YORK
SPACE SYSTEMS

Orbital Debris Mitigation Analysis and Plan

PExT

REVISION

Date	Rev.	Comment
09/27/2023	00	Initial Release (E.Tran)
11/15/2023	01	Added analysis results and compliance status (E.Tran)

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1 Introduction

The Inter-Agency Space Debris Coordination Committee (IADC) has provided guidelines (IADC-02-01) for mitigating the generation of space debris to reduce the risk for all space assets. They describe existing practices that have been identified and evaluated for limiting the generation of space debris in the environment. These guidelines fall in line with the U.S Government Orbital Debris Mitigation Standard Practices document as well as NASA-STD 8719.14. See Table 1 for specific relationships between relevant guidelines and objectives.

Table 1: Relation between IADC and USG standard guidelines/objectives.

IADC-02-01 Section ID	USG Orbital Debris Mitigation Standard Practices Objective ID	NASA-STD 8719.14C Requirement	Summary of Section/Objective
Section 5.1	Objective 1	Requirements 4.3	Limit debris released during normal operations
Section 5.2	Objective 2	Requirements 4.4	Minimize potential for on orbit break-ups
Section 5.3	Objective 4	Requirements 4.6 and 4.7	Post Mission Disposal Plan
Section 5.4	Objective 3	Requirements 4.5	Prevention of on-orbit collisions

The Guidelines cover the overall environmental impact of the mission with a focus on the following:

(1) Limitation of debris released during normal operations
(2) Minimization of the potential for on-orbit break-ups
(3) Post-mission disposal
(4) Prevention of on-orbit collisions

1.1 Acronyms and Abbreviations

ACS: Attitude Control Subsystem
EPS: Electrical Power Subsystem
ESA: European Space Agency
FSW: Flight Software
IADC: Inter-Agency Space Debris Coordination Committee
IF: Interface
LTAN: Local Time of Ascending Node
LV: Launch Vehicle
NASA: National Aeronautics and Space Administration
OCT: Optical Communications Terminal
RW: Reaction Wheel
Rx: Receiver
SA: Solar Array
SV: Space Vehicle
SSO: Sun-Synchronous Orbit
USG: U.S. Government

2 Applicable/Reference Documents

Agency/Organization	Document Title	Rev.	Release Date	Applicability
IADC	IADC Space Debris Mitigation Guidelines (IADC-02-01)	2	Mar-2020	Document containing referenced guidelines.
NASA	Process for Limiting Orbital Debris (NASA-STD-8719.14C)	C	Nov-2021	Document containing referenced requirements.
U.S. Government	U.S Government Orbital Debris Mitigation Standard Practices, November 2019 Update	1	2019	Document containing objectives listed in Table 1.

3 Mission Overview

3.1 Description of Mission

The spacecraft will be one of several payloads of a SpaceX Falcon-9 rocket. The spacecraft will launch into a circular SSO at 515 ± 15 km altitude and 97.40 ± 0.1-degree inclination with an LTAN of 22:30:00 ± 30 min. The nominal mission duration is 6 months.

3.2 Mitigation Plan Summary

The results of the analysis were obtained using the NASA provided tool, DAS v3.2.5, and higher fidelity software's (NASA ORDEM 3.2, MEM3) for a complete and thorough analysis where applicable. Upon completion of this analysis, it has been determined that the spacecraft is compliant with IADC guidelines and applicable NASA requirements, and it has been proven that the mission does not have:

(1) Any debris generation as part of normal operations
(2) A considerable probability for on-orbit break-ups
(3) Any probability of impacting the ground upon re-entry
(4) A considerable probability for an on-orbit collision

As such, the mitigation plan includes the following standard mitigation practices:

(1) Spacecraft is designed not to release any debris during normal operations
(2) There is no credible failure mode that results in explosion and all onboard sources of stored energy will be depleted or safed once they are no longer needed for operations
(3) Spacecraft will be disposed of via the atmospheric re-entry method and proven to have negligible remaining kinetic energy.
(4) Spacecraft mission profile inherently limits the probability of on-orbit collision

4 Assessment Report Format

The following report directly addresses each sub-section under section 5 - Mitigation Measures found in IADC-02-01. This report follows the aforementioned guidelines put forth by the IADC in conjunction with requirements presented by NASA (NASA-STD 8719.14) that ensure sufficient compliance with these guidelines. Corresponding NASA requirements that satisfy IADC guidelines are noted where applicable[1].

4.1 Limit Debris Released during Normal Operations

4.1.1 IADC section 5.1 Limit Debris Released during Normal Operations

"…spacecraft and orbital stages should be designed not to release debris during normal operations."

4.1.2 Summary of applicable NASA requirement(s)

4.1.2.1 Requirement 4.3-1. Debris passing through LEO – released debris with diameters of 1mm or larger:

- All released debris shall have a maximum orbital lifetime of 25 years.

4.1.3 Analysis

The spacecraft design does not have any debris generation as part of normal operations. There are two deployment events as part of normal operations. The deployments are:

(1) The deployment of the solar array panels from the stowed launch configuration to a fixed deployed configuration.

All deployments use non-explosive actuators to affect the release that do not generate debris. All the deployment mechanisms are designed not to generate debris during normal operations. Therefore, the lifetime of any released debris is 0 years.

4.1.4 Assessment of spacecraft compliance

- IADC Section 5.1: COMPLIANT
- NASA Requirement 4.3-1: COMPLIANT

[1] For simplicity, requirements described in NASA-STD 8719.14 and guidelines in IADC-02-01 that are not applicable to this mission have been omitted from this report.

4.2 Minimize the Potential for On-Orbit Break-ups

4.2.1 IADC section 5.2.1 Minimize the potential for post mission break-ups resulting from stored energy

"…all on-board sources of stored energy of a spacecraft or orbital stage, such as residual propellants, batteries, high-pressure vessels, self-destructive devices, flywheels and momentum wheels, should be depleted or safed when they are no longer required for mission operations or post-mission disposal."

4.2.2 Summary of applicable NASA requirement(s)

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

- Spacecraft shall have the ability and plan to deplete all onboard sources of energy when they are no longer required.

4.2.3 Analysis

(1) Residual propellants: The spacecraft is equipped with electric propulsion system that uses a single 14 mN thruster with solid zinc propellant for collision avoidance maneuvers. Upon mission completion, if there is propellant remaining, the spacecraft will not need to employ a mitigation strategy due to the inert nature of the propellant.

(2) Batteries: The battery charge control is maintained to avoid possible over-charge of the battery. The battery cells have individual safety devices to avoid over-charging and have vents to allow each cell to vent rather than rupture or explode.

(3) High-pressure vessels: There are no high-pressure vessels aboard the spacecraft.

(4) Self-destruct devices: There are no self-destruct devices aboard the spacecraft.

(5) Flywheels and momentum wheels: The spacecraft is equipped with 3 attitude control reaction wheels that will be terminated during the disposal phase by being powered off and spun down to remove all stored energy.

(6) Other: N/A

4.2.4 IADC Section 5.2.2 Minimize the potential for break-ups during operational phases

"…demonstrate, using failure mode and effects analyses or an equivalent analysis, that there is no probable failure mode leading to accidental break-ups."

4.2.5 Summary of applicable NASA requirement(s)

4.2.5.1 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:

- Demonstrate that the integrated possibility of accidental explosion is less than 0.001.

4.2.6 Analysis

1.1.1.1 *Battery*

The Li-Ion battery design contains features to mitigate against main credible failure modes. Rigorous testing and safety devices have been put in place to ensure that the probability of accidental explosion is well below 0.001.

The main failure modes associated with these Li-Ion cells that might eventually result in explosion are overcharging of the cells and a short circuit (over-current) external to the cells.

- *Overcharge Mitigation Factors*: At the battery level, battery charge management ensures that the entire overall battery voltage is maintained at or below the maximum allowable voltage. The charge limit voltage is settable by command on-orbit to allow for tailoring as needed.

In addition, at the cell level, each cell is equipped with a Current Interrupt Device (CID) that, if activated, results in a disconnect of current flow within the cell. Activation of the CID occurs when a maximum pressure level is reached. This process ensures that the battery is protected against unsafe overcharge at the cell level.

- *Over-current (short circuit) Mitigation Factors:* Each cell is equipped with a Positive Temperature Coefficient (PTC) Safety Device that, when activated, results in a decrease of the discharge current. Activation of the PTC Safety Device occurs when a short is applied on a cell and the discharge current level increases; this process results in a rise in temperature of the PTC device. In turn, a PTC temperature increase yields a resistance increase. The outcome will be a decrease in discharge current. This process ensures that the battery is protected against short circuit conditions external to the cell that result in unsafe discharge currents and possible battery over-heating.

Other failure modes resulting in battery explosion that have been identified and commonly referenced by industry are inoperable vents, crushing and excess temperatures due to environment. These three failure modes are all mitigated by proper spacecraft design, respectively: vents will not be structurally inhibited, no moving parts are within proximity to battery, spacecraft is thermally designed to maintain safe operating temperatures (10°C to 35°C).

The safety features detailed above are put in place to protect against anomalies and unsafe operation of the battery. For normal and safe operation of the battery, cell reliability has been quantifiably analyzed using publicly available data from ABSL.

Typically, Li-Ion cells have a Mean Time Between Failure (MTBF) anywhere between 2 and 200 million hours. Conservatively assuming that the Li-ion cells used in our battery have: (1) an MTBF of 50 million hours and (2) can be modeled by an exponential reliability "bathtub curve" results in a probability of failure of 0.00035. It should be noted that in the improbable case that a random failure does occur during nominal operations, the probability of it resulting in explosion will be less than 0.00035 due to the safety features described in the previous paragraphs.

1.1.1.2 *Propulsion*

There are two potential ways of a catastrophic failure modes of a typical propulsion system in orbit:

1. A direct impact and puncture of the fuel and/or oxidizer tank.

2. An extreme high temperature combined with a failure of the pressure relief valve at start of mission.

The first option is a direct impact of space debris that could lead to a failure of the tank. Depending on the nature of the impacting particle, the impact trajectory and speed, the impact location, the temperature (and thus pressure) of the tank, and the fill level of the tank, the consequences may vary. The second option will require assessment of the thermal loads onto the propulsion tanks.

For the PExT mission this potential for accidental explosion due propulsion high pressure vessels is not applicable since the systems uses an inert solid propellant system.

4.2.7 Assessment of spacecraft compliance

- IADC Section 5.2.1: COMPLIANT
- IADC Section 5.2.2: COMPLIANT
- NASA Requirement 4.4-2: COMPLIANT
- NASA Requirement 4.4-1: COMPLIANT

4.3 Post Mission Disposal

4.3.1 IADC Section 5.3.2 Objects Passing Through the LEO Region

"This IADC and some other studies and a number of existing national guidelines have found 25 years to be a reasonable and appropriate lifetime limit. If a spacecraft or orbital stage is to be disposed of by re-entry into the atmosphere, debris that survives to reach the surface of the Earth should not pose an undue risk to people or property."

4.3.2 Summary of applicable NASA requirement(s)

4.3.2.1 Requirement 4.6-1. Disposal for space structures in or passing through LEO:

- Spacecraft in LEO shall be disposed of within 25 years of completion of mission by one of three methods: atmospheric re-entry, storage orbit or direct retrieval.

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

- Spacecraft shall ensure that the planned post-mission disposal method has a probability of success no less than 0.90 at EOL.

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

- For uncontrolled re-entry of the spacecraft, the risk of human casualty shall not exceed 0.0001.

4.3.3 Analysis

(1) Spacecraft lifetime: A conservative approach was taken by assuming the smallest expected cross-sectional area, vehicle ZX plane rather than ZY plane, of 1.491 m^2 and a mass of 141.172 kg. This results in the longest possible estimated lifetime of 3.3 years. The apogee and perigee evolution of the vehicle was simulated utilizing NASA GMAT R2022a. A complete force model was incorporated to account for major space environment effects, most notably solar radiation pressure and atmospheric drag onto the vehicle. The total orbit lifetime for this mission is well within the suggested 25-year limit. See Table 2 and Figures 1 regarding this analysis.

Table 2: Orbital parameters as well as other input parameters considered in this calculation.

	Inputs
Start Year	2024.50
Perigee Alt [km]	530
Apogee Alt [km]	530
Inclination [deg]	97.365
Area to Mass ratio [m^2/kg]	0.01049

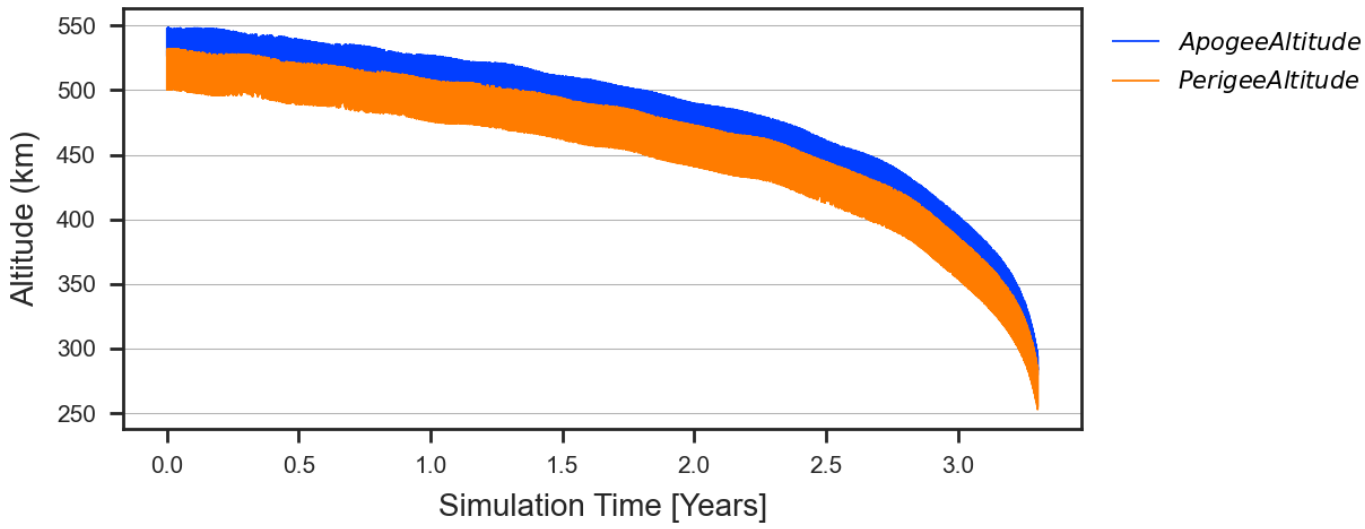

Figure 1 - Estimated orbit altitude over time with high fidelity force model in NASA GMAT R2022a

(2) Disposal Plan: Due to our 530 x 530 km orbit and subsequent calculated lifetime, the preferred de-orbit method of atmospheric re-entry will be implemented. No propellant is required to maintain a lifetime less than 25 years. As such, this disposal plan is solely dependent on the effects of atmospheric drag and completely independent of the performance of any spacecraft components (besides the overall surface area). Thus, the expected success probability is well above 0.90.

(3) Re-entry Risk: York performed a reentry risk assessment of the mission vehicle using NASA's DAS v3.2.5 software. Analysis shows that the York SV is compliant to the causality risk area requirement performing a passive uncontrolled reentry of Earth's atmosphere. Causality risk area requirement is to limit the risk of surviving components with >15 J of kinetic energy to be less than 0.0001. Results of the DAS reentry analysis are shown in Table 3.

The combined total risk of human casualty for York Sat under DAS analyses is 0.00005, which York calculated by entering the components found in Table 3 into the Input section in DAS: (Requirement 4.7-1) – Casualty Risk from Reentry Debris, see Figure 2 for a snapshot of this

analysis showing the 0.00005 risk of human casualty value (shown as 1:18000). For more detailed information on how DAS takes this information and calculates the risk of human casualty, see Debris Assessment Software User's Guide, Version 3.0, section 3.8.

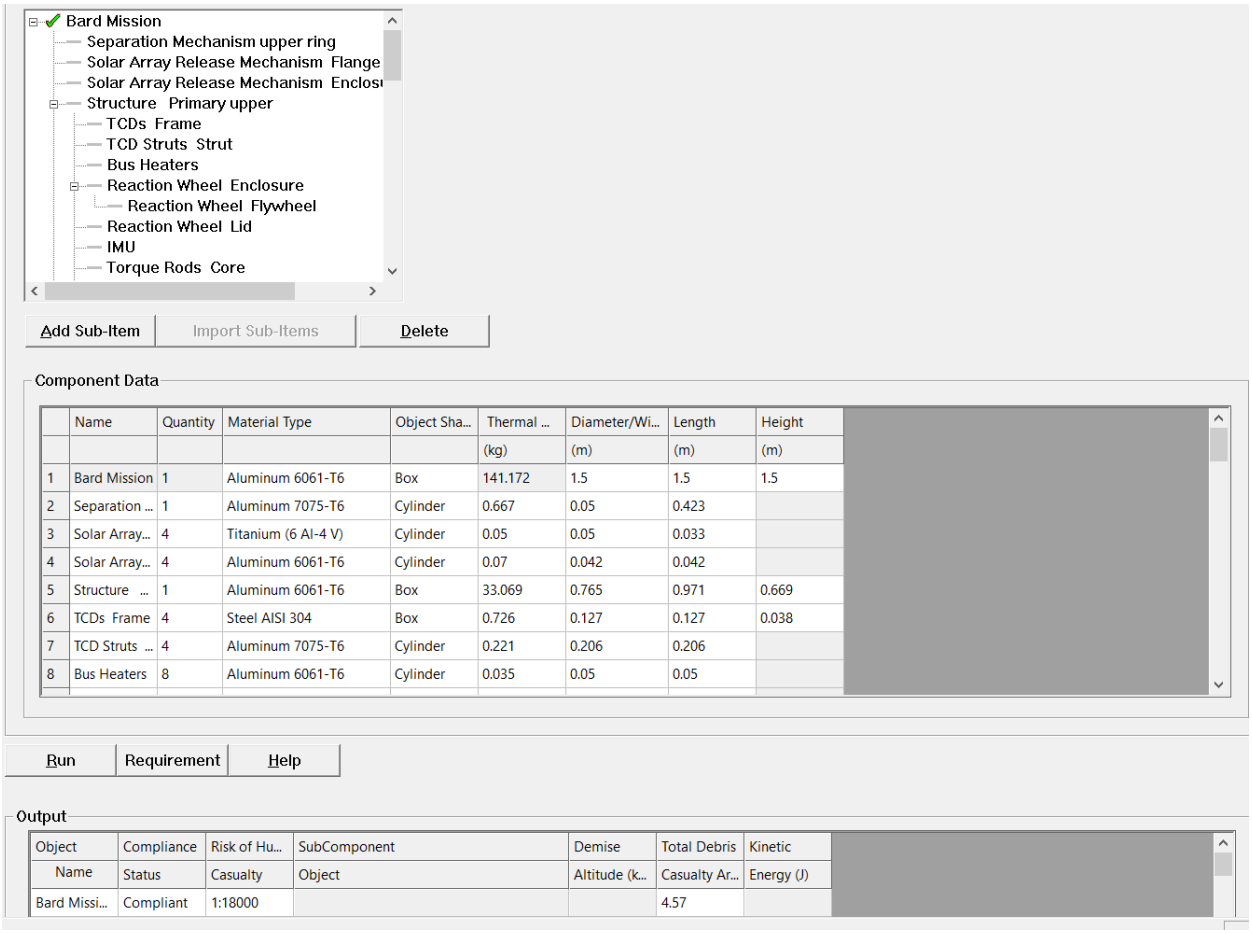

Figure 2 – DAS Requirement 4.7-1 window snapshot post-run

Table 3: Components analyzed in DAS – all are present on this spacecraft

Name	Qty	Material	Body Type	Thermal Mass	Diameter/Width	Length	Height	Demise Alt	Total DCA [m2]	KE [J]
Bard(PExT) Mission	*1*	*Aluminum 6061-T6*	*Box*	*141.172*	*1.5*	*1.5*	*1.5*		*4.57*	
Separation Mechanism upper ring	*1*	*Aluminum 7075-T6*	*Cylinder*	*0.667*	*0.05*	*0.423*		*73.9*	*0*	*0*
Solar Array Release Mechanism Flange	*4*	*Titanium (6 Al-4 V)*	*Cylinder*	*0.05*	*0.05*	*0.033*		*70.7*	*0*	*0*
Solar Array Release Mechanism Enclosure	*4*	*Aluminum 6061-T6*	*Cylinder*	*0.07*	*0.042*	*0.042*		*76.5*	*0*	*0*
Structure Primary upper	*1*	*Aluminum 6061-T6*	*Box*	*33.069*	*0.765*	*0.971*	*0.669*	*73.6*	*0*	*0*
TCDs Frame	*4*	*Steel AISI 304*	*Box*	*0.726*	*0.127*	*0.127*	*0.038*	*0*	*1.72*	*463.47*
TCD Struts Strut	*4*	*Aluminum 7075-T6*	*Cylinder*	*0.221*	*0.206*	*0.206*		*72.8*	*0*	*0*
Bus Heaters	*8*	*Aluminum 6061-T6*	*Cylinder*	*0.035*	*0.05*	*0.05*		*73.1*	*0*	*0*
Reaction Wheel Enclosure	*3*	*Aluminum 6061-T6*	*Cylinder*	*0.507*	*0.07*	*0.088*		*70.1*	*0*	*0*
Reaction Wheel Flywheel	*3*	*Brass-Muntz*	*Cylinder*	*0.66*	*0.04*	*0.089*		*62*	*0*	*0*
Reaction Wheel Lid	*3*	*Aluminum 6061-T6*	*Cylinder*	*0.024*	*0.05*	*0.097*		*73.4*	*0*	*0*

IMU	*1*	*Aluminum 6061-T6*	*Cylinder*	*0.145*	*0.035*	*0.065*		*71.2*	*0*	*0*
Torque Rods Core	*6*	*Iron*	*Cylinder*	*0.198*	*0.13*	*0.13*		*0*	*2.85*	*21.2*
Magnetometer	*1*	*Aluminum 6061-T6*	*Box*	*0.085*	*0.043*	*0.085*	*0.016*	*72.7*	*0*	*0*
Integrated Battery structure	*2*	*Aluminum 6061-T6*	*Box*	*0.72*	*0.174*	*0.235*	*0.098*	*72.6*	*0*	*0*
Integrated Battery li-ion cell	*160*	*Steel AISI 304*	*Cylinder*	*0.046*	*0.065*	*0.065*		*0*	*59.53*	*4.58*
power converters	*8*	*Aluminum 6061-T6*	*Box*	*0.086*	*0.037*	*0.058*	*0.018*	*72.4*	*0*	*0*
S-band SDR w/ diplexer	*1*	*Aluminum 6061-T6*	*Box*	*0.625*	*0.083*	*0.084*	*0.064*	*70.7*	*0*	*0*
Structure primary lower	*1*	*Aluminum 6061-T6*	*Cylinder*	*13.91*	*0.215*	*0.635*		*70.4*	*0*	*0*
Structure Primary center	*3*	*Aluminum 7075-T6*	*Flat Plate*	*1.778*	*0.474*	*0.474*		*74.5*	*0*	*0*
Bulkheads	*10*	*Steel AISI 304*	*Cylinder*	*1.014*	*0.051*	*0.07*		*56*	*0*	*0*
Star Tracker (ST) Mount	*2*	*Titanium (6 Al-4 V)*	*Box*	*0.029*	*0.064*	*0.064*	*0.026*	*0*	*0.71*	*2.55*
Star Tracker (ST) Flange	*1*	*Titanium (generic)*	*Box*	*0.083*	*0.06*	*0.06*	*0.024*	*72.9*	*0*	*0*
Star Tracker (ST) Barrel	*1*	*Titanium (generic)*	*Cylinder*	*0.04*	*0.032*	*0.032*		*72.1*	*0*	*0*

Star Tracker (ST) Spacers retainer ring	*1*	*Titanium (generic)*	*Cylinder*	*0.018*	*0.01*	*0.053*		*73.6*	*0*	*0*
Star Tracker (ST) Shim	*1*	*Titanium (generic)*	*Cylinder*	*0.005*	*0.01*	*0.019*		*74.9*	*0*	*0*
Star Tracker (ST) Lid	*1*	*Aluminum 6061-T6*	*Box*	*0.02*	*0.06*	*0.06*	*0.005*	*77.7*	*0*	*0*
Sun Sensors (SS) Enclosure	*2*	*Aluminum 6061-T6*	*Box*	*0.018*	*0.032*	*0.034*	*0.02*	*77.5*	*0*	*0*
LEO GPS Receiver	*1*	*Aluminum 6061-T6*	*Box*	*0.12*	*0.09*	*0.095*	*0.013*	*77.1*	*0*	*0*
LEO GPS Antenna	*1*	*Aluminum 6061-T6*	*Box*	*0.08*	*0.054*	*0.054*	*0.014*	*76.7*	*0*	*0*
Solar Arrays and Substrates Facesheets	*16*	*Graphite Epoxy 1*	*Flat Plate*	*0.5*	*0.57*	*0.85*		*77.8*	*0*	*0*
Solar Arrays and Substrates Core	*8*	*Aluminum 6061-T6*	*Flat Plate*	*0.6*	*0.57*	*0.85*		*77.8*	*0*	*0*
Solar Arrays and Substrates Cells	*432*	*Germanium*	*Flat Plate*	*0.004*	*0.08*	*0.08*		*77.9*	*0*	*0*
Solar Arrays and Substrates Fittings	*192*	*Aluminum 6061-T6*	*Flat Plate*	*0.012*	*0.036*	*0.076*		*77.8*	*0*	*0*
S-Band Antenna	*2*	*Aluminum 6061-T6*	*Flat Plate*	*0.17*	*0.095*	*0.095*		*76.6*	*0*	*0*

Deployment cams	*4*	*Aluminum 6061-T6*	*Box*	*0.075*	*0.043*	*0.048*	*0.042*	*77.1*	*0*	*0*
TTE Band Pass Filter Housing	*1*	*Aluminum 6061-T6*	*Box*	*0.50258*	*0.10008*	*0.16838*	*0.0381*	*76.4*	*0*	*0*
TTE Band Pass Filter Cover	*1*	*Aluminum 6061-T6*	*Flat Plate*	*0.10796*	*0.08788*	*0.14526*		*77.4*	*0*	*0*
TTE Band Pass Filter Resonator	*4*	*Aluminum 6061-T6*	*Cylinder*	*0.01315*	*0.00952*	*0.0762*		*77.5*	*0*	*0*
Propulsion Module	*1*	*Aluminum 6061-T6*	*Box*	*18*	*0.5*	*0.5*	*0.5*	*72.9*	*0*	*0*
Solid Zinc Propellant	*1*	*Zinc*	*Box*	*1*	*0.15*	*0.15*	*0.15*	*76.9*	*0*	*0*
7443-4000-09 Antenna Assembly Baseplate	*1*	*Aluminum 6061-T6*	*Flat Plate*	*6.29*	*0.6*	*0.6*		*74.5*	*0*	*0*
7443-4000-09 Antenna Assembly Primary Reflector	*1*	*Aluminum 6061-T6*	*Cylinder*	*2.78*	*0.6*	*0.5*		*77.2*	*0*	*0*
7443-4000-09 Antenna Assembly Secondary Reflector	*1*	*Aluminum 6061-T6*	*Cylinder*	*0.08*	*0.132*	*0.5*		*77.9*	*0*	*0*
7443-4000-09 Antenna Assembly Strut	*4*	*Aluminum 6061-T6*	*Cylinder*	*0.04*	*0.016*	*0.5*		*77.8*	*0*	*0*
7443-4000-09 Antenna Assembly Flexure	*3*	*Aluminum 6061-T6*	*Flat Plate*	*0.24*	*0.203*	*0.203*		*77.4*	*0*	*0*

7443-4000-09 Antenna Assembly Flexure (monopod)	*1*	*Aluminum 6061-T6*	*Flat Plate*	*0.08*	*0.203*	*0.203*		*77.8*	*0*	*0*
7443-4000-09 Antenna Assembly Diplexer	*2*	*Aluminum 6061-T6*	*Box*	*0.08*	*0.045*	*0.089*	*0.022*	*77.2*	*0*	*0*
7443-4000-09 Antenna Assembly Feed	*1*	*Aluminum 6061-T6*	*Box*	*0.42*	*0.116*	*0.184*	*0.022*	*76.7*	*0*	*0*
7443-8011-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.03*	*0.011*	*0.223*	*0.006*	*77.6*	*0*	*0*
7443-8012-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.05*	*0.011*	*0.518*	*0.006*	*77.7*	*0*	*0*
7443-8013-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.06*	*0.013*	*0.496*	*0.006*	*77.7*	*0*	*0*
7443-8014-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.05*	*0.013*	*0.425*	*0.006*	*77.7*	*0*	*0*
7443-8015-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.04*	*0.011*	*0.426*	*0.006*	*77.7*	*0*	*0*
7443-8016-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.02*	*0.011*	*0.152*	*0.006*	*77.6*	*0*	*0*
7443-8017-01 Waveguide	*1*	*Aluminum 6061-T6*	*Box*	*0.05*	*0.011*	*0.495*	*0.006*	*77.7*	*0*	*0*
33HJ-7334C30-X Waveguide Transfer Switch	*1*	*Aluminum 6061-T6*	*Box*	*0.145*	*0.038*	*0.074*	*0.038*	*76.7*	*0*	*0*

33HJ-7342C30-X Waveguide Transfer Switch	*2*	*Aluminum 6061-T6*	*Box*	*0.155*	*0.038*	*0.077*	*0.038*	*76.6*	*0*	*0*
7443-7000-09 Radio Assembly	*1*	*Aluminum 6061-T6*	*Box*	*2.5*	*0.147*	*0.203*	*0.122*	*74.4*	*0*	*0*
7443-1100-09 Solid State Power Amplifier	*1*	*Aluminum 6061-T6*	*Box*	*2.7*	*0.196*	*0.407*	*0.035*	*74.9*	*0*	*0*

4.3.4 Assessment of spacecraft compliance

- IADC Section 5.3.2: COMPLIANT
- NASA Requirement 4.6-1: COMPLIANT
- NASA Requirement 4.6-4: COMPLIANT
- NASA Requirement 4.7-1: COMPLIANT

4.4 Prevention of On-Orbit Collisions

4.4.1 IADC Section 5.4 Prevention of On-Orbit Collisions

"In developing the design and mission profile of a spacecraft or orbital stage, a program or project should estimate and limit the probability of accidental collision with known objects during the spacecraft or orbital stage's orbital lifetime."

4.4.2 Summary of applicable NASA requirement(s)

4.4.2.1 Requirement 4.5-1. Limiting debris generated by collisions with large objects when operating in Earth orbit:

- For all spacecraft passing though LEO, the probability of accidental collision with space objects larger than 10 cm in diameter shall be less than 0.001.

4.4.2.2 Requirement 4.5-2. Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit:

- For all spacecraft passing though LEO, the probability of accidental collision with space debris and meteoroids sufficient to prevent compliance with the post-mission disposal plan shall be less than 0.01.

4.4.3 Analysis

This analysis was performed assuming an Area-to-Mass(A-M) Ratio of 0.010487 m^2/kg that would assume the satellite in a deployed configuration, with margin. This A-M ratio was determined by taking the average worst case cross sectional area. This was calculated by taking the largest deployed vehicle area through any of the vehicle cross section planes (0.531 m^2). This was then combined with the average solar array effective surface area holding a sun

pointing orientation. The total effective area of 1.491 m^2 is thus taken along with a beginning of life mass of 142.172 kg to arrive at the stated A-M ratio. As per NASA-DAS v3.2.5 considering the vehicles orbit parameters and A-M ratio, the Probability of Collision with Large Objects is 1.0408E-05. Moreover, since the post-mission disposal plan is not reliant on any spacecraft components (see section 4.3.3), the probability of a collision sufficient enough to prevent compliance with said disposal plan is well below the required value of 0.01.

4.4.4 Assessment of spacecraft compliance:

- IADC Section 5.4: COMPLIANT
- NASA Requirement 4.5-1: COMPLIANT
- NASA Requirement 4.5-2: COMPLIANT

5 Conclusion

5.1 Analysis Summary

It has been shown that the PExT Mission will be compliant with all four guidelines put forth by the IADC as well as requirements developed by NASA that apply to this mission. Moreover, compliance with each section of IADC-02-01 also assures compliance with the U.S Government Orbital Debris Mitigation Standard Practices, 2019 Update objectives.

5.2 Compliance Matrix

Table 4: ASSESSMENT OF COMPLIANCE

Reference Document	Section/ Requirement ID	Section/Requirement Text	Compliance
IADC-02-01	5.1	Limit Debris Release During Normal Operations	COMPLY
IADC-02-01	5.2.1	Minimize the potential for post mission break-ups resulting from stored energy	COMPLY
IADC-02-01	5.2.2	Minimize the potential for break-ups during operational phases	COMPLY
IADC-02-01	5.3.2	Objects Passing Through the LEO Region	COMPLY
IADC-02-01	5.4	Prevention of On-Orbit Collisions	COMPLY
NASA-STD-8719.14	4.3-1	Debris passing through LEO – released debris with diameters of 1mm or larger	COMPLY
NASA-STD-8719.14	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	COMPLY
NASA-STD-8719.14	4.4-2	Design for passivation after completion of mission operations while in orbit about Earth or the Moon	COMPLY
NASA-STD-8719.14	4.5-1	Limiting debris generated by collisions with large objects when operating in Earth orbit	COMPLY

NASA-STD-8719.14	4.5-2	Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit	COMPLY
NASA-STD-8719.14	4.6-1	Disposal for space structures in or passing through LEO	COMPLY
NASA-STD-8719.14	4.6-4	Reliability of post-mission disposal operations in Earth orbit	COMPLY
NASA-STD-8719.14	4.7-1	Limit the risk of human casualty	COMPLY

Appendix A: DAS Activity Log

==========

Run Data

==========

INPUT

Space Structure Name = Bard Mission

Space Structure Type = Payload

Perigee Altitude = 530.000 (km)

Apogee Altitude = 530.000 (km)

Inclination = 97.365 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass Ratio = 0.0105 (m^2/kg)

Start Year = 2024.500 (yr)

Initial Mass = 142.172 (kg)

Final Mass = 141.172 (kg)

Duration = 3.000 (yr)

Station-Kept = False

Abandoned = True

Long-Term Reentry = True

OUTPUT

Collision Probability = 1.0408E-05

Returned Message: Normal Processing

Date Range Message: Normal Date Range

Status = Pass

**********INPUT****

Item Number = 1

name = Bard Mission

quantity = 1

parent = 0

materialID = 8

type = Box

Aero Mass = 141.171997

Thermal Mass = 141.171997

Diameter/Width = 1.500000

Length = 1.500000

Height = 1.500000

name = Separation Mechanism upper ring

quantity = 1

parent = 1

materialID = 9

type = Cylinder

Aero Mass = 0.667000

Thermal Mass = 0.667000

Diameter/Width = 0.050000

Length = 0.423000

name = Solar Array Release Mechanism Flange

quantity = 4

parent = 1

materialID = 65

type = Cylinder

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.050000

Length = 0.033000

name = Solar Array Release Mechanism Enclosure

quantity = 4

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 0.070000

Thermal Mass = 0.070000

Diameter/Width = 0.042000

Length = 0.042000

name = Structure Primary upper

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 52.241001

Thermal Mass = 33.069000

Diameter/Width = 0.765000

Length = 0.971000

Height = 0.669000

name = TCDs Frame

quantity = 4

parent = 5

materialID = 58

type = Box

Aero Mass = 0.726000

Thermal Mass = 0.726000

Diameter/Width = 0.127000

Length = 0.127000

Height = 0.038000

name = TCD Struts Strut

quantity = 4

parent = 5

materialID = 9

type = Cylinder

Aero Mass = 0.221000

Thermal Mass = 0.221000

Diameter/Width = 0.206000

Length = 0.206000

name = Bus Heaters

quantity = 8

parent = 5

materialID = 8

type = Cylinder

Aero Mass = 0.035000

Thermal Mass = 0.035000

Diameter/Width = 0.050000

Length = 0.050000

name = Reaction Wheel Enclosure

quantity = 3

parent = 5

materialID = 8

type = Cylinder

Aero Mass = 1.167000

Thermal Mass = 0.507000

Diameter/Width = 0.070000

Length = 0.088000

name = Reaction Wheel Flywheel

quantity = 3

parent = 9

materialID = 15

type = Cylinder

Aero Mass = 0.660000

Thermal Mass = 0.660000

Diameter/Width = 0.040000

Length = 0.089000

name = Reaction Wheel Lid

quantity = 3

parent = 5

materialID = 8

type = Cylinder

Aero Mass = 0.024000

Thermal Mass = 0.024000

Diameter/Width = 0.050000

Length = 0.097000

name = IMU

quantity = 1

parent = 5

materialID = 8

type = Cylinder

Aero Mass = 0.145000

Thermal Mass = 0.145000

Diameter/Width = 0.035000

Length = 0.065000

name = Torque Rods Core

quantity = 6

parent = 5

materialID = 38

type = Cylinder

Aero Mass = 0.198000

Thermal Mass = 0.198000

Diameter/Width = 0.130000

Length = 0.130000

name = Magnetometer

quantity = 1

parent = 5

materialID = 8

type = Box

Aero Mass = 0.085000

Thermal Mass = 0.085000

Diameter/Width = 0.043000

Length = 0.085000

Height = 0.016000

name = Integrated Battery structure

quantity = 2

parent = 5

materialID = 8

type = Box

Aero Mass = 0.720000

Thermal Mass = 0.720000

Diameter/Width = 0.174000

Length = 0.235000

Height = 0.098000

name = Integrated Battery li-ion cell

quantity = 160

parent = 5

materialID = 58

type = Cylinder

Aero Mass = 0.046000

Thermal Mass = 0.046000

Diameter/Width = 0.065000

Length = 0.065000

name = power converters

quantity = 8

parent = 5

materialID = 8

type = Box

Aero Mass = 0.086000

Thermal Mass = 0.086000

Diameter/Width = 0.037000

Length = 0.058000

Height = 0.018000

name = S-band SDR w/ diplexer

quantity = 1

parent = 5

materialID = 8

type = Box

Aero Mass = 0.625000

Thermal Mass = 0.625000

Diameter/Width = 0.083000

Length = 0.084000

Height = 0.064000

name = Structure primary lower

quantity = 1

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 13.910000

Thermal Mass = 13.910000

Diameter/Width = 0.215000

Length = 0.635000

name = Structure Primary center

quantity = 3

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 1.778000

Thermal Mass = 1.778000

Diameter/Width = 0.474000

Length = 0.474000

name = Bulkheads

quantity = 10

parent = 1

materialID = 58

type = Cylinder

Aero Mass = 1.014000

Thermal Mass = 1.014000

Diameter/Width = 0.051000

Length = 0.070000

name = Star Tracker (ST) Mount

quantity = 2

parent = 1

materialID = 65

type = Box

Aero Mass = 0.029000

Thermal Mass = 0.029000

Diameter/Width = 0.064000

Length = 0.064000

Height = 0.026000

name = Star Tracker (ST) Flange

quantity = 1

parent = 1

materialID = 66

type = Box

Aero Mass = 0.083000

Thermal Mass = 0.083000

Diameter/Width = 0.060000

Length = 0.060000

Height = 0.024000

name = Star Tracker (ST) Barrel

quantity = 1

parent = 1

materialID = 66

type = Cylinder

Aero Mass = 0.040000

Thermal Mass = 0.040000

Diameter/Width = 0.032000

Length = 0.032000

name = Star Tracker (ST) Spacers retainer ring

quantity = 1

parent = 1

materialID = 66

type = Cylinder

Aero Mass = 0.018000

Thermal Mass = 0.018000

Diameter/Width = 0.010000

Length = 0.053000

name = Star Tracker (ST) Shim

quantity = 1

parent = 1

materialID = 66

type = Cylinder

Aero Mass = 0.005000

Thermal Mass = 0.005000

Diameter/Width = 0.010000

Length = 0.019000

name = Star Tracker (ST) Lid

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.020000

Thermal Mass = 0.020000

Diameter/Width = 0.060000

Length = 0.060000

Height = 0.005000

name = Sun Sensors (SS) Enclosure

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 0.018000

Thermal Mass = 0.018000

Diameter/Width = 0.032000

Length = 0.034000

Height = 0.020000

name = LEO GPS Receiver

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.120000

Thermal Mass = 0.120000

Diameter/Width = 0.090000

Length = 0.095000

Height = 0.013000

name = LEO GPS Antenna

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.080000

Thermal Mass = 0.080000

Diameter/Width = 0.054000

Length = 0.054000

Height = 0.014000

name = Solar Arrays and Substrates Facesheets

quantity = 16

parent = 1

materialID = 27

type = Flat Plate

Aero Mass = 0.500000

Thermal Mass = 0.500000

Diameter/Width = 0.570000

Length = 0.850000

name = Solar Arrays and Substrates Core

quantity = 8

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.600000

Thermal Mass = 0.600000

Diameter/Width = 0.570000

Length = 0.850000

name = Solar Arrays and Substrates Cells

quantity = 432

parent = 1

materialID = 25

type = Flat Plate

Aero Mass = 0.004000

Thermal Mass = 0.004000

Diameter/Width = 0.080000

Length = 0.080000

name = Solar Arrays and Substrates Fittings

quantity = 192

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.012000

Thermal Mass = 0.012000

Diameter/Width = 0.036000

Length = 0.076000

name = S-Band Antenna

quantity = 2

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.170000

Thermal Mass = 0.170000

Diameter/Width = 0.095000

Length = 0.095000

name = Deployment cams

quantity = 4

parent = 1

materialID = 8

type = Box

Aero Mass = 0.075000

Thermal Mass = 0.075000

Diameter/Width = 0.043000

Length = 0.048000

Height = 0.042000

name = TTE Band Pass Filter Housing

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.502580

Thermal Mass = 0.502580

Diameter/Width = 0.100080

Length = 0.168380

Height = 0.038100

name = TTE Band Pass Filter Cover

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.107960

Thermal Mass = 0.107960

Diameter/Width = 0.087880

Length = 0.145260

name = TTE Band Pass Filter Resonator

quantity = 4

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 0.013150

Thermal Mass = 0.013150

Diameter/Width = 0.009520

Length = 0.076200

name = Propulsion Module

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 18.000000

Thermal Mass = 18.000000

Diameter/Width = 0.500000

Length = 0.500000

Height = 0.500000

name = Solid Zinc Propellant

quantity = 1

parent = 1

materialID = 70

type = Box

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.150000

Length = 0.150000

Height = 0.150000

name = 7443-4000-09 Antenna Assembly Baseplate

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 6.290000

Thermal Mass = 6.290000

Diameter/Width = 0.600000

Length = 0.600000

name = 7443-4000-09 Antenna Assembly Primary Reflector

quantity = 1

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 2.780000

Thermal Mass = 2.780000

Diameter/Width = 0.600000

Length = 0.500000

name = 7443-4000-09 Antenna Assembly Secondary Reflector

quantity = 1

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 0.080000

Thermal Mass = 0.080000

Diameter/Width = 0.132000

Length = 0.500000

name = 7443-4000-09 Antenna Assembly Strut

quantity = 4

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 0.040000

Thermal Mass = 0.040000

Diameter/Width = 0.016000

Length = 0.500000

name = 7443-4000-09 Antenna Assembly Flexure

quantity = 3

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.240000

Thermal Mass = 0.240000

Diameter/Width = 0.203000

Length = 0.203000

name = 7443-4000-09 Antenna Assembly Flexure (monopod)

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.080000

Thermal Mass = 0.080000

Diameter/Width = 0.203000

Length = 0.203000

name = 7443-4000-09 Antenna Assembly Diplexer

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 0.080000

Thermal Mass = 0.080000

Diameter/Width = 0.045000

Length = 0.089000

Height = 0.022000

name = 7443-4000-09 Antenna Assembly Feed

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.420000

Thermal Mass = 0.420000

Diameter/Width = 0.116000

Length = 0.184000

Height = 0.022000

name = 7443-8011-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.030000

Thermal Mass = 0.030000

Diameter/Width = 0.011000

Length = 0.223000

Height = 0.006000

name = 7443-8012-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.011000

Length = 0.518000

Height = 0.006000

name = 7443-8013-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.060000

Thermal Mass = 0.060000

Diameter/Width = 0.013000

Length = 0.496000

Height = 0.006000

name = 7443-8014-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.013000

Length = 0.425000

Height = 0.006000

name = 7443-8015-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.040000

Thermal Mass = 0.040000

Diameter/Width = 0.011000

Length = 0.426000

Height = 0.006000

name = 7443-8016-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.020000

Thermal Mass = 0.020000

Diameter/Width = 0.011000

Length = 0.152000

Height = 0.006000

name = 7443-8017-01 Waveguide

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.011000

Length = 0.495000

Height = 0.006000

name = 33HJ-7334C30-X Waveguide Transfer Switch

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.145000

Thermal Mass = 0.145000

Diameter/Width = 0.038000

Length = 0.074000

Height = 0.038000

name = 33HJ-7342C30-X Waveguide Transfer Switch

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 0.155000

Thermal Mass = 0.155000

Diameter/Width = 0.038000

Length = 0.077000

Height = 0.038000

name = 7443-7000-09 Radio Assembly

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 2.500000

Thermal Mass = 2.500000

Diameter/Width = 0.147000

Length = 0.203000

Height = 0.122000

name = 7443-1100-09 Solid State Power Amplifier

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 2.700000

Thermal Mass = 2.700000

Diameter/Width = 0.196000

Length = 0.407000

Height = 0.035000

**********OUTPUT****

Item Number = 1

name = Bard Mission

Demise Altitude = 77.996804

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Separation Mechanism upper ring

Demise Altitude = 73.926543

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Array Release Mechanism Flange

Demise Altitude = 70.702010

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Array Release Mechanism Enclosure

Demise Altitude = 76.542583

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Structure Primary upper

Demise Altitude = 73.568755

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TCDs Frame

Demise Altitude = 0.000000

Debris Casualty Area = 1.720987

Impact Kinetic Energy = 463.474770

****

name = TCD Struts Strut

Demise Altitude = 72.802735

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bus Heaters

Demise Altitude = 73.058795

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel Enclosure

Demise Altitude = 70.098621

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel Flywheel

Demise Altitude = 61.953394

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel Lid

Demise Altitude = 73.353530

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = IMU

Demise Altitude = 71.237861

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Torque Rods Core

Demise Altitude = 0.000000

Debris Casualty Area = 2.850486

Impact Kinetic Energy = 21.202947

****

name = Magnetometer

Demise Altitude = 72.712227

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Integrated Battery structure

Demise Altitude = 72.574156

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Integrated Battery li-ion cell

Demise Altitude = 0.000000

Debris Casualty Area = 59.532079

Impact Kinetic Energy = 4.577261

****

name = power converters

Demise Altitude = 72.359951

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = S-band SDR w/ diplexer

Demise Altitude = 70.681179

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Structure primary lower

Demise Altitude = 70.416039

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Structure Primary center

Demise Altitude = 74.454687

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bulkheads

Demise Altitude = 56.035521

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker (ST) Mount

Demise Altitude = 0.000000

Debris Casualty Area = 0.709958

Impact Kinetic Energy = 2.552092

****

name = Star Tracker (ST) Flange

Demise Altitude = 72.895521

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker (ST) Barrel

Demise Altitude = 72.060775

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker (ST) Spacers retainer ring

Demise Altitude = 73.560596

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker (ST) Shim

Demise Altitude = 74.948351

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker (ST) Lid

Demise Altitude = 77.673526

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Sun Sensors (SS) Enclosure

Demise Altitude = 77.508736

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = LEO GPS Receiver

Demise Altitude = 77.112595

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = LEO GPS Antenna

Demise Altitude = 76.742832

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Arrays and Substrates Facesheets

Demise Altitude = 77.819005

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Arrays and Substrates Core

Demise Altitude = 77.792847

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Arrays and Substrates Cells

Demise Altitude = 77.924985

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Arrays and Substrates Fittings

Demise Altitude = 77.754827

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = S-Band Antenna

Demise Altitude = 76.563686

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Deployment cams

Demise Altitude = 77.072533

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TTE Band Pass Filter Housing

Demise Altitude = 76.397184

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TTE Band Pass Filter Cover

Demise Altitude = 77.354421

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TTE Band Pass Filter Resonator

Demise Altitude = 77.463049

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Propulsion Module

Demise Altitude = 72.892987

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solid Zinc Propellant

Demise Altitude = 76.882904

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Baseplate

Demise Altitude = 74.526815

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Primary Reflector

Demise Altitude = 77.221723

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Secondary Reflector

Demise Altitude = 77.934478

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Strut

Demise Altitude = 77.817743

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Flexure

Demise Altitude = 77.357481

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Flexure (monopod)

Demise Altitude = 77.783406

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Diplexer

Demise Altitude = 77.240582

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-4000-09 Antenna Assembly Feed

Demise Altitude = 76.659285

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8011-01 Waveguide

Demise Altitude = 77.626845

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8012-01 Waveguide

Demise Altitude = 77.735856

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8013-01 Waveguide

Demise Altitude = 77.681655

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8014-01 Waveguide

Demise Altitude = 77.690740

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8015-01 Waveguide

Demise Altitude = 77.735921

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8016-01 Waveguide

Demise Altitude = 77.635989

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-8017-01 Waveguide

Demise Altitude = 77.717769

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 33HJ-7334C30-X Waveguide Transfer Switch

Demise Altitude = 76.672509

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 33HJ-7342C30-X Waveguide Transfer Switch

Demise Altitude = 76.634009

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-7000-09 Radio Assembly

Demise Altitude = 74.386115

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = 7443-1100-09 Solid State Power Amplifier

Demise Altitude = 74.931297

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

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