deorbit; therefore, no components are critical to deorbit.
4.6-1, Disposal for space structures passing through LEO	COMPLIANT	

4.6-2, Disposal for space structures passing through GEO	N/A	
4.6-3, Disposal for space structures between LEO and GEO	N/A	
4.6-4, Reliability of post-mission disposal operations	COMPLIANT	
4.7-1, Casualty risk from re-entry debris	COMPLIANT	
4.8-1, Collision Hazards of Space Tethers	N/A	

1.0 LS MISSION OVERVIEW

Program Management Overview: Carol Craig (CEO), Jamie Adams (CTO), John Curry (CMO)

Mission Overview: The LizzieSat (LS) satellites are each a 100kg satellite containing the satellite bus and hosted payloads. LS3 and LS4 will launch NET February 2024 on a SpaceX Falcon 9 rocket from Vandenburg Space Force Base (VSFB) as a rideshare payload on the Transporter 10 mission. LS5 and LS6 will launch NET June 2024 on a SpaceX Falcon 9 rocket from Vandenburg Space Force Base as a rideshare payload on the Transporter 11 mission. The mass does not decrease during the mission since there is no propulsion or other wet mass onboard. SpaceX will launch LS into a Sun Synchronous Orbit (97.5 deg) at a circular altitude of 525 km. LS deployment occurs via the 15" Exolaunch CarboNIX system which creates no debris at separation. The separation rate is 0.3m/s per SpaceX requirement. LS will operate for approximately 5 years based upon NASA and DAS 3.2.4 assessment of decay rate with no propulsion.

For this ODAR assessment, a worst-case altitude in terms of lifetime of 545 km is used (SpaceX dispersion around the 525 km circular orbit target is +/- 20 km).

ODAR Summary: No orbital debris will be produced by any of the LizzieSat satellites. Thus, the LizzieSat satellites are compliant with Requirements 4.3-1. There is no credible scenario for breakups, the collision probability with other objects is compliant with NASA standards, the estimated nominal decay lifetime due to atmospheric drag is less than 5 years (as calculated by DAS 3.2.4), in compliance with the 2022 Orbital Debris Mitigation Order.

Launch: LS3 and LS4 launch is scheduled to occur NET February 2024 on a SpaceX Falcon 9 rocket from VSFB Launch Complex. LS3 and LS4 are rideshare payloads on a Transporter mission. SpaceX has sole discretion over the launch date and orbit inclination and altitude for the Transporter launch.

LS5 and LS6 launch is scheduled to occur NET June 2024 on a SpaceX Falcon 9 rocket from VSFB Launch Complex. LS5 and LS6 are rideshare payloads on a Transporter mission. SpaceX has sole discretion over the launch date and orbit inclination and altitude for the Transporter launch.

Orbit Profile: LS3, LS4, LS5, and LS6 will deploy from the Falcon 9 launch vehicle into its near-circular 97.5 deg inclined orbit at an altitude of 525+/-20 km. Assuming LS deploys at 525 km circular, the orbital period is 95 minutes, 8 seconds. Mean Local Time of Ascending Node (MLTAN) is 13:00 + 60 minutes. There is no transfer or parking orbit. Since there is no propulsion, LS will slowly decay from this initial altitude until it burns up into the atmosphere. The decay rate is influenced by the solar cycle and the LizzieSat orientations which changes the ballistic drag coefficient during nominal operations. Sidus Mission Control Center (MCC) can change LizzieSat decay rates by using differential drag attitude maneuvers, as required, to change spacing between satellites in plane or to ensure satellites demise into the atmosphere within 5 years after completion of mission operations.

Mission Duration: The maximum altitude a LizzieSat can be deployed is 545 km. Since there is no propulsion onboard any of the LizzieSats, the satellites will not be station-kept. Thus, the expected time between launch and atmospheric reentry based upon a 5-year nominal mission duration with natural orbital decay will satisfy the requirement to fully demise the spacecraft within 5 years following end of mission even at the maximum deployment altitude of 545 km. This assessment was independently derived from performing decay estimates using the latest version of NASA Debris Assessment Software (v.3.2.4). More data is summarized on this actual assessment in Section 2.0.

2.0 LIZZIESAT SPACECRAFT DESCRIPTION

Physical Description of the Spacecraft: Each LizzieSat satellite has a launch mass maximum of 100kg. 65kg is allocated to the LS bus and 35 kg is available for Sidus and third-party provided payloads. There are 8 deployable solar arrays that will impact the ballistic coefficient. The solar arrays do NOT produce any debris at deployment. Power storage is provided by two Lithium-Ion cells. The batteries are recharged by solar cells mounted on the 8 deployable solar panels as well as solar cells mounted onto the -Z face of the LizzieSat. LizzieSat attitude is estimated with a mean accuracy of 0.01° (3-sigma) using filtering of sensor data from 2-star trackers, two Inertial Measurement Units (IMUs), 6 sun sensors, and a magnetorquer. LS attitude is nominally controlled by 4 reaction wheels (1 wheel provides redundancy, LS attitude can be controlled fully using 3 of the 4 reaction wheels). The 3 magnetorquers are used during detumbling and for wheel desaturation. The LizzieSat spacecraft is depicted in Figure 1.

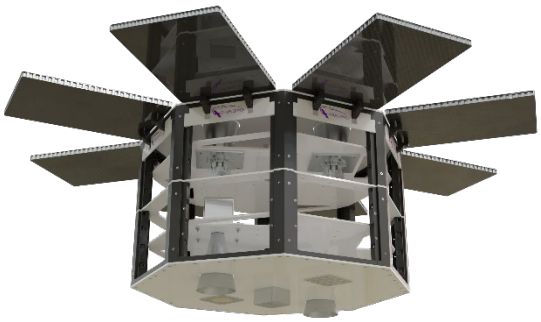

Figure 1: LizzieSat Rendering - Reverse Axis Isometric View, Body Mounted Panels Removed

Total satellite mass at launch (no propellant onboard): Maximum 100kg (65 kg LS bus, 35 kg Sidus and third-party provided payloads)

Description of all propulsion systems (cold gas, monopropellant, bi-propellant, electric, nuclear): There are no propellants or pressurized tanks onboard LS3, LS4, LS5, or LS6.

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 – No stored propellants on LS3, LS4, LS5, or LS6.

Fluids in Pressurized Batteries: None. LS3, LS4, LS5, and LS6 each use two unpressurized standard Lithium-Ion battery cells.

Description of attitude control system and indication of the nominal attitude of the spacecraft: LS uses magnetic rods to stabilize and "de-tumble" the satellites post deploy/separation at 0.3m/s separation rate. 3 of 4 reaction wheels oriented in the direction of the principal axes allow 3-axis control during nominal operation. Magnetorquers are also used for reaction wheel desaturation. The available LS attitude modes that are commanded by Sidus MCC and LS Onboard Computer (OBC) include:

Table 2: LizzieSat Attitude Modes

Mode	Description
Sun Tracking	The vehicle aligns its -z axis with the sun for maximum solar illumination. If the GPS position and velocity solution are valid, the source of the solar vector comes from the onboard model. If the GPS lost its solution, the sun position will be determined via the onboard sun sensors.
Safe	The vehicle de-tumbles, if required, and points S-band to Earth while constraining -z axis to the sun.
Detumble	The vehicle uses its magnetic torquers to bleed kinetic energy to null its rotational rates.
Downlink	The vehicle's x-band antenna vector, pointed in +x+y body axis direction, is targeted to point at a ground station's latitude/longitude. Rotation of the -z axis about the +x+y vector is allowed to point the solar panels in the direction of the sun (only if in daylight for battery charging)
Nadir Track	The vehicle points its +x body axis toward nadir while allowing rotation about the +x nadir vector such that the -z-axis solar panels face the sun (during daylight for battery charging).

During LS nominal operations, the spacecraft is in one of three of these orientations:

1. Sun Track mode – This is the orientation for periods when Earth imaging isn't required. This orientation maximizes sun on the solar panels during daylight. LS goes into this orientation after separation from the SpaceX Falcon 9.
2. Nadir Track mode – This is the orientation the Satellite defaults to when Earth observations are useful, but there isn't a specific target to image. LS goes into this orientation after Solar Battery SOC = 90%.
3. Downlink Mode – This orientation is for each of the 16 daily ground station passes.

At the end of life of LS, the 3-axis Reaction Wheel controller can be used to place the satellite attitude into its maximum drag configuration (Solar Panels orthogonal to the sun vector) which accelerates orbital decay.

Sidus performed decay analysis. LS3, LS4, LS5, and LS6 all have the same mass (100kg) and drag profiles listed below. Therefore, the decay analysis was the same for all LizzieSat satellites. Sidus used the NASA DAS (v.3.2.4) for all analysis and assessed decay rates and time from launch to disposal for the following:

a. **Nominal (Average) mission operations**. This analysis used the three attitudes LS flies during nominal mission operations: Sun Track, Nadir Track, and Downlink mode. This mission average attitude profile equates to 0.915m*2/100kg or 0.00915 m^2/kg.
b. **Maximum drag.** This analysis assumes 8 deployed solar panels into the velocity vector (LS +/– Z Body axis into V-bar). Max drag = 0.013 m^2/kg
c. **Gravity Gradient (GG orientation).** This analysis assumes LS orientation settles into its natural gravity gradient orientation over long durations when active attitude control isn't used or available. In the LS GG orientation, the LS solar arrays maintain the spacecraft in a mostly +Z body axis into the velocity vector.
d. **LizzieSat No-Solar Panel deploy case**. This case assumes failure of all 8 LizzieSat solar panels to deploy. This case is extremely unlikely since there is redundancy built into the solar panel deploy architecture.

NOTE: Minimum drag was not assessed since solar panels must be edge-on with respect to the velocity vector = 0.0035 m2/kg. This orientation is not used during nominal operations and is not a stable gravity gradient orientation.

Description of the electrical generation and storage system: Standard COTS Li-Ion battery cells are charged

before payload integration and provide electrical energy during the mission. The cells are recharged by solar cells mounted on the solar arrays. See Table 3 for a description of the electrical generation and storage system on LS.

Table 3: LizzieSat Electrical Generation and Storage System Description

SOLAR PANELS	Solar Power: 400W Deployable Panels: 8 Octagonal Surface Mount Panel: 1 Solar Cells: Triple Junction GaInP/GaAs/Ge on Ge substrate Structure: Aluminum honeycomb with composite skin	Solar cells are Azurspace solar cell assemblies (SCA), type 3G30A (HNR 0003401-01-01), with internal bypass diode. Azurspace solar cells have successfully flown in space. The substrate is based on a new prepreg, based on the M55J PAN fiber from Toray. The honeycomb and structural film adhesive are made by Hexcel which has space heritage. GTM has performed mechanical tests (e.g., flatwise tensile at room temperature and elevated temperature +125°C, lap shear, OMA, and ultrasonic inspection by Airscan method). GTM has flown solar panels. These ones are uniquely built for our LizzieSat application. The outgassing of the materials is per ESA standards.
POWER STORAGE	Battery Type: Lithium-Ion Energy Storage: 1100Wh (Two 550Wh battery assemblies) Operating Voltage: 24.0 to 33.6 V Maximum Continuous Discharge: 80 A	Batteries: Two Ibeos B28-550F Lithium-Ion battery packs with integrated fault-protection electronics, designed for space applications connect in parallel to the Ibeos E28-M0500-1210-4F Modular Power System. The batteries concurrently charge and discharge during normal operations. These Ibeos battery packs have space heritage.

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

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

Identification of any radioactive materials on board or an explicit statement that there are no radioactive materials onboard: None.

Description of any planned proximity operations or docking with other spacecraft: None.

3.0 SPACECRAFT DEBRIS RELEASED DURING LS NOMINAL OPERATIONS

Identification of any object (>1mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material: None.

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 of each object after release: N/A

Calculated orbital lifetime of each object, including time spent in LEO: N/A

Assessment of spacecraft compliance with Requirements 4.3-1 ad 4.3-2:
Requirement 4.3-1: Debris passing through LEO, released debris with diameters of 1mm or larger
No release of debris will occur during the lifetime of LS. The Exolaunch separation system used for LS deploy from the SpaceX Falcon 9, called CarboNIX, is a highly reliable, debris free system that relies upon magnets and springs for separation. All LS solar panel deployments use a burn wire to cut through vectran. The vectran remains connected to LizzieSat in two places to ensure there is no chance for debris. Additionally, there is no probable scenario for unintentional debris generation.

Result for Requirement 4.3-1: COMPLIANT

Requirement 4.3-2: Debris passing near GEO
There will be no intentional release of debris passing near GEO during the lifetime of the LS mission since the entire mission is conducted in low Earth orbit.
Result for Requirement 4.3-2: N/A

4.0 SPACECRAFT INTENTIONAL BREAKUPS AND POTENTIAL FOR EXPLOSIONS

Identification of all 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: In-mission failure of a battery cell 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 FMECA (see requirement 4.4-1 below) describe the combined faults that must occur for any of the 7 independent, mutually exclusive failure modes to lead to explosion. The LS battery unit also features temperature sensors to monitor battery cells for high temperatures.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions: There are no planned breakups.

List of components which are passivated at EOM. List includes method of passivation and amount which cannot be passivated: There is no planned passivation; passivation will occur naturally at the end of mission.

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
The probability of battery explosion is very low, believed to be much less than 0.001. There are no pressurized tanks onboard LS. The short LS orbital lifetime makes long-term effects of an unlikely explosion in LEO environment negligible. LS heat pipes have been space qualified through pressure testing, burst pressure testing, vibration testing and thermal vacuum cycling. At end of life, reaction wheels will be used to place LS in maximum drag orientation to accelerate the reentry of the satellite.

Failure mode 1: Internal short circuit.
Mitigation 1: Sidus is performing protoflight qualification 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: The likelihood that an internal short circuit failure mode is not discovered during environmental testing AND functional charge/discharge tests is very low.

Failure mode 2: Internal thermal rise due to high load discharge rate.
Mitigation 2: Cells will be tested in lab for high load discharge rates in a variety of flight like configurations to determine if the feasibility of an out-of-control thermal rise in the cell. Cells will also be tested in a hot

environment to test the upper limit of the cell's capability.
Combined faults required for realized failure: Spacecraft 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 will be 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 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 faults required for realized failure: The manufacturer 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 failures 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 will be 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.

Result for Requirement 4.4-1: COMPLIANT

Requirement 4.4-2: Design for passivation after mission operations complete while in Earth orbit
Passivation will happen naturally at the end of mission by depleting remaining energy contained in the batteries (either through uncontrolled tumbling in case of ADCS failure or attitude control in case of nominal ADCS operations) and natural orbit decay and re-entry within 5 years.
Result for Requirement 4.4-2: COMPLIANT

Requirement 4.4-3: Limiting the long-term risk to other space systems from planned breakups
There are no planned breakups during the mission.
Result for Requirement 4.4-3: N/A

Requirement 4.4-4: Limiting the short-term risk to other space systems from planned breakups
There are no planned breakups during the mission.
Result for Requirement 4.4-4: N/A

5.0 LIZZIESAT SPACECRAFT POTENTIAL FOR ON-ORBIT COLLISIONS

Since the orientation of the spacecraft during operations will vary, the probability of collision with other objects is computed in the worst-case scenario of the solar arrays being in the direction tangential to the velocity vector. NASA Debris Assessment Software v3.2.4 was used for orbit and collision analysis.

Requirement 4.5-1. Limiting debris generated by collisions with large objects when operating in Earth orbit.
The worst-case initial orbit for LS is a circular orbit at an altitude of 545 km (525 km + 20 km maximum dispersion from SpaceX separation) and an inclination of 97.57 deg. Requirement 4.5-1 computation were made from 545 km and the nominal operations altitude of 525 km. The area/mass ratio of the spacecraft is 0.013 m^2/kg in the worst-case attitude. The computed probability of collision with large objects for LS3 and LS4 is 0.00017376 at 545 km and 0.00011172 at 525 km. The computed probability of collision with large objects for LS5 and LS6 is 0.00016493 at 545 km and 0.000099549 at 525 km. These are both below the maximum acceptable probability of 0.01.

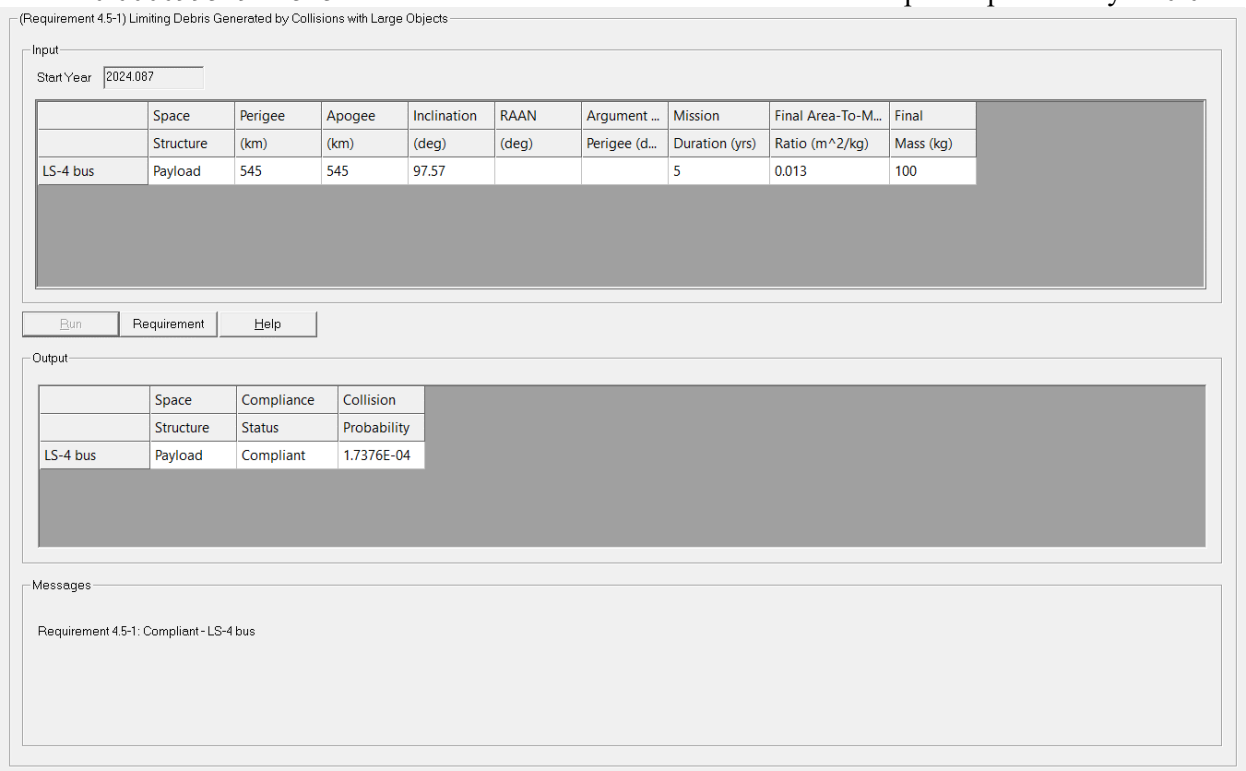

Figure 2: Requirement 4.5-1 LS3 and LS4 DAS Software Screenshot

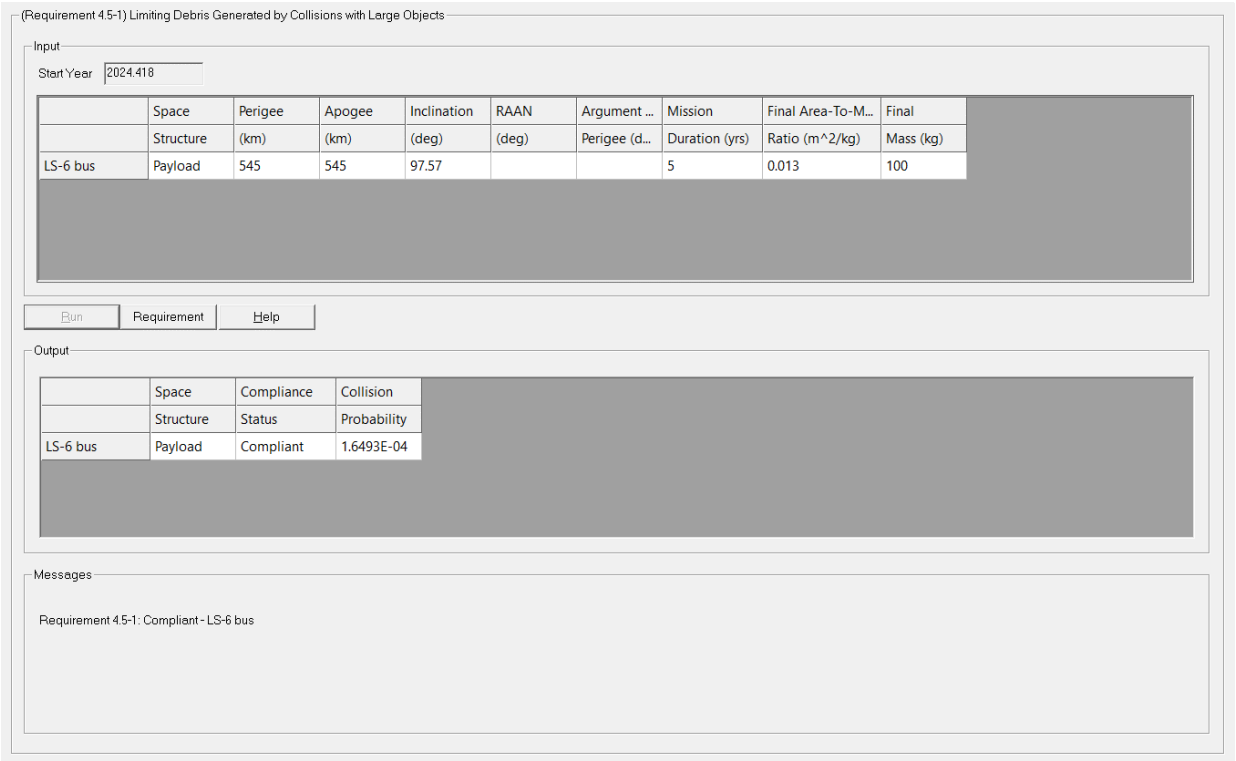

Figure 3: Requirement 4.5-1 LS5 and LS6 DAS Software Screenshot

Result for Requirement 4.5-1: COMPLIANT

Requirement 4.5-2. Limiting damage probability from small objects when operating in Earth or lunar orbit
None of the LS components are vital to completing LS post-mission disposal. LS has no propellent and therefore will not have a controlled re-entry. Sidus MCC team can slew LS into a maximum drag orientation that will work until entry interface under nominal conditions, but that is not mandatory for safe disposal of LS.

Result for Requirement 4.5-2: COMPLIANT

6.0 SPACECRAFT POST-MISSION DISPOSAL PLANS AND PROCEDURES

The orbit of the satellite will decay due to atmospheric drag and the satellites will eventually naturally de-orbit by atmospheric reentry. At the end of the spacecraft's operational lifetime, Sidus will begin the deorbit process by commanding LS attitude control system to orient the satellites into a maximum drag configuration with the flat surface of the solar panels in the direction of the velocity vector. This significantly accelerates LS orbital decay. These high-drag periods will be interleaved with sun-pointing periods to ensure spacecraft reserve power is maintained throughout the deorbit process. Even in the case of ADCS failure and tumbling spacecraft at end of life, LS will de-orbit within five years of its end of mission. This analysis is assuming a worst-case scenario, for lifetime purposes, of a tumbling spacecraft.

Requirement 4.6-1. Disposal for space structures in or passing through Low Earth Orbit (LEO)
The altitude of each LS satellite is computed from its worst case initial circular orbit altitude of 545 km, in its end of mission configuration. The average area to mass ratio for the tumbling spacecraft is used (0.00915 m^2/kg), and each

satellite's nominal mission lifetime is 5 years. Therefore, Sidus anticipates that each LS satellite's nominal end of mission activities will begin in 2029. According to the DAS 3.2.4 computations with no orbit maintenance (*i.e.*, decay only) predict LS3 and LS4 will fully demise in Earth's atmosphere in 2033, and LS5 and LS6 satellites are predicted to fully demise in Earth's atmosphere in 2034. Thus, each satellite will complete deorbit in less than 5 years following end of mission. Sidus has also built significant critical system redundancy into the spacecraft bus to increase the likelihood of nominal LS mission performance. In the unlikely event an LS spacecraft is deployed DOA, Sidus will seek appropriate waivers pursuant to the *2022 Orbital Debris Mitigation Order*'s case-by-case treatment.

Result for Requirement 4.6-1: COMPLIANT

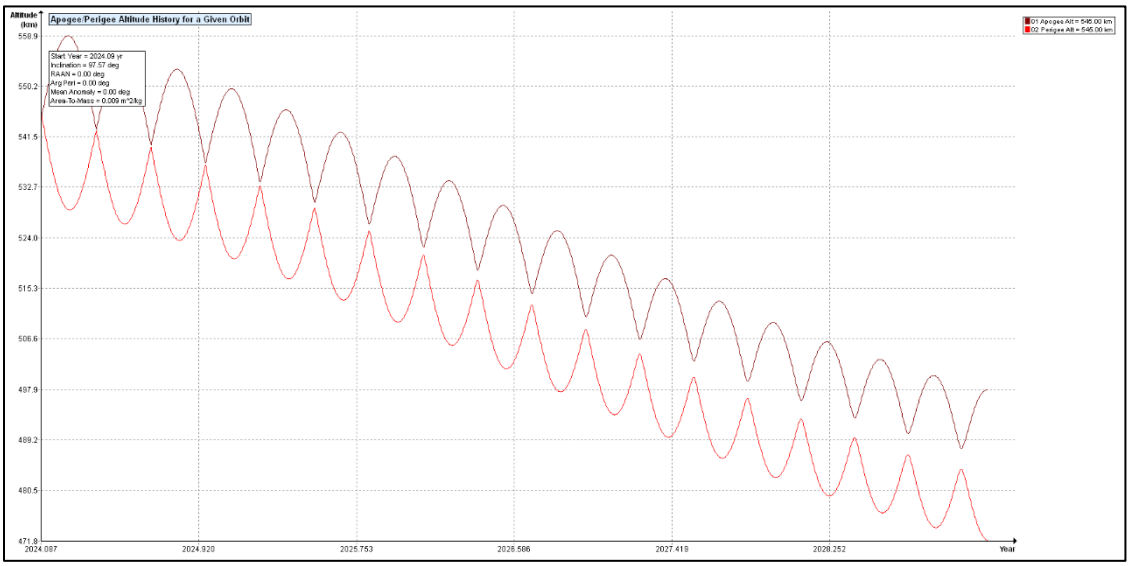

Figure 4: Requirement 4.6-1 LS3 and LS4 DAS Software Screenshot – Nominal Drag Profile – 5yr Mission Duration

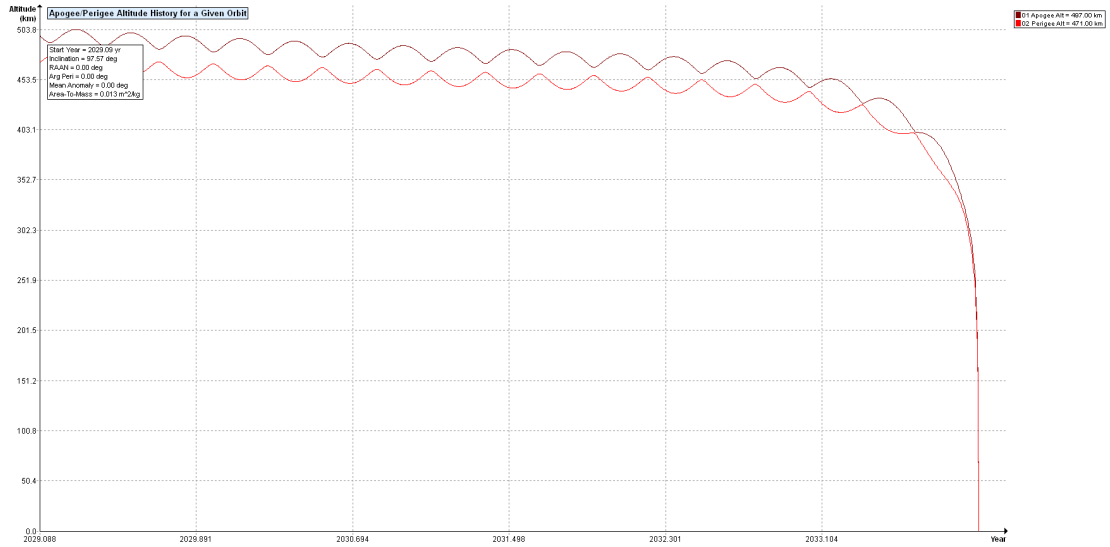

Figure 5: Requirement 4.6-1 LS3 and LS4 DAS Software Screenshot – Max Drag Profile - End of Life

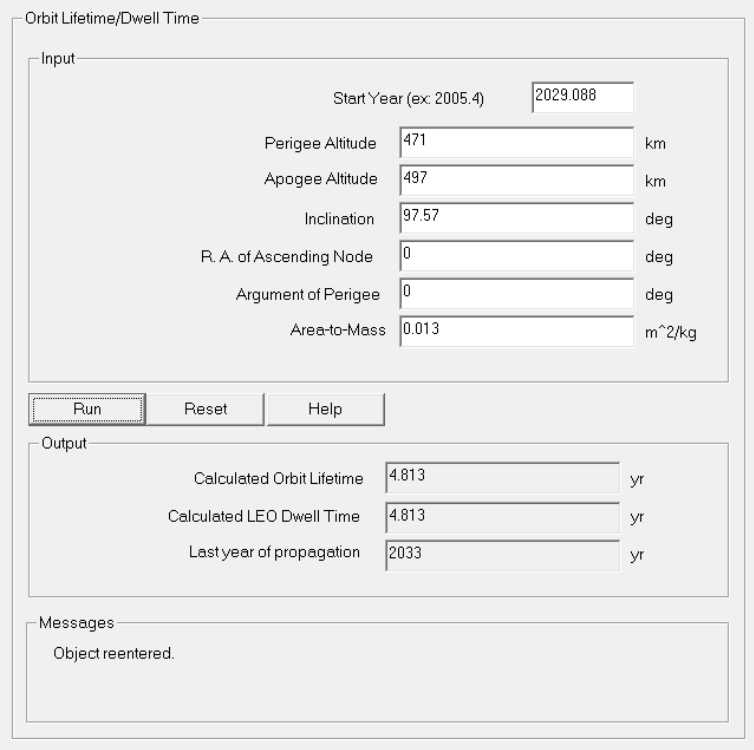

Figure 6: Requirement 4.6-1 LS3 and LS4 DAS Software Screenshot – Max Drag Profile - End of Life Decay Time

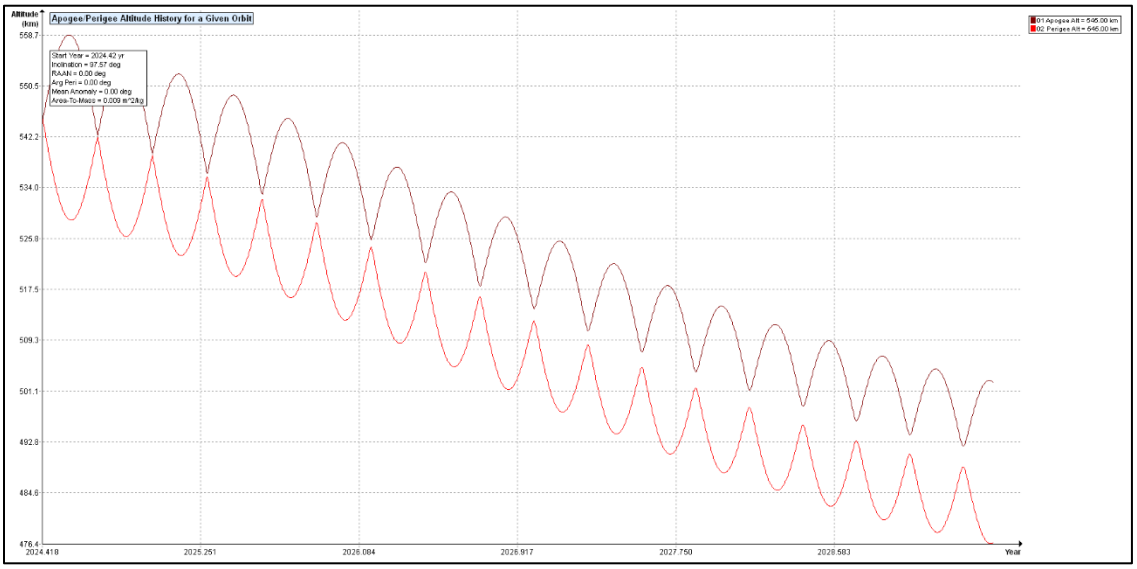

Figure 7: Requirement 4.6-1 LS5 and LS6 DAS Software Screenshot - Nominal Drag Profile – 5yr Mission Duration

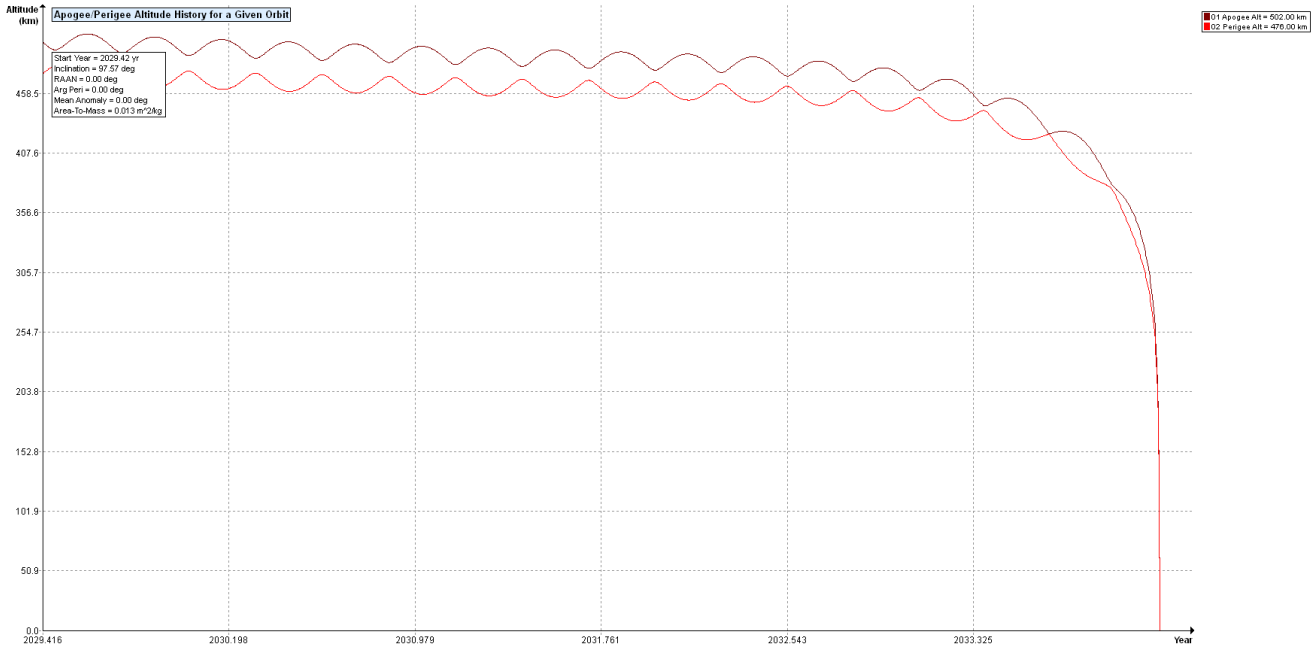

Figure 8: Requirement 4.6-1 LS5 and LS6 DAS Software Screenshot – Max Drag Profile - End of Life

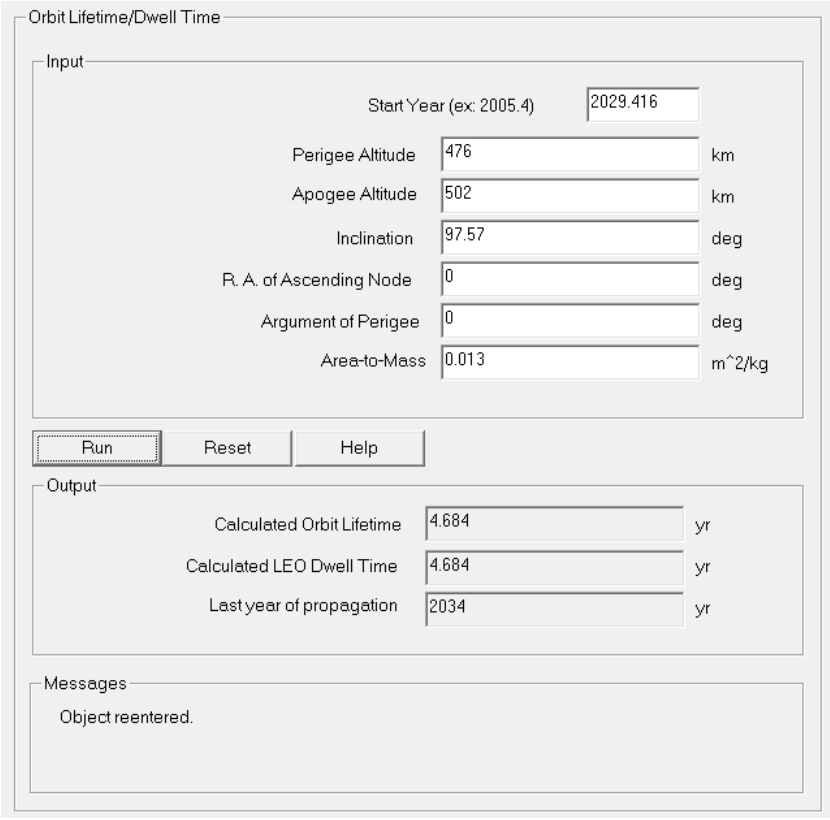

Figure 9: Requirement 4.6-1 LS5 and LS6 DAS Software Screenshot – Max Drag Profile - End of Life Decay Time

Requirement 4.6-2. Disposal for space structures near GEO

There are no space structures near GEO involved in this mission.

Result for Requirement 4.6-2: N/A

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

There are no space structures between LEO and GEO involved in this mission.

Result for Requirement 4.6-3: N/A

Requirement 4.6-4. Reliability of post-mission disposal operations in Earth orbit

The above analysis has been performed with an average area to mass ratio, which means that even in the case of massive power or ADCS failure, a tumbling spacecraft, the spacecraft will deorbit within 5 years.

Result for Requirement 4.6-4: COMPLIANT

7.0 SPACECRAFT REENTRY DEBRIS CASUALTY RISKS

Requirement 4.7-1. Limit the risk of human casualty.

The risk of human casualty was computed by DAS v3.2.4 for an uncontrolled re-entry to be 0 for the LS satellites. The analysis is modeled on LS4 since it has all the same payloads as LS3, LS5, and LS6, plus one additional payload unique to it. The spacecraft model for LS4 is summarized in the table below.

Table 4: LS4 Component Data

ID	Name	Parent	Qty	Material	Body Type	Thermal Mass	Diameter/Width	Length	Height
1	LS-4 bus	0	1	Aluminum 6061-T6	Box	100	0.7609	0.7609	0.47568
2	Deployable Panels	1	8	Aluminum (generic)	Box	0.517	0.254	0.434	0.00965
3	Solar Cells Panels	2	240	GaAs	Box	0.00356	0.04015	0.08015	0.00028
4	Body Panels	1	8	Aluminum 6061-T6	Box	0.394	0.3048	0.431	0.00635
5	Center Ring	1	1	Aluminum 6061-T6	Flat Plate	1.45	0.7609	0.7609	
6	Upper Plate	1	1	Aluminum 6061-T6	Flat Plate	1.396	0.7609	0.7609	
7	Solar Cells Oct Face	6	90	GaAs	Box	0.00356	0.04015	0.08015	0.00028
8	FH Screw	1	128	Stainless Steel (generic)	Cylinder	0.004	0.00762	0.013	
9	Bottom Plate	1	1	Aluminum 6061-T6	Flat Plate	11.07	0.7609	0.7609	
10	E903 Enclosure	1	1	Aluminum 6061-T6	Box	8.16	0.203	0.233	0.18
11	SP0-S	10	1	Aluminum (generic)	Box	0.35	0.1	0.16	0.02
12	S740-22	10	1	Aluminum (generic)	Box	0.25	0.1	0.16	0.02
13	FPGA	10	1	Aluminum (generic)	Box	0.1016	0.074	0.149	0.013
14	CM950	10	2	Aluminum (generic)	Box	0.198	0.1	0.16	0.02
15	P900	10	1	Aluminum (generic)	Box	0.49	0.086	0.16	0.026
16	P901	10	1	Aluminum (generic)	Box	0.48	0.086	0.16	0.026
17	GPGPU	1	2	Aluminum (generic)	Box	1.2	0.127	0.129	0.052
18	Ethernet Switch	1	1	Aluminum 6061-T6	Box	2.5	0.181	0.231	0.064
19	Reaction Wheel	1	4	Aluminum (generic)	Box	1.55	0.102	0.105	0.102
20	IMU	1	2	Aluminum (generic)	Box	0.055	0.038	0.0448	0.0215
21	Magnetorquer	1	3	Aluminum (generic)	Box	0.47	0.05	0.26	0.0252
22	Magnetometer	1	1	Aluminum (generic)	Box	0.1	0.0351	0.0826	0.0323
23	Star Tracker	1	2	Aluminum (generic)	Box	0.475	0.065	0.07	0.055
24	Sun Sensor	1	6	Aluminum (generic)	Box	0.01	0.019	0.028	0.012
25	GPS Receiver	1	1	Aluminum (generic)	Box	0.048	0.06	0.1	0.009
26	GPS Antenna	1	1	Aluminum (generic)	Box	0.082	0.0528	0.0528	0.0175
27	Bus Bars	1	24	Aluminum (generic)	Flat Plate	0.024	0.03	0.07	
28	Li-Ion Battery	1	2	Aluminum (generic)	Box	3.92	0.147	0.235	0.086
29	MPS	1	1	Aluminum (generic)	Box	1	0.1016	0.114	0.099
30	SB Transceiver	1	1	Aluminum (generic)	Box	0.2	0.065	0.09	0.0253
31	SB Antenna (primary)	1	1	Aluminum (generic)	Box	0.138	0.0843	0.0843	0.0121
32	SB Antenna (backup)	1	1	Aluminum (generic)	Cylinder	0.075	0.071	0.04521	
33	SB Diplexer	1	1	Aluminum (generic)	Box	0.822136	0.0762	0.1473	0.04445
34	SB Switch	1	1	Aluminum (generic)	Box	0.244	0.06096	0.0668	0.0254
35	XB Transmitter	1	1	Aluminum (generic)	Box	0.275	0.0902	0.0959	0.0284
36	FeatherBox	1	1	Stainless Steel (generic)	Box	1.4	0.096	0.096	0.0495
37	AIS Receiver	1	1	Aluminum (generic)	Box	0.185	0.0872	0.093	0.0125
38	Post Upper	1	8	Aluminum (generic)	Cylinder	0.255	0.094	0.203	
39	Post Lower	1	8	Aluminum (generic)	Cylinder	0.257	0.094	0.203	
40	Link Upper	1	8	Aluminum 6061-T6	Cylinder	0.053	0.213	0.13	
41	Link Lower	1	8	Aluminum 6061-T6	Cylinder	0.053	0.213	0.13	
42	Post Center	1	1	Aluminum 6061-T6	Cylinder	0.186	0.032	0.191	
43	Mount Center	1	2	Aluminum 6061-T6	Cylinder	0.19	0.102	0.044	
44	Bracket upright	1	1	Aluminum 6061-T6	Box	0.794	0.175	0.259	0.013
45	Bracket base	1	1	Aluminum 6061-T6	Box	0.883	0.228	0.259	0.013
46	Bracket gusset	1	1	Aluminum 6061-T6	Box	0.115	0.048	0.1	0.013
47	Bracket star tracker	1	1	Aluminum 6061-T6	Cylinder	0.112	0.106	0.044	
48	Bracket star tracker 2	1	1	Aluminum 6061-T6	Cylinder	0.1	0.057	0.019	
49	83450 sensor mount	1	2	Aluminum (generic)	Cylinder	0.031	0.067	0.032	
50	Bracket GPS Ant	1	1	Aluminum (generic)	Cylinder	0.152	0.1	0.111	
51	Bracket Magnetorquer	1	2	Aluminum 6061-T6	Box	0.066	0.088	0.113	0.013
52	Bracket Reaction Wheels	1	4	Aluminum 6061-T6	Box	0.191	0.102	0.102	0.06
53	Mount GPS Ant	1	1	Aluminum (generic)	Box	0.209	0.102	0.106	0.102
54	Mount Featherbox	1	1	Aluminum 6061-T6	Box	0.01	0.017	0.017	0.017
55	Separation Ring	1	1	Aluminum (generic)	Cylinder	0.337	0.381	0.381	
56	Sep Ring Fasteners	55	24	Stainless Steel (generic)	Cylinder	0.0001	0.0009	0.0254	
57	AIS Antenna	1	1	Stainless Steel (generic)	Cylinder	0.08	0.009	0.279	
58	Raptor Photonics OWL	1	1	Aluminum (generic)	Box	0.247	0.05	0.0676	0.05
59	Raptor Photonics Hawk	1	1	Aluminum (generic)	Box	0.095	0.043	0.043	0.037
60	Holmes Imager	1	1	Aluminum (generic)	Box	2.3	0.125	0.274	0.115

Result for Requirement 4.7-1: COMPLIANT

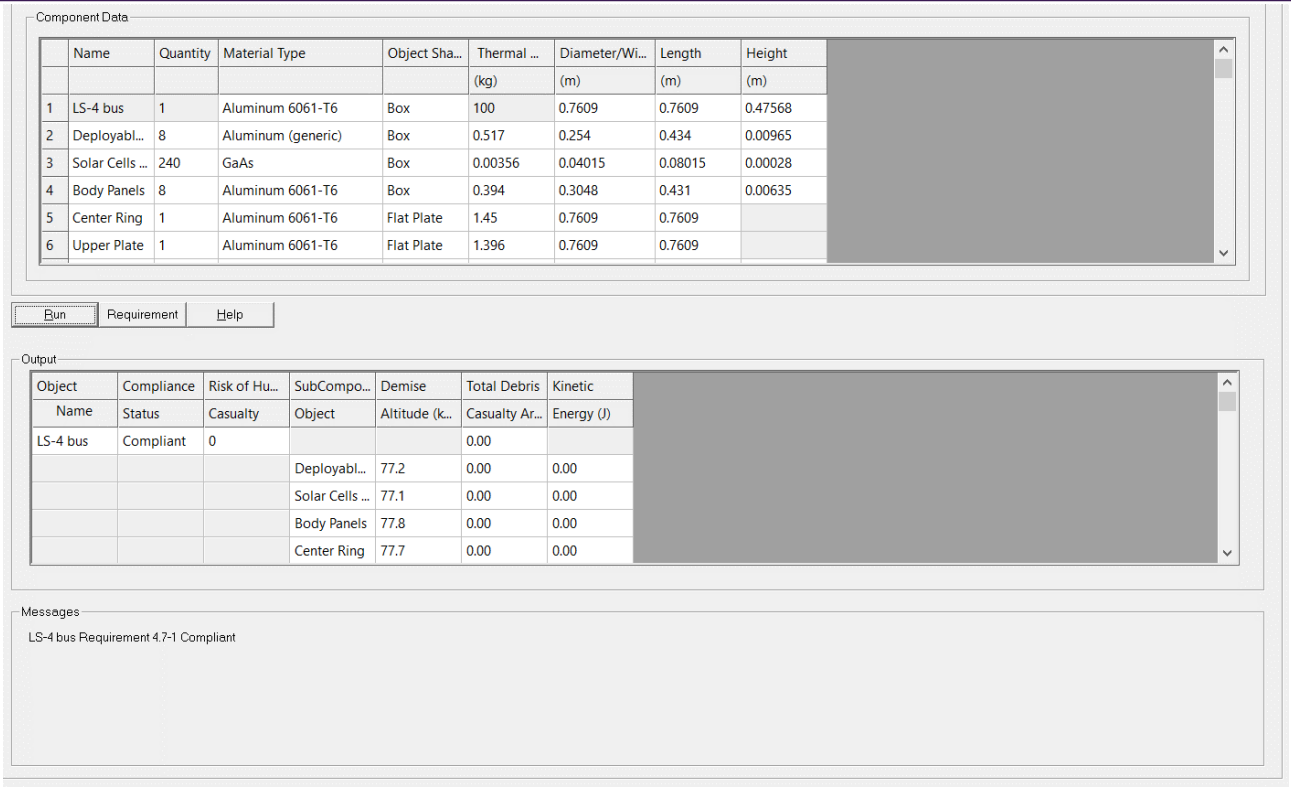

Figure 10: Requirement 4.7-1 DAS Software Screenshot

8.0 COLLISION RISK POSED BY TETHER SYSTEMS

Requirement 4.8-1. Mitigate the collision hazards of space tethers in Earth or Lunar orbits
No tethers are to be used in LS missions.

Result for Requirement 4.8-1: N/A

END OF ODAR FOR LS

Approved:

John Curry, Sidus Chief Mission Operations Office

Lindsey Waitt, LizzieSat Systems Engineering and Integration (SE&I) Lead

9.0 APPENDIX

The following is the activity log from DAS Software.

05 25 2023; 18:50:05PM Activity Log Started
06 12 2023; 23:16:22PM Opened Project Y:\SIDUS SPACE\PROJECT LIBRARY (NON-CAD ONLY)\00 - SIDUS SPACE\LIZZIESAT\Mission Operations\Licenses and Agreements_Mission Ops\FCC License\DAS324 Software ODAR\LS4_LW_545ALT\
06 12 2023; 23:16:29PM Project Data Saved To File
06 12 2023; 23:26:20PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = LS-4 bus
Space Structure Type = Payload
Perigee Altitude = 545.000 (km)
Apogee Altitude = 545.000 (km)
Inclination = 97.570 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0130 (m^2/kg)
Start Year = 2024.087 (yr)
Initial Mass = 100.000 (kg)
Final Mass = 100.000 (kg)

Duration = 5.000 (yr)
Station-Kept = False
Abandoned = True
Long-Term Reentry = True

OUTPUT

Collision Probability = 1.7376E-04
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==========

========== End of Requirement 4.5-1 ========== 06 12 2023; 22:52:01PM
Opened Project Y:\SIDUS SPACE\PROJECT LIBRARY (NON-CAD ONLY)\00 - SIDUS SPACE\LIZZIESAT\Mission Operations\Licenses and Agreements_Mission Ops\FCC License\DAS324 Software ODAR\LS6_LW_545ALT\
06 12 2023; 22:52:10PM Project Data Saved To File
06 12 2023; 23:00:18PM Mission Editor Changes Applied
06 12 2023; 23:00:18PM Project Data Saved To File
06 12 2023; 23:00:19PM Project Data Saved To File
06 12 2023; 23:05:46PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = LS-6 bus
Space Structure Type = Payload
Perigee Altitude = 545.000 (km)
Apogee Altitude = 545.000 (km)
Inclination = 97.570 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0130 (m^2/kg)
Start Year = 2024.418 (yr)
Initial Mass = 100.000 (kg)
Final Mass = 100.000 (kg)
Duration = 5.000 (yr)
Station-Kept = False
Abandoned = True
Long-Term Reentry = True

OUTPUT

Collision Probability = 1.6493E-04
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==========

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

06 12 2023; 22:19:33PM Opened Project Y:\SIDUS SPACE\PROJECT LIBRARY (NON-CAD ONLY)\00 - SIDUS SPACE\LIZZIESAT\Mission Operations\Licenses and Agreements_Mission Ops\FCC License\DAS324 Software ODAR\LS4_LW_545ALT\
06 12 2023; 22:26:35PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 545.000000 (km)
Apogee Altitude = 545.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.009150 (m^2/kg)
Start Year = 2024.087000 (yr)
Integration Time = 5.000000 (yr)

OUTPUT

Plot
06 12 2023; 22:28:42PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 471.000000 (km)
Apogee Altitude = 497.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.013000 (m^2/kg)
Start Year = 2029.088000 (yr)
Integration Time = 5.000000 (yr)

OUTPUT

Plot

06 12 2023; 22:30:35PM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2029.088000 (yr)
Perigee Altitude = 471.000000 (km)
Apogee Altitude = 497.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Area-To-Mass Ratio = 0.013000 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 4.813142 (yr)
Time Spent in LEO during Lifetime = 4.813142 (yr)
Last year of Propagation = 2033 (yr)
Returned Error Message: Object reentered

06 12 2023; 22:33:57PM Project Data Saved To File
06 12 2023; 22:37:26PM Opened Project Y:\SIDUS SPACE\PROJECT LIBRARY (NON-CAD ONLY)\00 - SIDUS SPACE\LIZZIESAT\Mission Operations\Licenses and Agreements_Mission Ops\FCC License\DAS324 Software ODAR\LS6_LW_545ALT\
06 12 2023; 22:38:15PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 545.000000 (km)
Apogee Altitude = 545.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.009150 (m^2/kg)
Start Year = 2024.418000 (yr)
Integration Time = 5.000000 (yr)

OUTPUT

Plot

06 12 2023; 22:41:08PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 476.000000 (km)
Apogee Altitude = 502.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)

Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.013000 (m^2/kg)
Start Year = 2029.416000 (yr)
Integration Time = 5.000000 (yr)

OUTPUT

Plot
06 12 2023; 22:42:32PM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2029.416000 (yr)
Perigee Altitude = 476.000000 (km)
Apogee Altitude = 502.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Area-To-Mass Ratio = 0.013000 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 4.684463 (yr)
Time Spent in LEO during Lifetime = 4.684463 (yr)
Last year of Propagation = 2034 (yr)
Returned Error Message: Object reentered

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

INPUT

Space Structure Name = LS-4 bus
Space Structure Type = Payload

Perigee Altitude = 545.000000 (km)
Apogee Altitude = 545.000000 (km)
Inclination = 97.570000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.013000 (m^2/kg)
Start Year = 2024.087000 (yr)
Initial Mass = 100.000000 (kg)
Final Mass = 100.000000 (kg)
Duration = 3.000000 (yr)
Station Kept = False

Abandoned = True
PMD Perigee Altitude = 480.234912 (km)
PMD Apogee Altitude = 480.980444 (km)
PMD Inclination = 97.676429 (deg)
PMD RAAN = 18.401152 (deg)
PMD Argument of Perigee = 179.048676 (deg)
PMD Mean Anomaly = 0.000000 (deg)
Long-Term Reentry = True

OUTPUT

Suggested Perigee Altitude = 100.000000 (km)
Suggested Apogee Altitude = 480.980444 (km)
Returned Error Message = Passes Long-term reentry orbit criteria

Released Year = 2027 (yr)
Requirement = 63
Compliance Status = Pass

==========

========== End of Requirement 4.6 ==========
05 25 2023; 19:01:26PM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = LS-4 bus
quantity = 1
parent = 0
materialID = 8
type = Box
Aero Mass = 100.000000
Thermal Mass = 100.000000
Diameter/Width = 0.760900
Length = 0.760900
Height = 0.475680

name = Deployable Panels
quantity = 8
parent = 1
materialID = 5
type = Box
Aero Mass = 0.623800
Thermal Mass = 0.517000
Diameter/Width = 0.254000
Length = 0.434000

Height = 0.009650

name = Solar Cells Panels
quantity = 240
parent = 2
materialID = 24
type = Box
Aero Mass = 0.003560
Thermal Mass = 0.003560
Diameter/Width = 0.040150
Length = 0.080150
Height = 0.000280

name = Body Panels
quantity = 8
parent = 1
materialID = 8
type = Box
Aero Mass = 0.394000
Thermal Mass = 0.394000
Diameter/Width = 0.304800
Length = 0.431000
Height = 0.006350

name = Center Ring
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.450000
Thermal Mass = 1.450000
Diameter/Width = 0.760900
Length = 0.760900

name = Upper Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.716400
Thermal Mass = 1.396000
Diameter/Width = 0.760900
Length = 0.760900

name = Solar Cells Oct Face
quantity = 90
parent = 6
materialID = 24

type = Box
Aero Mass = 0.003560
Thermal Mass = 0.003560
Diameter/Width = 0.040150
Length = 0.080150
Height = 0.000280

name = FH Screw
quantity = 128
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.004000
Thermal Mass = 0.004000
Diameter/Width = 0.007620
Length = 0.013000

name = Bottom Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 11.070000
Thermal Mass = 11.070000
Diameter/Width = 0.760900
Length = 0.760900

name = E903 Enclosure
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 10.227600
Thermal Mass = 8.160000
Diameter/Width = 0.203000
Length = 0.233000
Height = 0.180000

name = SP0-S
quantity = 1
parent = 10
materialID = 5
type = Box
Aero Mass = 0.350000
Thermal Mass = 0.350000
Diameter/Width = 0.100000
Length = 0.160000
Height = 0.020000

name = S740-22
quantity = 1
parent = 10
materialID = 5
type = Box
Aero Mass = 0.250000
Thermal Mass = 0.250000
Diameter/Width = 0.100000
Length = 0.160000
Height = 0.020000

name = FPGA
quantity = 1
parent = 10
materialID = 5
type = Box
Aero Mass = 0.101600
Thermal Mass = 0.101600
Diameter/Width = 0.074000
Length = 0.149000
Height = 0.013000

name = CM950
quantity = 2
parent = 10
materialID = 5
type = Box
Aero Mass = 0.198000
Thermal Mass = 0.198000
Diameter/Width = 0.100000
Length = 0.160000
Height = 0.020000

name = P900
quantity = 1
parent = 10
materialID = 5
type = Box
Aero Mass = 0.490000
Thermal Mass = 0.490000
Diameter/Width = 0.086000
Length = 0.160000
Height = 0.026000

name = P901
quantity = 1
parent = 10

materialID = 5
type = Box
Aero Mass = 0.480000
Thermal Mass = 0.480000
Diameter/Width = 0.086000
Length = 0.160000
Height = 0.026000

name = GPGPU
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 1.200000
Thermal Mass = 1.200000
Diameter/Width = 0.127000
Length = 0.129000
Height = 0.052000

name = Ethernet Switch
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.181000
Length = 0.231000
Height = 0.064000

name = Reaction Wheel
quantity = 4
parent = 1
materialID = 5
type = Box
Aero Mass = 1.550000
Thermal Mass = 1.550000
Diameter/Width = 0.102000
Length = 0.105000
Height = 0.102000

name = IMU
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.055000
Thermal Mass = 0.055000

Diameter/Width = 0.038000
Length = 0.044800
Height = 0.021500

name = Magnetorquer
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.470000
Thermal Mass = 0.470000
Diameter/Width = 0.050000
Length = 0.260000
Height = 0.025200

name = Magnetometer
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.035100
Length = 0.082600
Height = 0.032300

name = Star Tracker
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.475000
Thermal Mass = 0.475000
Diameter/Width = 0.065000
Length = 0.070000
Height = 0.055000

name = Sun Sensor
quantity = 6
parent = 1
materialID = 5
type = Box
Aero Mass = 0.010000
Thermal Mass = 0.010000
Diameter/Width = 0.019000
Length = 0.028000
Height = 0.012000

name = GPS Receiver
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.048000
Thermal Mass = 0.048000
Diameter/Width = 0.060000
Length = 0.100000
Height = 0.009000

name = GPS Antenna
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.082000
Thermal Mass = 0.082000
Diameter/Width = 0.052800
Length = 0.052800
Height = 0.017500

name = Bus Bars
quantity = 24
parent = 1
materialID = 5
type = Flat Plate
Aero Mass = 0.024000
Thermal Mass = 0.024000
Diameter/Width = 0.030000
Length = 0.070000

name = Li-Ion Battery
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 3.920000
Thermal Mass = 3.920000
Diameter/Width = 0.147000
Length = 0.235000
Height = 0.086000

name = MPS
quantity = 1
parent = 1
materialID = 5
type = Box

Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.101600
Length = 0.114000
Height = 0.099000

name = SB Transceiver
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.065000
Length = 0.090000
Height = 0.025300

name = SB Antenna (primary)
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.138000
Thermal Mass = 0.138000
Diameter/Width = 0.084300
Length = 0.084300
Height = 0.012100

name = SB Antenna (backup)
quantity = 1
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.075000
Thermal Mass = 0.075000
Diameter/Width = 0.071000
Length = 0.045210

name = SB Diplexer
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.822136
Thermal Mass = 0.822136
Diameter/Width = 0.076200
Length = 0.147300
Height = 0.044450

name = SB Switch
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.244000
Thermal Mass = 0.244000
Diameter/Width = 0.060960
Length = 0.066800
Height = 0.025400

name = XB Transmitter
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.275000
Thermal Mass = 0.275000
Diameter/Width = 0.090200
Length = 0.095900
Height = 0.028400

name = FeatherBox
quantity = 1
parent = 1
materialID = 54
type = Box
Aero Mass = 1.400000
Thermal Mass = 1.400000
Diameter/Width = 0.096000
Length = 0.096000
Height = 0.049500

name = AIS Receiver
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.185000
Thermal Mass = 0.185000
Diameter/Width = 0.087200
Length = 0.093000
Height = 0.012500

name = Post Upper
quantity = 8
parent = 1

materialID = 5
type = Cylinder
Aero Mass = 0.255000
Thermal Mass = 0.255000
Diameter/Width = 0.094000
Length = 0.203000

name = Post Lower
quantity = 8
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.257000
Thermal Mass = 0.257000
Diameter/Width = 0.094000
Length = 0.203000

name = Link Upper
quantity = 8
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.053000
Thermal Mass = 0.053000
Diameter/Width = 0.213000
Length = 0.130000

name = Link Lower
quantity = 8
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.053000
Thermal Mass = 0.053000
Diameter/Width = 0.213000
Length = 0.130000

name = Post Center
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.186000
Thermal Mass = 0.186000
Diameter/Width = 0.032000
Length = 0.191000

name = Mount Center

quantity = 2
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.190000
Thermal Mass = 0.190000
Diameter/Width = 0.102000
Length = 0.044000

name = Bracket upright
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.794000
Thermal Mass = 0.794000
Diameter/Width = 0.175000
Length = 0.259000
Height = 0.013000

name = Bracket base
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.883000
Thermal Mass = 0.883000
Diameter/Width = 0.228000
Length = 0.259000
Height = 0.013000

name = Bracket gusset
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.115000
Thermal Mass = 0.115000
Diameter/Width = 0.048000
Length = 0.100000
Height = 0.013000

name = Bracket star tracker
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.112000

Thermal Mass = 0.112000
Diameter/Width = 0.106000
Length = 0.044000

name = Bracket star tracker 2
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.057000
Length = 0.019000

name = 83450 sensor mount
quantity = 2
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.031000
Thermal Mass = 0.031000
Diameter/Width = 0.067000
Length = 0.032000

name = Bracket GPS Ant
quantity = 1
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.152000
Thermal Mass = 0.152000
Diameter/Width = 0.100000
Length = 0.111000

name = Bracket Magnetorquer
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 0.066000
Thermal Mass = 0.066000
Diameter/Width = 0.088000
Length = 0.113000
Height = 0.013000

name = Bracket Reaction Wheels
quantity = 4
parent = 1

materialID = 8
type = Box
Aero Mass = 0.191000
Thermal Mass = 0.191000
Diameter/Width = 0.102000
Length = 0.102000
Height = 0.060000

name = Mount GPS Ant
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.209000
Thermal Mass = 0.209000
Diameter/Width = 0.102000
Length = 0.106000
Height = 0.102000

name = Mount Featherbox
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.010000
Thermal Mass = 0.010000
Diameter/Width = 0.017000
Length = 0.017000
Height = 0.017000

name = Separation Ring
quantity = 1
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.339400
Thermal Mass = 0.337000
Diameter/Width = 0.381000
Length = 0.381000

name = Sep Ring Fasteners
quantity = 24
parent = 55
materialID = 54
type = Cylinder
Aero Mass = 0.000100
Thermal Mass = 0.000100
Diameter/Width = 0.000900

Length = 0.025400

name = AIS Antenna
quantity = 1
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.009000
Length = 0.279000

name = Raptor Photonics OWL
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.247000
Thermal Mass = 0.247000
Diameter/Width = 0.050000
Length = 0.067600
Height = 0.050000

name = Raptor Photonics Hawk
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.095000
Thermal Mass = 0.095000
Diameter/Width = 0.043000
Length = 0.043000
Height = 0.037000

name = Holmes Imager
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.300000
Thermal Mass = 2.300000
Diameter/Width = 0.125000
Length = 0.274000
Height = 0.115000

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

name = LS-4 bus
Demise Altitude = 77.997802
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Deployable Panels
Demise Altitude = 77.177136
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Solar Cells Panels
Demise Altitude = 77.151944
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Body Panels
Demise Altitude = 77.775208
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Center Ring
Demise Altitude = 77.667174
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Upper Plate
Demise Altitude = 77.689879
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Solar Cells Oct Face
Demise Altitude = 77.668718
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = FH Screw
Demise Altitude = 76.323279
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bottom Plate
Demise Altitude = 75.490823
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = E903 Enclosure
Demise Altitude = 73.458375
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = SP0-S
Demise Altitude = 71.575713
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = S740-22
Demise Altitude = 72.110555
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = FPGA
Demise Altitude = 72.727251
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = CM950
Demise Altitude = 72.391453
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = P900
Demise Altitude = 70.836314
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = P901
Demise Altitude = 70.888486
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = GPGPU
Demise Altitude = 72.281266
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Ethernet Switch
Demise Altitude = 75.634933
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel
Demise Altitude = 71.461287
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = IMU
Demise Altitude = 76.480727
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Magnetorquer
Demise Altitude = 75.349323
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Magnetometer
Demise Altitude = 76.618513
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Star Tracker
Demise Altitude = 73.501693
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Sun Sensor
Demise Altitude = 77.269411
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = GPS Receiver
Demise Altitude = 77.342774
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = GPS Antenna
Demise Altitude = 76.163240
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bus Bars
Demise Altitude = 77.079514
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Li-Ion Battery
Demise Altitude = 69.782648
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = MPS
Demise Altitude = 73.824986
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = SB Transceiver
Demise Altitude = 75.795321
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = SB Antenna (primary)
Demise Altitude = 76.241520
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = SB Antenna (backup)
Demise Altitude = 76.640861
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = SB Diplexer
Demise Altitude = 73.665537
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = SB Switch
Demise Altitude = 74.463129
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = XB Transmitter
Demise Altitude = 75.550897
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = FeatherBox
Demise Altitude = 66.619291
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = AIS Receiver
Demise Altitude = 75.910358
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Post Upper
Demise Altitude = 76.748858
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Post Lower
Demise Altitude = 76.735670
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Link Upper
Demise Altitude = 77.959227
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Link Lower
Demise Altitude = 77.959227
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Post Center
Demise Altitude = 77.192565
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Mount Center
Demise Altitude = 77.109032
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket upright
Demise Altitude = 77.065033
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket base
Demise Altitude = 77.073040
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket gusset
Demise Altitude = 77.353280
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket star tracker
Demise Altitude = 77.495585
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket star tracker 2
Demise Altitude = 76.573544
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = 83450 sensor mount
Demise Altitude = 77.274626
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket GPS Ant
Demise Altitude = 76.880903
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket Magnetorquer
Demise Altitude = 77.760813
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket Reaction Wheels
Demise Altitude = 77.533203
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Mount GPS Ant
Demise Altitude = 77.033724
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Mount Featherbox
Demise Altitude = 77.602305
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Separation Ring
Demise Altitude = 77.702312
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Sep Ring Fasteners
Demise Altitude = 77.486977
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = AIS Antenna
Demise Altitude = 76.187639
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Raptor Photonics OWL
Demise Altitude = 75.218434
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Raptor Photonics Hawk
Demise Altitude = 75.989356
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Holmes Imager
Demise Altitude = 73.880103
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

========== End of Requirement 4.7-1 ==========
05 25 2023; 19:01:26PM Project Data Saved To File