Orbital Debris Assessment Report

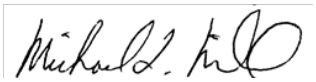
DUPLEX

per NASA-STD 8719.14B

Signature Page

February 4, 2023

David L. Carroll, President
CU Aerospace, L.L.C.



February 3, 2023

Michael L. Miller, Licensing Coordinator
Sterk Solutions Corp.

February 3, 2023

Mike H. Miller, Licensing Analyst
Sterk Solutions Corp.

REFERENCES:

A. *NASA Procedural Requirements for Limiting Orbital Debris Generation,* NPR 8715.6A, *5* February 2008
B. *Process for Limiting Orbital Debris,* NAS A-STD-8719.14B, 25 May 2012
C. International Space Station Reference Trajectory, delivered May 2017
D. McKissock , Barba ra, Patricia Loyselle, and Elisa Vogel. *Guidelines on Lithium-ion Battery Use in Space Applications.* Tech. no. RP-08-75. NASA Glenn Research Center Cleveland, Ohio
E. *UL Standard for Safety.for Lithium Batteries, UL 1642.* 1JL Standard. 4th ed. Northbrook, IL, Underwriters Laboratories, 2007
F. Kwas, Robert. Thermal Analysis of ELaNa-4 CubeSat Batteries, ELVL-2012-0043254; Nov 2012
G. Range Safety User Requirements Manual Volume 3- Launch Vehicles, Payloads, and Ground Support Systems Requirements, AFSCM 91-710 V3.
H. HQ OSMA Policy Memo/Email to 8719.14: CubeSat Battery Non-Passivation, Suzanne Aleman to Justin Treptow, 10, March 2014
I. HQ OSMA Emai1:6U CubcSat Battery Non Passivation Suzanne Aleman to Justin Treptow, 8 August 2017

This report is intended to satisfy the orbital debris requirements listed in *NASA Procedural Requirements for Limiting Orbital Debris Generation,* NPR 8715.6A, *5* February 2008, for the DUPLEX mission.

Sections 1 through 8 of *Process for Limiting Orbital Debris,* NASA-STD-8719.14B, 25 May 2012, are addressed in this document; Sections 9 through 14 are in the domain of the launch provider and are addressed by others.

RECORD OF REVISIONS		
REV	**DESCRIPTION**	**DATE**
0	Original Project Internal	August 10, 2021
1	Completed Appendix; Added Minor Non Demising Components Project Internal	September 2, 2021
2	Updated references to NASA-STD-8719.14B to reflect Revision B Project internal	September 10, 2021
3	Updated for revised launch and orbit. Initial submittal to FCC	October 29, 2022
4	Updated for launch and orbit information, and nested components in DAS reentry model.	February 4, 2023

The following table summarizes the compliance status of the DUPLEX spacecraft. They all are fully compliant with all applicable requirements.

Requirements	**Compliance Assessment**	**Comments**
4.3-1a	Not Applicable	No planned debris release
4.3-1b	Not Applicable	No planned debris release
4.3-2	Not Applicable	No planned debris release
4.4-1	Compliant	Batteries incapable of debris producing failure
4.4-2	Compliant	Batteries incapable of debris producing failure
4.4-3	Not Applicable	No planned breakups
4.4.-4	Not Applicable	No planned breakups
4.5-1	Compliant	

Table 1 Compliance Assessment per Requirement

Section 1: Mission Overview

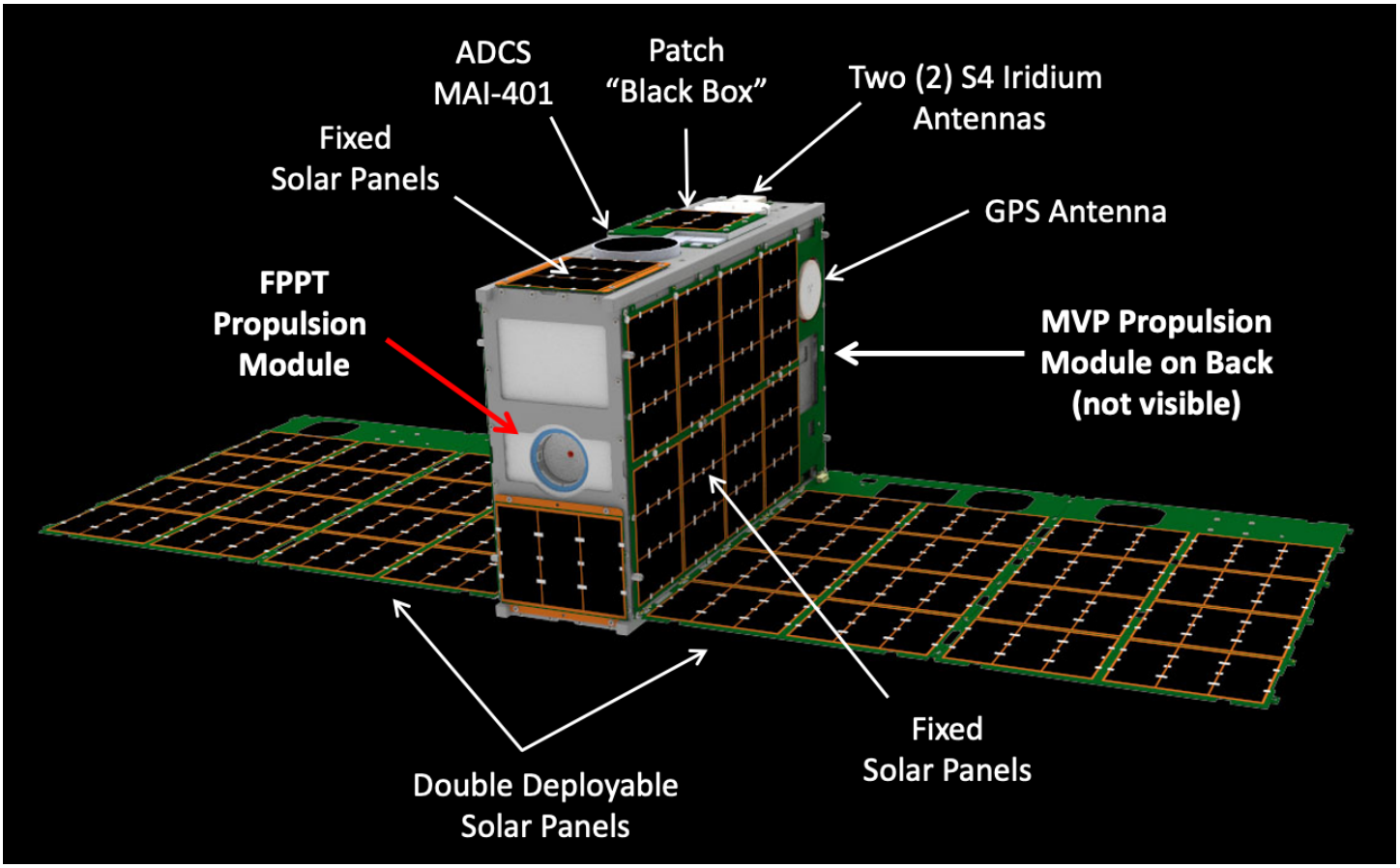
The overall goal of the Dual Propulsion Experiment (DUPLEX) mission, is to test and establish flight heritage in low Earth orbit on a 6U cubesat, two polymer fiber propulsion systems, and a new sensor system. Specifically, these systems are the Fiber-fed Pulsed Plasma Thruster (FPPT), the Monofilament Vaporization Propulsion (MVP), and the Distributed Inertial Sensor Integration (DISI) Kit.

The experiment will be carried to the ISS as cargo aboard the SpaceX 28 resupply vehicle launching from Cape Canaveral FL, no earlier than June 1, 2023. DUPLEX will deploy from the ISS no earlier than June 3, 2023, into Low Earth Orbit (LEO), at approximately a 420 km circular orbit, on an inclination from the equator of 51.6° degrees.

Section 2: Spacecraft Description

DUPLEX is a 6U CubeSat with dimensions of 116.5 mm x 237.7 mm x 366 mm stowed, and a total mass of approximately 10.5 kg. The exterior structure is comprised of anodized aluminum and there are double-deployable solar arrays, which are stowed flush with the spacecraft bus during launch.

Figure 1 shows two perspectives of DUPLEX with solar panels deployed.



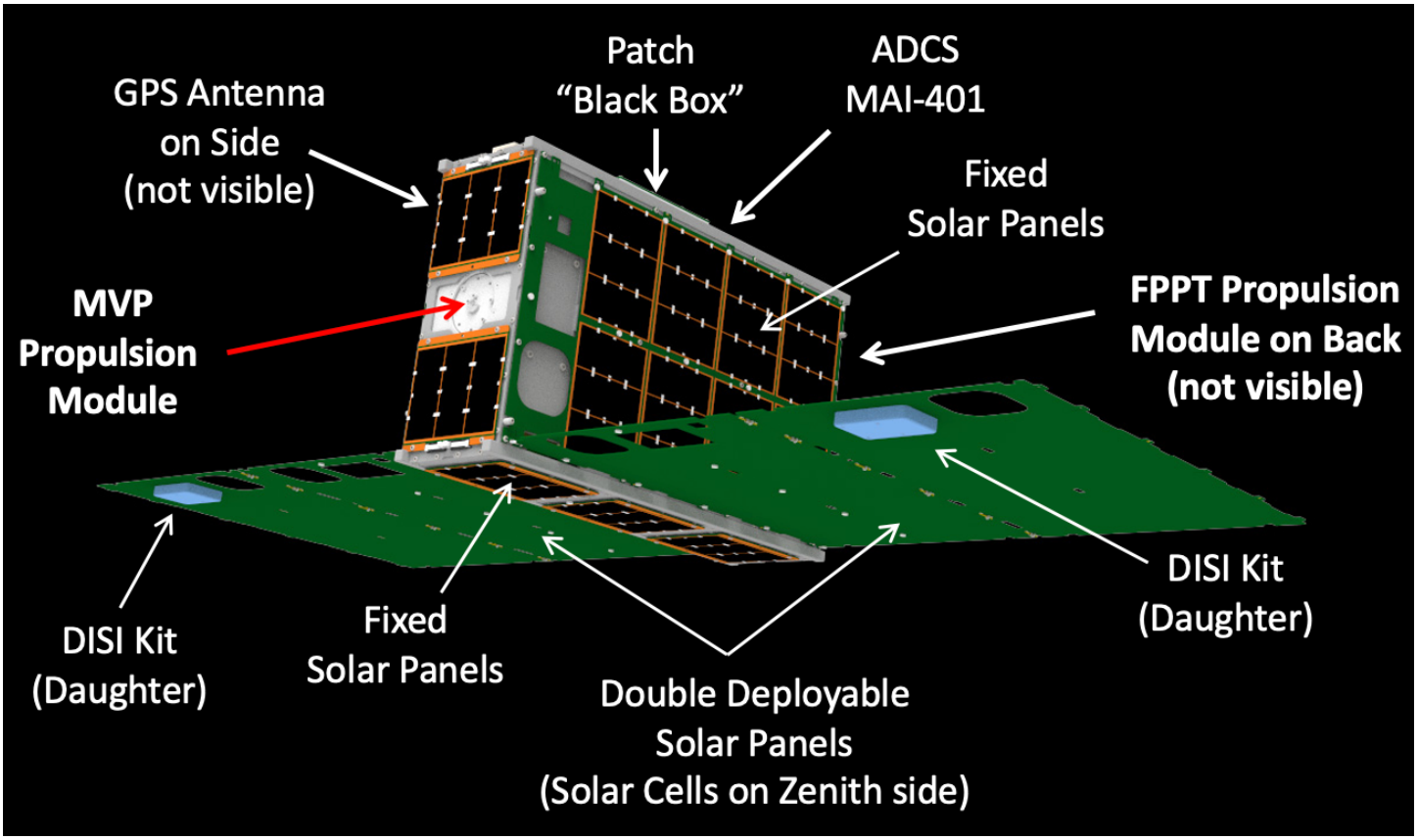


Figure 1 Duplex Satellite, Deployed, Two Perspectives

The Appendix lists all of the components in the spacecraft, with the characteristics of each, as input to the DAS software.

Hazards

There are no pressure vessels, hazardous, or exotic materials.

Batteries

The NSL battery NSL140743 (UL Listing:BBCV2.MH50009), (UN38.4: ZKS1912000469-1), is a pouch type cell, using Polymer Li-ion chemistry. It stores 700 mAh at 3.7 volts. It is used with a battery circuit protection module providing over-charge/over-current protection and over-discharge circuitry.

Tests have been conducted to demonstrate compliance with JSC EP-WI-032 "Statement of Work: Engineering Evaluation, Qualification and Flight Acceptance Tests for Lithium-ion Cells and Battery Packs for Small Satellite Systems."

Section 3: Assessment of Spacecraft Debris Released during Normal Operations

The assessment of spacecraft debris requires the identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material.

Section 3 requires rationale/necessity for release of each object, time of release of each object, relative to launch time, release velocity of each object with respect to spacecraft, expected orbital parameters (apogee, perigee, and inclination) of each object after release, calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO), and an assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2.

No releases are planned, therefore this section is not applicable.

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

There are NO plans for designed spacecraft breakups, explosions, or intentional collisions.

The probability of battery explosion is very low, and, due to the very small mass of the satellites, and the pouch type construction, the effect of an explosion on the far-term LEO environment is negligible, per HQ OSMA Policy Memo/Email to 8719.14: CubeSat Battery Non-Passivation, Suzanne Aleman to Justin Treptow, 10, March 2014

The batteries meet Reg. 56450 (4.4-2), per this reference, by virtue of the HQ OSMA policy regarding battery disconnect stating "Cube Sats as a satellite class need not disconnect their batteries if flown in LEO with orbital lifetimes less than 25 years."

Passivation of the batteries at end of mission is provided for in the command structure. However, the low amount of energy stored and small battery cells prevents a catastrophic failure; so that passivation at EOM is not necessary to prevent an explosion or deflagration large enough to release orbital debris.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4 shows that the DUPLEX spacecraft is compliant.

Section 5: Assessment of Spacecraft Potential for On Orbit Collisions

Requirement 4.5.1 Calculation of spacecraft probability of collision with space objects larger than 10 *cm* in diameter during the orbital lifetime of the spacecraft takes into account both the mean cross sectional area (MCSA) and orbital lifetime.

There are 2 extreme DAS cases: 1) Nominal experiment operation; and 2) no systems functional, no panels deployed and aerodynamic stabilization to minimum effective cross sectional area.

Case 1: Nominal Execution of Propulsion Experiment

Nominal execution of the propulsion experiment, ending by maneuvering to a disposal orbit at 250 km altitude, will result in an orbit lifetime far less than would be provided by natural orbit decay. The orbit altitude vs. time is shown in Figure 2. The plan is for a total lifetime on orbit of less than 2 years.

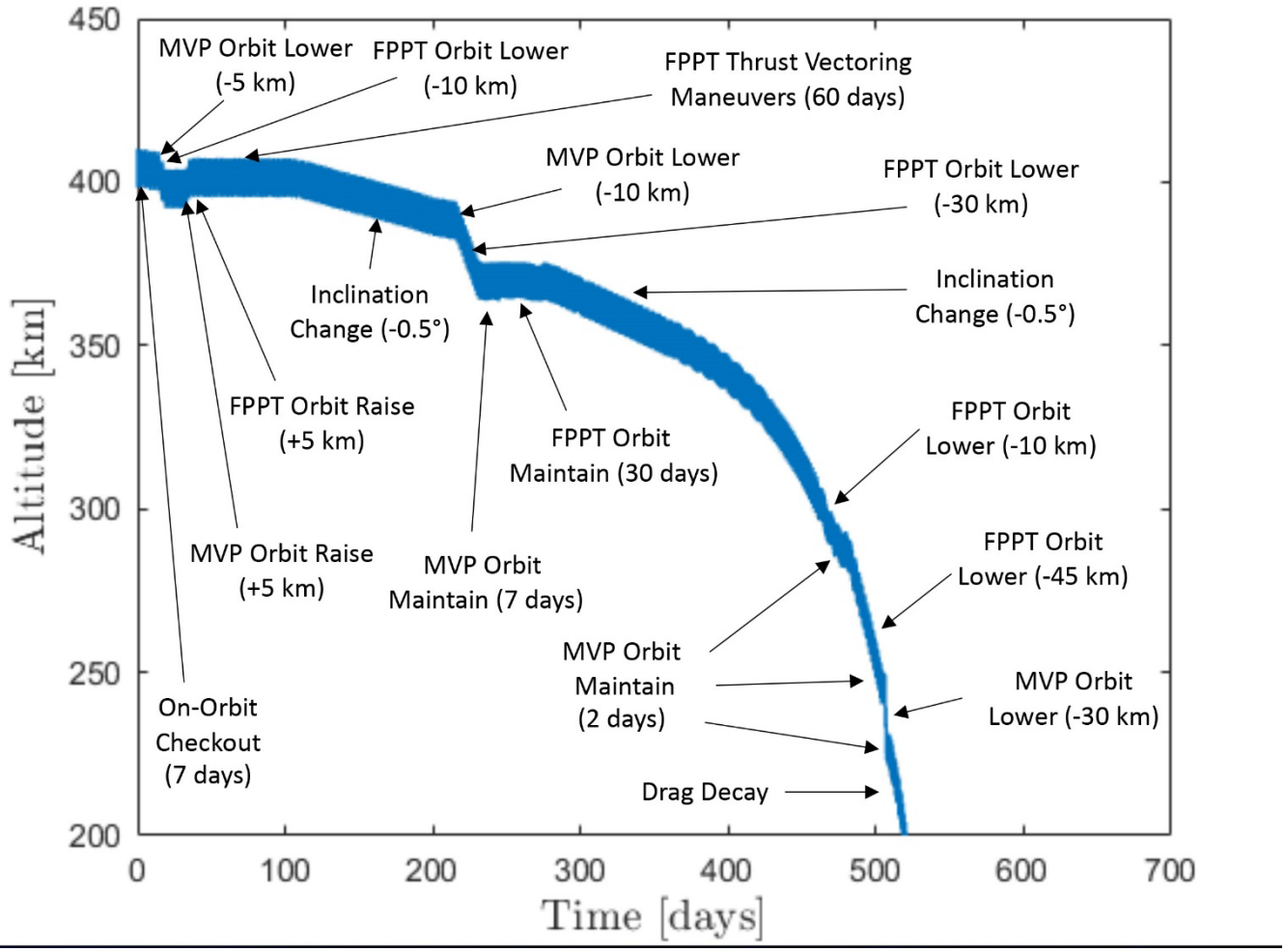


Figure 2 Orbit Altitude vs. Time, with Nominal Experiment Conduct

Case 2: Un-Deployed With Aerodynamic Stabilization

The longest orbit lifetime would result if the spacecraft was deployed from the ISS airlock, no systems are functional, no panels deployed, and aerodynamic stabilization presents the minimum effective cross sectional area in the RAM direction. This yields an area of 116.5 mm x 237.7 mm, or 0.0277 m^2. The maximum orbit lifetime in this extreme contingency case, would be 2.924 years.

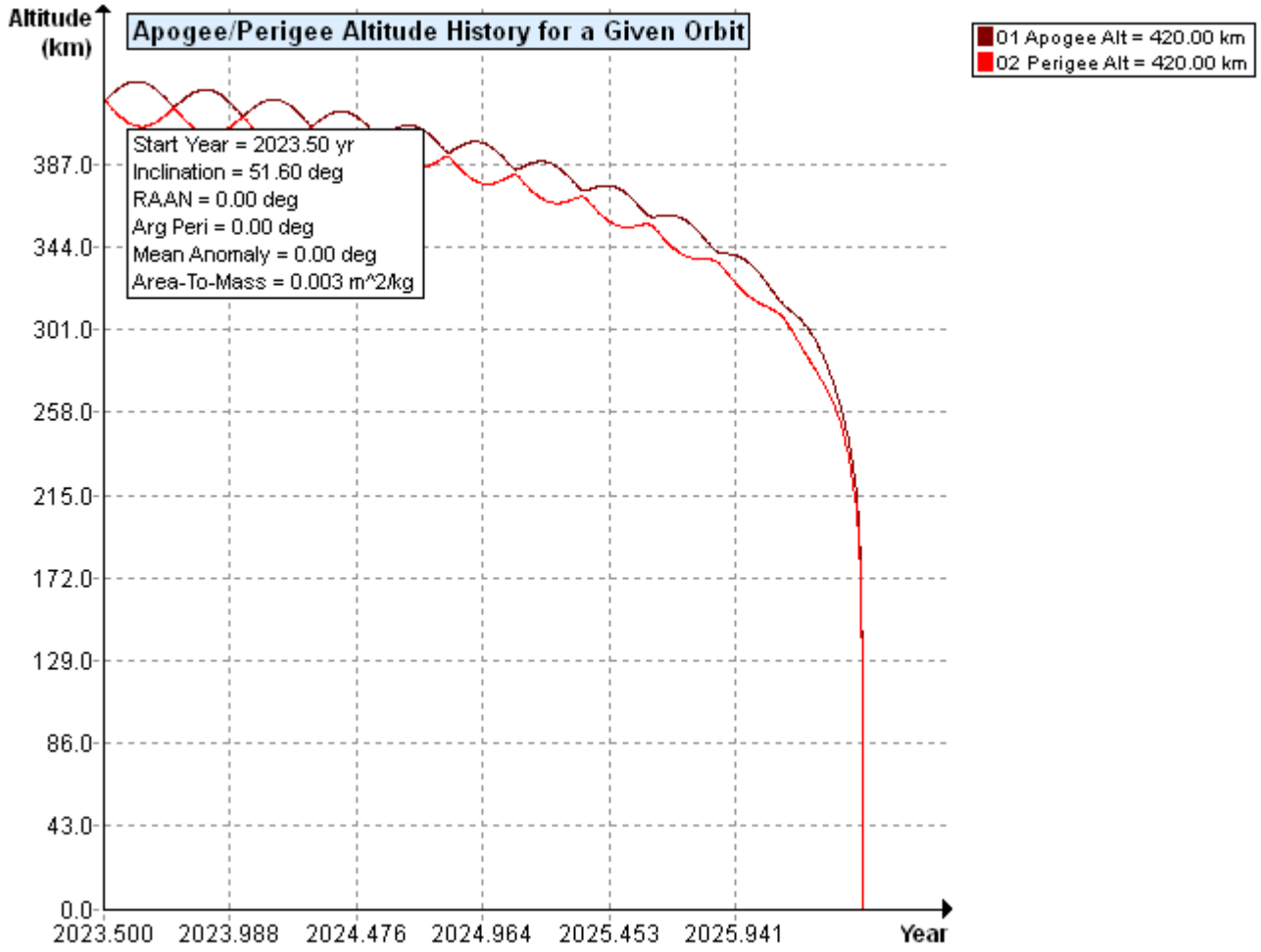


Figure 3 Orbit Altitude vs. Time, Undeployed, Aerodynamic

The total mass, obtained by summing the masses of the components of the spacecraft as shown in the Appendix, was used to determine the Area to Mass ratio, shown in the following Table 2. Table 2 also shows the orbit lifetime and the probability of collision, provided by the DAS calculations. See Appendix for DAS Analysis Input Data and Output Results.

Effective Cross Sectional Area, m^2	Mass, kg	Area/Mass m^2/ kg	Orbit Lifetime Years (DAS)	Probability of Collision (DAS)
0.0277	10.5	.00264	2.924	7.0270 E-08

Table 2
Area, Mass, Area to Mass Ratio, Lifetime and Probability of Collision, Case 2

From Table 2, the orbit lifetime in this contingency case would be 2.924 years, the maximum possible.

Review of All Cases

The probability of any collision with debris or meteoroids greater than 10 cm in diameter is 7.7835 e-08, per DAS for the 2.924 year lifetime given in Case 2. This satisfies the 0.001 maximum probability requirement 4.5-l.

Assessment of spacecraft compliance with Requirements 4.5-1 shows the spacecraft to be compliant.

Section 6: Assessment of Spacecraft Postmission Disposal Plans and Procedures

Per Case 2 above, the spacecraft will naturally decay from orbit within 25 years after deploy, even with no active propulsion, satisfying requirement 4.6- l. With active propulsion as in Case 1, the lifetime will be less.

Planning for spacecraft maneuvers to accomplish post-mission disposal is not applicable. Planning is that the mission will continue until atmospheric reentry.

Summary of DAS 3.2.3 Orbital Lifetime Calculations:

DAS inputs are: 420 km circular orbit, with an inclination of 51.6° at deployment no earlier than Q2, 2023.

From Section 5, Case 1, in the nominal operation case, the lifetime of the spacecraft is estimated to be less than 600 days, based on the propulsion experiment plan.

From Section 5, Case 2, the longest orbit lifetime would result if the spacecraft was deployed from the ISS airlock, no systems are functional, no panels deployed, and aerodynamic stabilization presents the minimum effective cross sectional area in the RAM direction. The maximum orbit lifetime in this extreme contingency case, would be 2.924 years, which is less than the 25 year requirement.

The assessment of the spacecraft illustrates they are compliant with Requirements 4.6-1 through 4.6-5.

Section 7: Assessment of Spacecraft Reentry Hazards

A detailed assessment of the components of the spacecraft was performed using DAS 3.2.3, to verify Requirement 4.7-1. See Appendix for a complete log of DAS inputs and outputs for all cases. The analysis provides a bounding analysis for characterizing the survivability of a component during re-entry. It is conservative in that when it shows terminal energy of a component surviving reentry, it is does not consider any loss material from ablation or charring. Both of these may for some materials decrease the mass and dimensions of the re-entering components, reducing the risk below that calculated.

The surviving components are shown in Table 3.

Surviving Component	Original Mass Each, kg	Impact Kinetic Energy, Joules*	Casualty Area, m^2*	Spacecraft Risk of Human Casualty
Bulkhead Internal	**0.003413**	**0.30**	**0.41**	
Ceramic_NZ_Mount_2	**0.00873**	**0.31**	**2.09**	
Solar Panel DB Enclosure	**0.01074**	**0.65**	**1.67**	
Solar Panel DB	**0.0025**	**0**	**0**	
Total Risk				**0**

Table 3: Surviving Component Analysis

The only surviving components are the 4 components identified in Table 3. DAS gives a risk of human casualty probability of 0, because each of these components show an impact energy of less than 15 joules.

The other components demise upon reentry, and the spacecraft complies with the less than 1:10,000 probability of Human Casualty Requirement 4.7-1.

The DUPLEX spacecraft thus is in compliance with Requirement 4.7-1 of NASA-STD-8719.14B.

Section 8: Assessment for Tether Missions

No tethers are used. Requirement 4.8-1 is satisfied.

Section 9 through 14:

ODAR sections 9 through 14 pertain to the launch vehicle, and are not covered here.

Appendix – DAS Activity Log

```
02 03 2023; 14:08:26PM Science and Engineering - Orbit Lifetime/Dwell Time
**INPUT**
      Start Year = 2023.500000 (yr)
      Perigee Altitude = 420.000000 (km)
      Apogee Altitude = 420.000000 (km)
      Inclination = 51.600000 (deg)
      RAAN = 0.000000 (deg)
      Argument of Perigee = 0.000000 (deg)
      Area-To-Mass Ratio = 0.002640 (m^2/kg)
**OUTPUT**
      Orbital Lifetime from Startyr = 2.924025 (yr)
      Time Spent in LEO during Lifetime  = 2.924025 (yr)
      Last year of Propagation = 2026 (yr)
      Returned Error Message: Object reentered
02 03 2023; 14:08:46PM Science and Engineering - Apogee/Perigee History for a Given
Orbit
**INPUT**
      Perigee Altitude = 420.000000 (km)
      Apogee Altitude = 420.000000 (km)
      Inclination = 51.600000 (deg)
      RAAN = 0.000000 (deg)
      Argument of Perigee = 0.000000 (deg)
      Mean Anomaly = 0.000000 (deg)
      Area-To-Mass Ratio = 0.002640 (m^2/kg)
      Start Year = 2023.500000 (yr)
      Integration Time = 3.000000 (yr)
**OUTPUT**
      Plot
02 03 2023; 14:11:45PM Processing Requirement 4.5-1:     Return Status :  Passed
==============
Run Data
==============
**INPUT**
      Space Structure Name = DUPLEX
      Space Structure Type = Payload
      Perigee Altitude = 420.000 (km)
      Apogee Altitude = 420.000 (km)
      Inclination = 51.600 (deg)
      RAAN = 0.000 (deg)
      Argument of Perigee = 0.000 (deg)
      Mean Anomaly = 0.000 (deg)
      Final Area-To-Mass Ratio = 0.0026 (m^2/kg)
      Start Year = 2023.000 (yr)
      Initial Mass = 10.500 (kg)
      Final Mass = 10.500 (kg)
      Duration = 5.000 (yr)
      Station-Kept = False
      Abandoned = True
      Long-Term Reentry = False
**OUTPUT**
      Collision Probability = 7.0270E-08
      Returned Message: Normal Processing
      Date Range Message: Normal Date Range
      Status = Pass
==============
============== End of Requirement 4.5-1 ==============
02 03 2023; 14:15:48PM *********Processing Requirement 4.7-1
```

```
      Return Status :  Passed
***********INPUT****
 Item Number = 1
name = DUPLEX
quantity = 1
parent = 0
materialID = 8
type = Box
Aero Mass = 10.500000
Thermal Mass = 10.500000
Diameter/Width = 0.230000
Length = 0.370000
Height = 0.100000
name = 3x2U CubeSat Chassis
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 1.350000
Thermal Mass = 1.350000
Diameter/Width = 0.226300
Length = 0.366000
Height = 0.100000
name = NSL EPS
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.214000
Thermal Mass = 0.214000
Diameter/Width = 0.075000
Length = 0.075000
Height = 0.020000
name = EPS Battery Packs
quantity = 8
parent = 1
materialID = 5
type = Box
Aero Mass = 0.027000
Thermal Mass = 0.027000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.017000
name = Extra Battery Packs
quantity = 8
parent = 1
materialID = 5
type = Box
Aero Mass = 0.027000
Thermal Mass = 0.027000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.017000
name = Extra Battery PCB
quantity = 2
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.019000
Thermal Mass = 0.019000
```

```
Diameter/Width = 0.050000
Length = 0.073000
name = Flight Processor
quantity = 1
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.076000
Length = 0.076000
name = EyeStar-S3
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.022000
Thermal Mass = 0.022000
Diameter/Width = 0.026000
Length = 0.055000
Height = 0.015000
name = EyeStar-D2
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.136000
Thermal Mass = 0.136000
Diameter/Width = 0.064000
Length = 0.119000
Height = 0.027000
name = S3 Antenna
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.014000
Thermal Mass = 0.014000
Diameter/Width = 0.025000
Length = 0.030000
Height = 0.010000
name = D2 Antenna
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.065000
Thermal Mass = 0.065000
Diameter/Width = 0.059000
Length = 0.059000
Height = 0.014000
name = Black Box - Patch
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.150000
Thermal Mass = 0.150000
Diameter/Width = 0.082000
Length = 0.100000
```

```
Height = 0.010000
name = FP + S3 Carrier PCB
quantity = 1
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.040000
Thermal Mass = 0.040000
Diameter/Width = 0.076000
Length = 0.119000
name = 1U Solar Array
quantity = 7
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.027000
Thermal Mass = 0.027000
Diameter/Width = 0.080000
Length = 0.100000
name = 3x2U Fixed Solar Array
quantity = 2
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.230000
Thermal Mass = 0.230000
Diameter/Width = 0.209000
Length = 0.349000
name = 3x2U Deploy Solar Array
quantity = 4
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.215000
Thermal Mass = 0.215000
Diameter/Width = 0.209000
Length = 0.349000
name = Burn PCB
quantity = 2
parent = 1
materialID = 23
type = Box
Aero Mass = 0.009000
Thermal Mass = 0.009000
Diameter/Width = 0.020000
Length = 0.052000
Height = 0.005000
name = PIN Diode
quantity = 3
parent = 1
materialID = 19
type = Flat Plate
Aero Mass = 0.005000
Thermal Mass = 0.005000
Diameter/Width = 0.015000
Length = 0.025000
name = NSL IMU
quantity = 1
parent = 1
materialID = 23
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type = Box
Aero Mass = 0.002000
Thermal Mass = 0.002000
Diameter/Width = 0.020000
Length = 0.022000
Height = 0.005000
name = Sep Switches
quantity = 4
parent = 1
materialID = 54
type = Box
Aero Mass = 0.002000
Thermal Mass = 0.002000
Diameter/Width = 0.010250
Length = 0.020000
Height = 0.006500
name = RBF Switch Assembly
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.003000
Thermal Mass = 0.003000
Diameter/Width = 0.010000
Length = 0.011000
Height = 0.010000
name = Diag Assembly
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.003000
Thermal Mass = 0.003000
Diameter/Width = 0.011000
Length = 0.014000
Height = 0.011000
name = Fasteners / Spacers
quantity = 10
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.020000
Thermal Mass = 0.020000
Diameter/Width = 0.050000
Length = 0.025000
name = Cabling
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.020000
Length = 0.500000
name = NovAtel OEM 719
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.031000
```

Thermal Mass = 0.031000
Diameter/Width = 0.046000
Length = 0.071000
Height = 0.009000
name = GPS Antenna
quantity = 1
parent = 1
materialID = 23
type = Cylinder
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.030000
Length = 0.100000
name = Extra Mass
quantity = 1
parent = 1
materialID = 19
type = Box
Aero Mass = 0.535260
Thermal Mass = 0.535260
Diameter/Width = 0.050000
Length = 0.100000
Height = 0.012000
name = ADCS - Reaction Wheel Housings
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.028600
Thermal Mass = 0.028600
Diameter/Width = 0.032000
Length = 0.034000
Height = 0.032000
name = ADCS - Reaction Wheels
quantity = 3
parent = 1
materialID = 67
type = Cylinder
Aero Mass = 0.090400
Thermal Mass = 0.090400
Diameter/Width = 0.013000
Length = 0.035000
name = ADCS - Magnetic Torque Rods
quantity = 3
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.018000
Thermal Mass = 0.018000
Diameter/Width = 0.020000
Length = 0.021000
name = ADCS Frame
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.109000
Thermal Mass = 0.109000
Diameter/Width = 0.097000
Length = 0.097000

```
Height = 0.055000
name = ADCS Star Tracker
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.183000
Thermal Mass = 0.183000
Diameter/Width = 0.040000
Length = 0.041000
Height = 0.040000
name = ADCS Star Tracker Baffle
quantity = 1
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.095191
Thermal Mass = 0.095191
Diameter/Width = 0.061000
Length = 0.056000
name = ADCS Housing
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.197000
Thermal Mass = 0.197000
Diameter/Width = 0.100000
Length = 0.102000
Height = 0.056000
name = RM3000
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.005000
Thermal Mass = 0.005000
Diameter/Width = 0.025000
Length = 0.025000
Height = 0.005000
name = Cabling (26 AWG 7/34)
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.001759
Thermal Mass = 0.001759
Diameter/Width = 0.000500
Length = 1.000000
name = Nozzle_Flight_3
quantity = 1
parent = 1
materialID = 56
type = Box
Aero Mass = 0.001219
Thermal Mass = 0.001219
Diameter/Width = 0.006350
Length = 0.016440
Height = 0.001500
name = DF13C-4P-1.25V_
```

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quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.000076
Thermal Mass = 0.000076
Diameter/Width = 0.001050
Length = 0.062450
Height = 0.001050
name = Microcontroller
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.000177
Thermal Mass = 0.000177
Diameter/Width = 0.009900
Length = 0.009900
Height = 0.001290
name = 527451297
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.000079
Thermal Mass = 0.000079
Diameter/Width = 0.002500
Length = 0.010000
Height = 0.002500
name = Anti_Snag_Guide_v2
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.045949
Thermal Mass = 0.045949
Diameter/Width = 0.092040
Length = 0.092040
Height = 0.002010
name = c82
quantity = 1
parent = 1
materialID = 40
type = Box
Aero Mass = 0.000154
Thermal Mass = 0.000154
Diameter/Width = 0.003000
Length = 0.007000
Height = 0.003000
name = Bulkhead_Internal
quantity = 1
parent = 1
materialID = 1
type = Box
Aero Mass = 0.003413
Thermal Mass = 0.003413
Diameter/Width = 0.019150
Length = 0.030480
Height = 0.001480
name = Heater_Block_Flight_3
```

```
quantity = 1
parent = 1
materialID = 56
type = Cylinder
Aero Mass = 0.005000
Thermal Mass = 0.005000
Diameter/Width = 0.015000
Length = 0.027710
name = DF13C-8P-1.25V_
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.000117
Thermal Mass = 0.000117
Diameter/Width = 0.005000
Length = 0.005000
Height = 0.005000
name = Ceramic_Nz_Mount_2
quantity = 1
parent = 1
materialID = 1
type = Box
Aero Mass = 0.008730
Thermal Mass = 0.008730
Diameter/Width = 0.012000
Length = 0.063000
Height = 0.003000
name = Motor Controller
quantity = 1
parent = 1
materialID = 23
type = Cylinder
Aero Mass = 0.000062
Thermal Mass = 0.000062
Diameter/Width = 0.004670
Length = 0.007900
name = Inductor 3.3v
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.001066
Thermal Mass = 0.001066
Diameter/Width = 0.007300
Length = 0.007300
name = Spool_Center_Tube_wirerouting_simple
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.054566
Thermal Mass = 0.054566
Diameter/Width = 0.030000
Length = 0.030000
name = RS422
quantity = 1
parent = 1
materialID = 23
type = Box
```

```
Aero Mass = 0.000010
Thermal Mass = 0.000010
Diameter/Width = 0.002850
Length = 0.003150
Height = 0.000780
name = Spool_Core_v3
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.040243
Thermal Mass = 0.040243
Diameter/Width = 0.030000
Length = 0.030000
name = Tall_bottom_capacitor
quantity = 2
parent = 1
materialID = 40
type = Cylinder
Aero Mass = 0.000058
Thermal Mass = 0.000058
Diameter/Width = 0.002500
Length = 0.004500
name = Standoff_2_56_5_8_Hex_Female_Al_91780A612
quantity = 4
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.000251
Thermal Mass = 0.000251
Diameter/Width = 0.005000
Length = 0.005000
name = DF13A-8P-1.25H_
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.000124
Thermal Mass = 0.000124
Diameter/Width = 0.001070
Length = 0.096390
Height = 0.001070
name = Nozzle_Power_Lead
quantity = 2
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.000047
Thermal Mass = 0.000047
Diameter/Width = 0.004060
Length = 0.004060
name = End_Plate_Blank
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.093306
Thermal Mass = 0.093306
Diameter/Width = 0.092000
Length = 0.092000
```

```
name = 0824_M_012_Motor
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.006347
Thermal Mass = 0.006347
Diameter/Width = 0.007740
Length = 0.021210
name = Heater_Cartridge_H050-15-24-01_.5in
quantity = 1
parent = 1
materialID = 1
type = Cylinder
Aero Mass = 0.000397
Thermal Mass = 0.000397
Diameter/Width = 0.003220
Length = 0.012700
name = Spool_Face_Nozzleside
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.046072
Thermal Mass = 0.046072
Diameter/Width = 0.045000
Length = 0.154870
Height = 0.002450
name = RTD_HEL-707
quantity = 1
parent = 1
materialID = 1
type = Cylinder
Aero Mass = 0.000119
Thermal Mass = 0.000119
Diameter/Width = 0.006160
Length = 0.006350
name = Housing_92mm
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.270085
Thermal Mass = 0.270085
Diameter/Width = 0.092000
Length = 0.100000
Height = 0.092000
name = Large_Inductor
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.002619
Thermal Mass = 0.002619
Diameter/Width = 0.006650
Length = 0.010100
name = Spool_End_Unspool_side
quantity = 1
parent = 1
materialID = 8
```

```
type = Cylinder
Aero Mass = 0.023108
Thermal Mass = 0.023108
Diameter/Width = 0.067160
Length = 0.067160
name = PCB_updated
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.003576
Thermal Mass = 0.003576
Diameter/Width = 0.030000
Length = 0.055880
Height = 0.001500
name = Tantalum Cap _updated
quantity = 3
parent = 1
materialID = 23
type = Cylinder
Aero Mass = 0.000296
Thermal Mass = 0.000296
Diameter/Width = 0.006600
Length = 0.008000
name = Motor_Clamp_v2
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.002865
Thermal Mass = 0.002865
Diameter/Width = 0.005450
Length = 0.035720
Height = 0.005450
name = Heater Switch
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.000043
Thermal Mass = 0.000043
Diameter/Width = 0.003880
Length = 0.005150
Height = 0.001540
name = Delrin Propellant
quantity = 1
parent = 1
materialID = 76
type = Box
Aero Mass = 0.430000
Thermal Mass = 0.430000
Diameter/Width = 0.067000
Length = 0.085000
Height = 0.067000
name = Transformer_VPH5_0155_R_Vectoring
quantity = 1
parent = 1
materialID = 19
type = Box
Aero Mass = 0.024021
```

```
Thermal Mass = 0.024021
Diameter/Width = 0.021000
Length = 0.028800
Height = 0.007940
name = Spacer_M2_5_13mm_94669A106
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.000357
Thermal Mass = 0.000357
Diameter/Width = 0.002000
Length = 0.045000
name = Bulkhead_PCB_Electronics_to_Caps
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.025169
Thermal Mass = 0.025169
Diameter/Width = 0.080000
Length = 0.220000
Height = 0.001000
name = Spacer_M2_5_8mm_94669A102
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.000220
Thermal Mass = 0.000220
Diameter/Width = 0.002000
Length = 0.030000
name = Insulator_Conical_v1
quantity = 1
parent = 1
materialID = 40
type = Cylinder
Aero Mass = 0.023803
Thermal Mass = 0.023803
Diameter/Width = 0.025000
Length = 0.099260
name = Bulkhead_AL_Caps_to_exterior
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.092644
Thermal Mass = 0.092644
Diameter/Width = 0.079230
Length = 0.217000
name = Vishay_Cap
quantity = 1224
parent = 1
materialID = 40
type = Box
Aero Mass = 0.000467
Thermal Mass = 0.000467
Diameter/Width = 0.006000
Length = 0.010000
Height = 0.003000
```

```
name = Barrier_PCB_Electronics
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.050596
Thermal Mass = 0.050596
Diameter/Width = 0.080000
Length = 0.210000
Height = 0.002500
name = Bulkhead_AL_Electronics_to_Caps
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.085839
Thermal Mass = 0.085839
Diameter/Width = 0.074350
Length = 0.217000
name = CapHolder_CATHODE_SIDE_B
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.019487
Thermal Mass = 0.019487
Diameter/Width = 0.058720
Length = 0.104140
Height = 0.001180
name = Idler_mount
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.010877
Thermal Mass = 0.010877
Diameter/Width = 0.032000
Length = 0.035010
Height = 0.003600
name = Small_Box_Face
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 0.017854
Thermal Mass = 0.017854
Diameter/Width = 0.046330
Length = 0.074000
Height = 0.001930
name = Bulkhead_PCB_Caps_to_exterior
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.027716
Thermal Mass = 0.027716
Diameter/Width = 0.080320
Length = 0.217000
Height = 0.009990
name = CapHolder_CATHODE_SIDE_A
```

```
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.019487
Thermal Mass = 0.019487
Diameter/Width = 0.058720
Length = 0.104140
Height = 0.001180
name = Screw_Nylon_M2x4_93840A551
quantity = 52
parent = 1
materialID = 50
type = Cylinder
Aero Mass = 0.000017
Thermal Mass = 0.000017
Diameter/Width = 0.001010
Length = 0.015210
name = Anode_with_busbar
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.010891
Thermal Mass = 0.010891
Diameter/Width = 0.020470
Length = 0.061000
name = corner_bracket
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.026461
Thermal Mass = 0.026461
Diameter/Width = 0.010380
Length = 0.094410
Height = 0.010000
name = Polyimide_Walls_Longaxis
quantity = 2
parent = 1
materialID = 50
type = Box
Aero Mass = 0.018853
Thermal Mass = 0.018853
Diameter/Width = 0.030000
Length = 0.201000
Height = 0.003000
name = Polyimide_Walls_Shortaxis
quantity = 2
parent = 1
materialID = 50
type = Box
Aero Mass = 0.007461
Thermal Mass = 0.007461
Diameter/Width = 0.033000
Length = 0.074000
Height = 0.002500
name = PEEK_Center_Support_Capbank
quantity = 8
parent = 1
```

```
materialID = 50
type = Cylinder
Aero Mass = 0.000239
Thermal Mass = 0.000239
Diameter/Width = 0.008220
Length = 0.015000
name = AM0820_Motor_gear_encoder
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.014463
Thermal Mass = 0.014463
Diameter/Width = 0.021120
Length = 0.022000
name = Example_PCB_Main
quantity = 1
parent = 1
materialID = 50
type = Box
Aero Mass = 0.042273
Thermal Mass = 0.042273
Diameter/Width = 0.065000
Length = 0.210000
Height = 0.002500
name = PEEK_insulating_ring
quantity = 2
parent = 1
materialID = 50
type = Cylinder
Aero Mass = 0.000642
Thermal Mass = 0.000642
Diameter/Width = 0.011520
Length = 0.046300
name = Cathode
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.014942
Thermal Mass = 0.014942
Diameter/Width = 0.005000
Length = 0.299160
name = Motor_Retainer_low_profile
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.002469
Thermal Mass = 0.002469
Diameter/Width = 0.017160
Length = 0.020000
Height = 0.002660
name = Contoured_Drivewheel
quantity = 2
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.003354
Thermal Mass = 0.003354
```

```
Diameter/Width = 0.009000
Length = 0.021300
name = Bulkhead_Prop_to_Electronics
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.095286
Thermal Mass = 0.095286
Diameter/Width = 0.083140
Length = 0.217000
Height = 0.001960
name = Large_Box_Face
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 0.049272
Thermal Mass = 0.049272
Diameter/Width = 0.046140
Length = 0.201000
Height = 0.001970
name = CapHolder_ANODE_SIDE_A
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.024107
Thermal Mass = 0.024107
Diameter/Width = 0.080860
Length = 0.104140
Height = 0.001060
name = Igniter_Insulator_MCM_8746K559
quantity = 2
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.000542
Thermal Mass = 0.000542
Diameter/Width = 0.011600
Length = 0.014000
name = PEEK_Corner_Support_Capbank
quantity = 4
parent = 1
materialID = 50
type = Box
Aero Mass = 0.000718
Thermal Mass = 0.000718
Diameter/Width = 0.015000
Length = 0.018650
Height = 0.002290
name = Electronics_Column
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.207032
Thermal Mass = 0.207032
Diameter/Width = 0.086940
Length = 0.217000
```

```
name = Bulkhead_Prop_to_Exterior
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.134117
Thermal Mass = 0.104117
Diameter/Width = 0.090200
Length = 0.217000
Height = 0.001970
name = Motherboard
quantity = 1
parent = 101
materialID = 23
type = Flat Plate
Aero Mass = 0.030000
Thermal Mass = 0.030000
Diameter/Width = 0.061000
Length = 0.063000
name = Solar Panel DB Enclosure
quantity = 2
parent = 1
materialID = 1
type = Box
Aero Mass = 0.013240
Thermal Mass = 0.010740
Diameter/Width = 0.035000
Length = 0.052000
Height = 0.008000
name = SP DB
quantity = 2
parent = 103
materialID = 23
type = Box
Aero Mass = 0.002500
Thermal Mass = 0.002500
Diameter/Width = 0.031000
Length = 0.031000
Height = 0.007500
name = Bus DB Enclosure
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.014500
Thermal Mass = 0.012000
Diameter/Width = 0.036000
Length = 0.036000
Height = 0.012000
name = Bus DB
quantity = 3
parent = 105
materialID = 23
type = Box
Aero Mass = 0.002500
Thermal Mass = 0.002500
Diameter/Width = 0.031000
Length = 0.031000
Height = 0.007500
name = Insulating_HV_Interconnect
```

```
quantity = 2
parent = 1
materialID = 50
type = Box
Aero Mass = 0.005435
Thermal Mass = 0.005435
Diameter/Width = 0.025000
Length = 0.058110
Height = 0.003340
name = Motor_lower_bracket
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.021447
Thermal Mass = 0.021447
Diameter/Width = 0.045000
Length = 0.052240
name = Teflon_Propellant_FPPT_1_7
quantity = 1
parent = 1
materialID = 64
type = Box
Aero Mass = 1.047232
Thermal Mass = 1.047232
Diameter/Width = 0.127000
Length = 0.171230
Height = 0.021890
name = Misc Fasteners etc
quantity = 213
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.000683
Thermal Mass = 0.000683
Diameter/Width = 0.007000
Length = 0.018400
name = MB Enclosure
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.032000
Thermal Mass = 0.032000
Diameter/Width = 0.067000
Length = 0.070000
Height = 0.015000
**************OUTPUT****
Item Number = 1
name = DUPLEX
Demise Altitude = 77.993637
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = 3x2U CubeSat Chassis
Demise Altitude = 77.117558
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = NSL EPS
```

```
Demise Altitude = 74.590046
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = EPS Battery Packs
Demise Altitude = 77.152797
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Extra Battery Packs
Demise Altitude = 77.152797
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Extra Battery PCB
Demise Altitude = 77.421402
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Flight Processor
Demise Altitude = 76.883505
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = EyeStar-S3
Demise Altitude = 77.155229
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = EyeStar-D2
Demise Altitude = 76.565859
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = S3 Antenna
Demise Altitude = 76.904879
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = D2 Antenna
Demise Altitude = 76.371193
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Black Box - Patch
Demise Altitude = 75.936511
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = FP + S3 Carrier PCB
Demise Altitude = 77.422767
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = 1U Solar Array
Demise Altitude = 77.548189
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = 3x2U Fixed Solar Array
```

```
Demise Altitude = 77.313311
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = 3x2U Deploy Solar Array
Demise Altitude = 77.353046
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Burn PCB
Demise Altitude = 77.405561
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = PIN Diode
Demise Altitude = 77.235343
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = NSL IMU
Demise Altitude = 77.702816
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Sep Switches
Demise Altitude = 77.401822
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = RBF Switch Assembly
Demise Altitude = 77.638478
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Diag Assembly
Demise Altitude = 77.344185
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Fasteners / Spacers
Demise Altitude = 76.721549
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Cabling
Demise Altitude = 76.902473
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = NovAtel OEM 719
Demise Altitude = 77.178753
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = GPS Antenna
Demise Altitude = 75.508563
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Extra Mass
```

```
Demise Altitude = 71.985579
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS - Reaction Wheel Housings
Demise Altitude = 76.870664
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS - Reaction Wheels
Demise Altitude = 69.674565
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS - Magnetic Torque Rods
Demise Altitude = 75.788528
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS Frame
Demise Altitude = 77.039930
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS Star Tracker
Demise Altitude = 73.395541
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS Star Tracker Baffle
Demise Altitude = 75.814092
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = ADCS Housing
Demise Altitude = 76.381338
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = RM3000
Demise Altitude = 77.433064
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Cabling (26 AWG 7/34)
Demise Altitude = 77.902280
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Nozzle_Flight_3
Demise Altitude = 77.003391
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = DF13C-4P-1.25V_
Demise Altitude = 77.982664
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Microcontroller
```

```
Demise Altitude = 77.924560
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = 527451297
Demise Altitude = 77.947008
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Anti_Snag_Guide_v2
Demise Altitude = 77.705849
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = c82
Demise Altitude = 77.753436
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_Internal
Demise Altitude = 0.000000
Debris Casualty Area = 0.302476
Impact Kinetic Energy = 0.410541
************************************
name = Heater_Block_Flight_3
Demise Altitude = 76.948209
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = DF13C-8P-1.25V_
Demise Altitude = 77.930624
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Ceramic_Nz_Mount_2
Demise Altitude = 0.000000
Debris Casualty Area = 0.308201
Impact Kinetic Energy = 2.093398
************************************
name = Motor Controller
Demise Altitude = 77.951628
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Inductor 3.3v
Demise Altitude = 77.495611
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Spool_Center_Tube_wirerouting_simple
Demise Altitude = 76.616773
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = RS422
Demise Altitude = 77.950267
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Spool_Core_v3
```

```
Demise Altitude = 76.970660
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Tall_bottom_capacitor
Demise Altitude = 77.812817
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Standoff_2_56_5_8_Hex_Female_Al_91780A612
Demise Altitude = 77.875966
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = DF13A-8P-1.25H_
Demise Altitude = 77.982328
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Nozzle_Power_Lead
Demise Altitude = 77.959733
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = End_Plate_Blank
Demise Altitude = 77.393114
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = 0824_M_012_Motor
Demise Altitude = 76.761774
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Heater_Cartridge_H050-15-24-01_.5in
Demise Altitude = 76.422797
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Spool_Face_Nozzleside
Demise Altitude = 77.699029
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = RTD_HEL-707
Demise Altitude = 77.731348
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Housing_92mm
Demise Altitude = 77.304313
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Large_Inductor
Demise Altitude = 76.940904
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Spool_End_Unspool_side
```

```
Demise Altitude = 77.830622
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = PCB_updated
Demise Altitude = 77.889742
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Tantalum Cap _updated
Demise Altitude = 77.793656
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Motor_Clamp_v2
Demise Altitude = 77.783461
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Heater Switch
Demise Altitude = 77.938625
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Delrin Propellant
Demise Altitude = 76.849858
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Transformer_VPH5_0155_R_Vectoring
Demise Altitude = 76.354235
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Spacer_M2_5_13mm_94669A106
Demise Altitude = 77.934823
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_PCB_Electronics_to_Caps
Demise Altitude = 77.902116
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Spacer_M2_5_8mm_94669A102
Demise Altitude = 77.941355
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Insulator_Conical_v1
Demise Altitude = 77.176961
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_AL_Caps_to_exterior
Demise Altitude = 77.758564
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Vishay_Cap
```

```
Demise Altitude = 77.617555
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Barrier_PCB_Electronics
Demise Altitude = 77.772820
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_AL_Electronics_to_Caps
Demise Altitude = 77.765105
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = CapHolder_CATHODE_SIDE_B
Demise Altitude = 77.850155
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Idler_mount
Demise Altitude = 77.678652
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Small_Box_Face
Demise Altitude = 77.784411
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_PCB_Caps_to_exterior
Demise Altitude = 77.898629
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = CapHolder_CATHODE_SIDE_A
Demise Altitude = 77.850155
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Screw_Nylon_M2x4_93840A551
Demise Altitude = 77.980351
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Anode_with_busbar
Demise Altitude = 77.570008
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = corner_bracket
Demise Altitude = 77.544238
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Polyimide_Walls_Longaxis
Demise Altitude = 77.811883
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Polyimide_Walls_Shortaxis
```

```
Demise Altitude = 77.844060
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = PEEK_Center_Support_Capbank
Demise Altitude = 77.950418
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = AM0820_Motor_gear_encoder
Demise Altitude = 76.833008
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Example_PCB_Main
Demise Altitude = 77.772837
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = PEEK_insulating_ring
Demise Altitude = 77.969485
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Cathode
Demise Altitude = 77.816865
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Motor_Retainer_low_profile
Demise Altitude = 77.803926
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Contoured_Drivewheel
Demise Altitude = 76.845987
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_Prop_to_Electronics
Demise Altitude = 77.705948
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Large_Box_Face
Demise Altitude = 77.732303
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = CapHolder_ANODE_SIDE_A
Demise Altitude = 77.850251
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Igniter_Insulator_MCM_8746K559
Demise Altitude = 77.869792
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = PEEK_Corner_Support_Capbank
```

```
Demise Altitude = 77.902661
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Electronics_Column
Demise Altitude = 77.500380
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bulkhead_Prop_to_Exterior
Demise Altitude = 77.698514
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Motherboard
Demise Altitude = 76.727133
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Solar Panel DB Enclosure
Demise Altitude = 0.000000
Debris Casualty Area = 0.650209
Impact Kinetic Energy = 1.672578
************************************
name = SP DB
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bus DB Enclosure
Demise Altitude = 77.344291
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Bus DB
Demise Altitude = 77.138218
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Insulating_HV_Interconnect
Demise Altitude = 77.830911
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Motor_lower_bracket
Demise Altitude = 77.731938
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Teflon_Propellant_FPPT_1_7
Demise Altitude = 75.738504
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = Misc Fasteners etc
Demise Altitude = 77.679198
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
name = MB Enclosure
```

```
Demise Altitude = 77.328633
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
************************************
=============== End of Requirement 4.7-1 ===============
```