DARTMOUTH
Report Version: 1
Dec 22, 2020

Exhibit 6: REAL Orbital Debris Assessment Report (ODAR)

This report describes the analysis performed to assess orbital debris for the Dartmouth College Relativistic Electron Atmospheric Loss (REAL) CubeSat. Table 1 in Section 1 shows a summary of analysis results. The analysis demonstrates compliance with requirements established by the NASA Orbital Debris Program Office (OPDO). REAL will be launched on a rideshare launch, thus this report does not include analysis of potential debris from the launch vehicle.

The analysis performed for this report used the Debris Assessment Software (DAS) version 3.0.1 provided by the NASA OPDO at Johnson Space Center (JSC) and follows the requirement structure of NASA-STD 8719.14B, *Process for Limiting Orbital Debris*. This analysis complies with the methodology described in Section 4.2.6 of NS 8719.14B.

Record of Revisions		
Rev.	**Description**	**Date**
0	Original Submission	8/2/20
1	Corrected cut/paste error (missing input information) in DAS log (appendix); added UHF antenna to DAS analysis, Figure 1 replaced with results from new DAS 4.7-1 run.	12/22/20

Section 1: Program Management and Mission Overview

A complete description of the REAL mission is provided in Exhibit 1 of the REAL STA Application. A brief summary is provided here (see Section 2 for spacecraft description).

REAL is sponsored by a research grant from the Science Mission Directorate, Heliophysics Division, at NASA Headquarters. Responsible program/project manager and senior scientific and management personnel are as follows:

Prof. Robyn Millan, Dartmouth College, Principal Investigator
Dr. Leslie Woodger, Dartmouth College, Project Manager

The Dartmouth satellite, REAL, has not received support of any form from any foreign government or space agency.

REAL has been designed without propulsion and has no pressure vessels on-board, and there are no plans to intentionally release debris during nominal satellite operation. Before launch, Dartmouth will designate a point of contact for receiving JSpOC conjunction assessments, and plans for collision avoidance activities will be developed if necessary. REAL does have the ability, upon receipt of a ground command, to orient itself at a given attitude in order to vary its cross-sectional area in the vector of motion.

Table 1 below summarizes the compliance status of REAL.

Table 1: Orbital Debris Requirement Compliance Matrix

Requirement	**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	On board energy source (batteries) incapable of debris-producing failure
4.4-2	Compliant	On board energy source (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	
4.5-2	Not applicable	Passive disposal
4.6-1	Compliant	Disposal via atmospheric re-entry (method a) with worst-case lifetime 3.7 yrs
4.6-2	Not applicable	
4.6-3	Not applicable	
4.6-4	Not applicable	Passive disposal
4.7-1	Compliant	Non-credible risk of human casualty
4.8-1	Not applicable	No planned tether release

Section 2: Spacecraft Description

REAL is a 3-axis controlled, 3U CubeSat designed for use in a low earth orbit (LEO) with two deployed solar arrays. There is also a deployed UHF antenna and a fixed S-band patch antenna. The total spacecraft mass (and dry mass) is 4.24 kg. The dimensions of the 3U spacecraft are 10.84 cm x 11.3 cm x 34.05 cm in the stowed configuration. When fully deployed, the UHF antenna extends approximately 16.88 cm height and 0.59 cm width, the two deployed solar arrays have a structural dimension of 16.6 cm x 31.05 cm each.

The CubeSat structure is made of Aluminum 6061. The 3-axis inertial pointing system contains three reaction wheel assemblies, three torque rods, a single miniaturized star tracker, two sun sensors and a processor board. The REAL bus battery is a 335-gram, 40 Watt-hr Clyde Space Optimus lithium polymer battery assembly with over-charge/current protection circuitry.

The REAL instrument includes Si solid state detectors and an electrostatic analyzer. All sensors on REAL are passive and there are no lasers, propellants, radioactive, pyrotechnic devices, pressure vessels, or other hazardous materials on board the spacecraft.

Section 3: Assessment of Spacecraft Debris Released during Normal Operations

The assessment of spacecraft debris for requirements 4.3-1a,b and 4.3-2 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.

There are no plans to intentionally release debris during nominal satellite operation for the REAL CubeSat, therefore this section is not applicable.

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

There are no plans for designed breakups, explosions, or intentional collisions for REAL.

REAL's battery charge circuits include overcharge protection to limit the risk of battery failure. The probability of battery explosion is thus very low. Moreover, due to the very small mass of the CubeSat and short orbital lifetime, the effect of an explosion on the far-term LEO environment is negligible. Thus REAL is compliant with requirement 4.4-1 to limit the risk of accidental explosion.

The battery meets requirement 4.4-2 for end of mission passivation by virtue of the NASA HQ OSMA policy regarding CubeSat battery disconnect stating; *“CubeSats as a satellite class need*

not disconnect their batteries if flown in LEO with orbital lifetimes less than 25 years." Due to short duration (3.7 years maximum, see Section 6) of the mission before passive reentry and burn up, the lithium polymer battery used for the REAL CubeSat is deemed not necessary to passivate for EOM.

Requirements 4.4-3 and 4.4-4 to limit the risk of planned breakups are not applicable since there are no planned breakups for the REAL CubeSat mission.

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

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 was carried out using DAS v3.0.1, and calculation methods provided in NASA-STD-8719.14, Section 4.5.4.

Requirement 4.5-1: Limiting debris generated by collisions with large objects when operating in Earth orbit: *"For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001. "*

Large Object Impact and Debris Generation Probability (DAS 3.0.1):
Collision Probability: 0.00000; COMPLIANT.

Requirement 4.5-2: Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit: "*For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post-mission disposal requirements is less than 0.01."*

Requirement 4.5-2 is not applicable for the REAL mission because REAL uses a passive mission disposal method. There are no vital subsystems for post-mission disposal, since the satellite's orbit will naturally decay within 1.9 years in the nominal case and 3.7 years in the worst case scenario (see Section 6 below).

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

Description of Spacecraft Disposal Option Selected: REAL will de-orbit naturally by atmospheric re-entry in 1.9 years (nominal case) and within 3.7 years in the worst case scenario, as shown in the Lifetime Analysis section below. This satisfies requirement 4.6-1 via method a, highlighted in blue below.

Requirement 4.6-1: Disposal for Space Structures Passing Through LEO:
A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods:
a. Atmospheric Re-Entry Option:

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

b. Storage Orbit Option:

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

c. Direct Retrieval:

- *Retrieve the space structure and remove it from orbit within 10 years after completion of mission.*

Plan for Any Spacecraft Maneuvers Required to Accomplish Post-Mission Disposal: No maneuvers are required. The passive disposal method will be used.

Description of Lifetime Analysis:

The analysis was carried out using DAS v3.0.1. An initial orbit of 550 x 550 km altitude and 90.0 degrees inclination was input into the DAS software to determine the orbital lifetime. The DAS software was also used to calculate the cross sectional area of the spacecraft for random tumbling. A detailed mass budget was used to accurately estimate the fully integrated spacecraft mass. Random tumbling was selected because neither the nadir direction nor the velocity vector will be maintained throughout the duration of the mission. During operations, when REAL is in view of the earth station it will track the earth station, and when not in view of the earth station, REAL will orient along Earth's magnetic field (for science data collection) or will orient itself to align the solar arrays with the sun.

Two configurations were analyzed: 1) a nominal deployed configuration, in which both the solar arrays deploy, and 2) a stowed configuration, in which the solar arrays are stowed . The stowed

configuration is highly unlikely, and would only exist in the event of an anomaly. Table 2 provides a summary of the geometry and orbital lifetime calculations for both configurations..

Configuration	Cross-sectional Area (m^2)	Area to Mass Ratio (m^2/kg)	Orbital Lifetime (years)
Fully Deployed	0.0792	0.0187	1.895
Fully Stowed	0.0438	0.0103	3.723

Table 2: Summary of geometry and orbital lifetime for two configurations. Fully stowed configuration is the worst case scenario and occurs only in the event of an anomaly (failure of solar panel deployment).

The worst-case orbit dwell time is 3.7 years (stowed configuration), which only happens in the event of an anomaly (solar panels fail to deploy). Thus REAL meets the requirement even in the worst-case. However, the plan is to re-enter in the fully deployed configuration, which has an orbital lifetime of 1.9 years. Due to the uncertainty in CubeSat launch availability, additional sun synchronous orbits were also analyzed. Re-entry within 25 years occurs up to an altitude of 650 km for the worst-case stowed configuration (which only happens in the event of an anomaly). Therefore, we will ensure that REAL is not deployed above 650 km.

Requirement 4.6-2: Disposal for Space Structures Near GEO:
Analysis: Not Applicable.

Requirement 4.6-3: Disposal for Space Structures Between LEO and GEO:
Analysis: Not Applicable.

Requirement 4.6-4: Reliability of Post-Mission Disposal Operations:
Analysis: Not Applicable.

Section 7: Assessment of Spacecraft Reentry Hazards

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

The risk of human casualty was analyzed using DAS v3.0.1. The analysis demonstrates compliance with requirement 4.7-1. All major spacecraft components were included in the analysis, including structural components, battery components, solar panels, radios, antenna, and instrument components. The inputs to the DAS object tree (spacecraft model) are shown in

the DAS log file in the appendix. These were nested according to the DAS Users Guide to provide a realistic reentry model and used the standard materials database provided in the application.

Summary of Analysis Results: Numerical results for the risk of human casualty for the total mission is shown in Figure 1. The risk of human casualty is "1:100000000" and the total casualty area is 0 m^2. The analysis demonstrates that the spacecraft and all of its internal components oblate with a negligible risk and that REAL is compliant with Requirement 4.7-1.

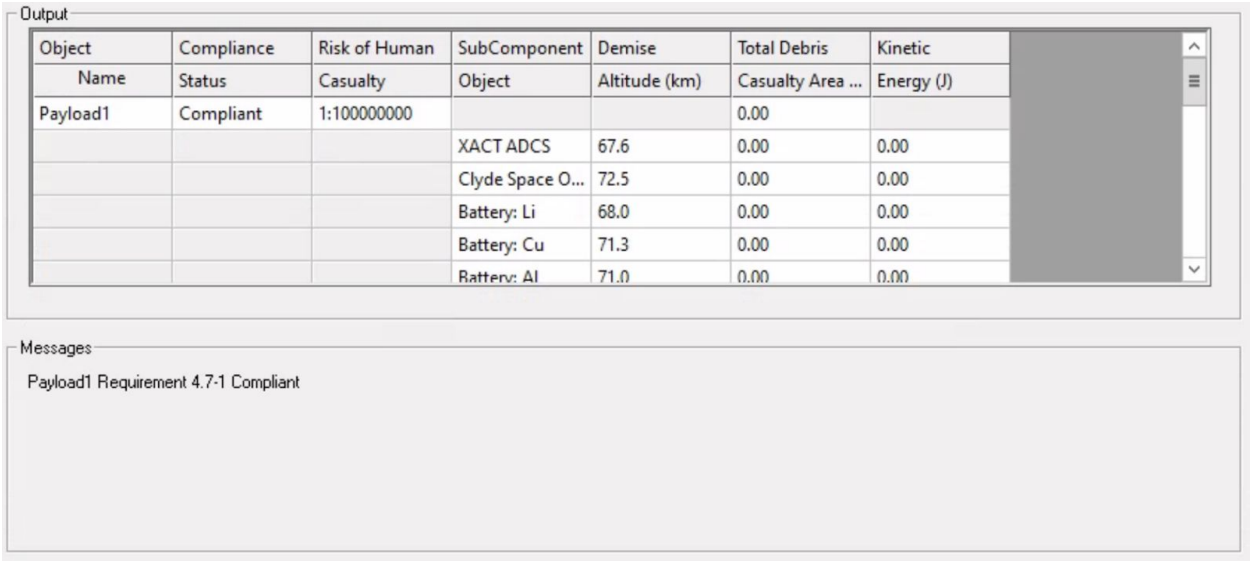

Figure 1: REAL risk of human casualty from DAS v3.0.1 analysis.

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

Requirement 4.7-1, b:
For controlled re-entry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign land masses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627).
Analysis: Not Applicable.

Requirement 4.7-1, c):
For controlled re-entries, the product of the probability of failure of the re-entry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled re-entry shall not exceed 0.0001 (1:10,000) (Requirement 56628))
Analysis: Not Applicable.

Section 8: Assessment for Tether Missions

Not applicable. There are no tethers in the REAL mission.

Summary

An orbital debris analysis showed that the REAL 3U CubeSat mission is compliant with the applicable requirements for spacecraft disposal and risk to human casualty contained in NASA STD 8719.14B. The analysis used Debris Assessment Software (DAS v3.0.1) provided by the NASA ODPO and followed the requirement structure of the Process for Limiting Orbital Debris, NASA-STD 8719.14B.

On November 1, 2021, REAL will be launched into a 550 km altitude, 90 degree inclination orbit and spacecraft disposal is accomplished through atmospheric reentry. The REAL spacecraft is estimated to reenter in 1.9 years (fully deployed configuration). Thus, REAL is compliant with the requirement to reenter the atmosphere within 25 years after mission completion or 30 years after launch.

REAL meets all applicable requirements for the process of limiting orbital debris.

Appendix

DAS 3.0.1 REQUIREMENTS FOR DEPLOYED (NOMINAL CASE) AND UNDEPLOYED (WORST CASE SCENARIO) CUBESAT

==========
ANALYSIS OF WORST CASE SCENARIO
==========

========== End of Requirement 4.3-1 ==========
05 20 2020; 00:48:16AM Processing Requirement 4.3-2: Return Status : Passed

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

========== End of Requirement 4.3-2 ========== 05 20 2020; 01:12:40AM Processing Requirement 4.5-1: Return Status : Passed

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

Space Structure Name = Payload 1
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 90.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0103 (m^2/kg)
Start Year = 2021.830 (yr)
Initial Mass = 4.239 (kg)
Final Mass = 4.239 (kg)
Duration = 0.500 (yr)
Station-Kept = False
Abandoned = True

OUTPUT
Collision Probability = 2.6920E-07
Returned Message: Normal Processing

Date Range Message: Normal Date Range
Status = Pass

==========

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

05 20 2020; 01:12:55AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = Payload 1
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 90.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.010331 (m^2/kg)
Start Year = 2021.830000 (yr)
Initial Mass = 4.239000 (kg)
Final Mass = 4.239000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 541.132377 (km)
PMD Apogee Altitude = 541.132377 (km)
PMD Inclination = 89.996540 (deg)
PMD RAAN = 359.910118 (deg)
PMD Argument of Perigee = 48.057956 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 541.132377 (km)
Suggested Apogee Altitude = 541.132377 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2025 (yr)
Requirement = 61
Compliance Status = Pass

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

==========
ANALYSIS OF NOMINAL CASE
==========

05 20 2020; 01:13:50AM Mission Editor Changes Applied
05 20 2020; 01:13:50AM Project Data Saved To File

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

========== End of Requirement 4.3-1 ========== 05 20 2020; 01:13:58AM Processing Requirement 4.3-2: Return Status : Passed

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

========== End of Requirement 4.3-2 ========== 05 20 2020; 01:34:52AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Payload 1
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (km)
Inclination = 90.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)

Final Area-To-Mass Ratio = 0.0187 (m^2/kg)
Start Year = 2021.830 (yr)
Initial Mass = 4.239 (kg)
Final Mass = 4.239 (kg)
Duration = 0.500 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 2.6082E-07
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==========

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

12 21 2020; 06:31:43AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = Payload1
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 90.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.017797 (m^2/kg)
Start Year = 2021.830000 (yr)
Initial Mass = 4.246000 (kg)
Final Mass = 4.246000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = True

```
      PMD Perigee Altitude = 527.110527 (km)
      PMD Apogee Altitude = 540.426909 (km)
      PMD Inclination = 89.995471 (deg)
      PMD RAAN = 359.900194 (deg)
      PMD Argument of Perigee = 23.374163 (deg)
      PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

      Suggested Perigee Altitude = 527.110527 (km)
      Suggested Apogee Altitude = 540.426909 (km)
      Returned Error Message = Passes LEO reentry orbit criteria.

      Released Year = 2023 (yr)
      Requirement = 61
      Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
12 21 2020; 06:31:44AM *********Processing Requirement 4.7-1
      Return Status :  Passed

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

name = Payload1
quantity = 1
parent = 0
materialID = 8
type = Box
Aero Mass = 4.246000
Thermal Mass = 4.246000
Diameter/Width = 0.113000
Length = 0.340500
Height = 0.108400

name = XACT ADCS
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.910000
Thermal Mass = 0.910000
Diameter/Width = 0.100000
```

```
Length = 0.100000
Height = 0.050000

name = Clyde Space Optimus-40 40 Wh Battery
quantity = 1
parent = 1
materialID = -4
type = Box
Aero Mass = 0.643500
Thermal Mass = 0.351000
Diameter/Width = 0.090170
Length = 0.095890
Height = 0.025600

name = Battery: Li
quantity = 1
parent = 3
materialID = -4
type = Box
Aero Mass = 0.175500
Thermal Mass = 0.175500
Diameter/Width = 0.090170
Length = 0.095890
Height = 0.005074

name = Battery: Cu
quantity = 1
parent = 3
materialID = 19
type = Box
Aero Mass = 0.058500
Thermal Mass = 0.058500
Diameter/Width = 0.090170
Length = 0.095890
Height = 0.001135

name = Battery: Al
quantity = 1
parent = 3
materialID = 8
type = Box
Aero Mass = 0.058500
Thermal Mass = 0.058500
Diameter/Width = 0.090170
Length = 0.095890
```

```
Height = 0.002506

name = UHF Transceiver
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.044000
Thermal Mass = 0.044000
Diameter/Width = 0.032000
Length = 0.062000
Height = 0.008830

name = S-band transceiver
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.056700
Thermal Mass = 0.056700
Diameter/Width = 0.031750
Length = 0.086360
Height = 0.007620

name = Structure - ADCS Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.037216
Thermal Mass = 0.037216
Diameter/Width = 0.100000
Length = 0.100000

name = Structure - ADCS Bracket
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.035041
Thermal Mass = 0.035041
Diameter/Width = 0.098000
Length = 0.098000

name = Structure - ADCS-to-rods plate
```

quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.025247
Thermal Mass = 0.025247
Diameter/Width = 0.093940
Length = 0.093940

name = Structure - Collimator Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.034281
Thermal Mass = 0.034281
Diameter/Width = 0.093940
Length = 0.093940

name = GPS antenna
quantity = 1
parent = 1
materialID = -3
type = Cylinder
Aero Mass = 0.016000
Thermal Mass = 0.016000
Diameter/Width = 0.045200
Length = 0.045200

name = Solar Array Left Interface Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.059200
Thermal Mass = 0.059200
Diameter/Width = 0.081000
Length = 0.307300

name = Solar Array Right Interface Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.066500

```
Thermal Mass = 0.066500
Diameter/Width = 0.081000
Length = 0.307300

name = Solar Array Panels
quantity = 4
parent = 1
materialID = 24
type = Flat Plate
Aero Mass = 0.125180
Thermal Mass = 0.125180
Diameter/Width = 0.081000
Length = 0.310500

name = Instrument - collimator
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.382880
Thermal Mass = 0.382880
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.014180

name = UHF Antenna
quantity = 1
parent = 1
materialID = -1
type = Box
Aero Mass = 0.000980
Thermal Mass = 0.000980
Diameter/Width = 0.005900
Length = 0.168800
Height = 0.000125

name = Structure-Outer
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.311000
Thermal Mass = 0.311000
Diameter/Width = 0.100000
Length = 0.280000
```

```
Height = 0.100000

name = ESA (1)
quantity = 1
parent = 1
materialID = 66
type = Box
Aero Mass = 0.012900
Thermal Mass = 0.012900
Diameter/Width = 0.019990
Length = 0.064998
Height = 0.008788

name = ESA (2)
quantity = 2
parent = 1
materialID = 66
type = Box
Aero Mass = 0.004018
Thermal Mass = 0.004018
Diameter/Width = 0.011990
Length = 0.034340
Height = 0.007493

name = ESA (3)
quantity = 1
parent = 1
materialID = 66
type = Box
Aero Mass = 0.013560
Thermal Mass = 0.013560
Diameter/Width = 0.019990
Length = 0.064998
Height = 0.010670

name = SSDs
quantity = 6
parent = 1
materialID = -2
type = Box
Aero Mass = 0.009400
Thermal Mass = 0.009400
Diameter/Width = 0.046000
Length = 0.068000
Height = 0.001187
```

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

name = Payload1
Demise Altitude = 77.994057
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = XACT ADCS
Demise Altitude = 67.568306
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Clyde Space Optimus-40 40 Wh Battery
Demise Altitude = 72.452095
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Battery: Li
Demise Altitude = 67.960457
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Battery: Cu
Demise Altitude = 71.308800
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Battery: Al
Demise Altitude = 70.970482
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = UHF Transceiver
Demise Altitude = 75.632507
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
```

```
************************************
name = S-band transceiver
Demise Altitude = 75.595200
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Structure - ADCS Plate
Demise Altitude = 77.176712
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Structure - ADCS Bracket
Demise Altitude = 77.201767
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Structure - ADCS-to-rods plate
Demise Altitude = 77.390274
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Structure - Collimator Plate
Demise Altitude = 77.169266
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = GPS antenna
Demise Altitude = 0.000000
Debris Casualty Area = 0.416283
Impact Kinetic Energy = 1.143978

************************************
name = Solar Array Left Interface Plate
Demise Altitude = 77.416435
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Solar Array Right Interface Plate
Demise Altitude = 77.338867
```

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Solar Array Panels
Demise Altitude = 77.598213
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Instrument - collimator
Demise Altitude = 71.275108
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = UHF Antenna
Demise Altitude = 0.000000
Debris Casualty Area = 0.387569
Impact Kinetic Energy = 0.021636

****
name = Structure-Outer
Demise Altitude = 76.766403
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ESA (1)
Demise Altitude = 0.000000
Debris Casualty Area = 0.397634
Impact Kinetic Energy = 2.325394

****
name = ESA (2)
Demise Altitude = 0.000000
Debris Casualty Area = 0.764565
Impact Kinetic Energy = 0.639556

****
name = ESA (3)
Demise Altitude = 0.000000
Debris Casualty Area = 0.398876
Impact Kinetic Energy = 2.475865

```
************************************
name = SSDs
Demise Altitude = 0.000000
Debris Casualty Area = 2.458018
Impact Kinetic Energy = 0.614180

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

=============== End of Requirement 4.7-1 ===============
12 21 2020; 06:31:44AM Project Data Saved To File
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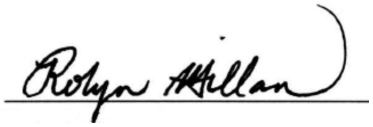
Submitted By:



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