ELVL-2021-0046035
February 14, 2023

Orbital Debris Assessment for
The CURIE CubeSat
per NASA-STD 8719.14A

Signature Page

Digitally signed by Emily Boehmer
Date: 2023.02.14 14:14:53 -05'00'

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ELVL-2021-0046035
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Reply to Attn of: VA-H1

TO: Norman Phelps, LSP Mission Manager, NASA/KSC/VA-C

FROM: Emily Boehmer, NASA/KSC/VA-H1

SUBJECT: Orbital Debris Assessment Report (ODAR) for the CURIE CubeSat

REFERENCES:

A. *NASA Procedural Requirements for Limiting Orbital Debris Generation*, NPR 8715.6B, 6 February 2017
B. *Process for Limiting Orbital Debris*, NASA-STD-8719.14C, 5 November 2021
C. International Space Station Reference Trajectory, delivered August 2022
D. McKissock, Barbara, 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*. UL Standard. 5th ed. Northbrook, IL, Underwriters Laboratories, 2012
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. ODPO Guidance Email: Fasteners and Screws, John Opiela to Yusef Johnson, 12 February 2020
J. ODPO Guidance Email: 6U CubeSat Battery Concerns, J.C. Liou to Eric Haddox, 18 May 2021
K. Debris Assessment Software User’s Guide: Version 3.2, NASA/TP-2019-220300

The intent of this report is to satisfy the orbital debris requirements listed in ref. (a) for the CURIE CubeSat launching on the Ariane 6 launch vehicle. It serves as the final submittal in support of the spacecraft Safety and mission Success Review (SMSR). Sections 1 through 8 of ref. (b) are addressed in this document; sections 9 through 14 fall under the requirements levied on the primary mission and are not presented here. This CubeSat will passively reenter, and therefore this ODAR will also serve as the End of Mission Plan (EOMP) for this CubeSat.

RECORD OF REVISIONS		
REV	**DESCRIPTION**	**DATE**
0	Original submission	May 2021
A	Update to CURIE responsible POC	May 2021
B	Update to CURIE mission manifest and LV	May 2022
C	Update to LV launch date and CURIE mass	February 2023

Section 1: Program Management and Mission Overview

CURIE is sponsored by the Space Operations Mission Directorate at NASA Headquarters. The acting Program Executive is Serkan Bastug. Responsible program/project manager and senior scientific and management personnel are as follows:

David Sundkvist, Principal Investigator, University of California at Berkeley

The following table summarizes the compliance status of CURIE, which will be flown on the Arianne 6 launch vehicle. The current launch date is planned for NET October 1, 2023. DAS version 3.2.3 was used to generate the data provided in this document. CURIE is fully compliant with all applicable requirements.

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	
4.6-1(a)	Compliant	Worst case lifetime 20.539 years
4.6-1(b)	Not applicable	
4.6-1(c)	Not applicable	
4.6-2	Not applicable	
4.6-3	Not applicable	
4.6-4	Not applicable	Passive disposal
4.6-5	Compliant	
4.7-1	Compliant	Non-credible risk of human casualty
4.8-1	Compliant	No planned tether releases

Section 2: Spacecraft Description

Table 2 outlines its generic attributes.

Table 2: CURIE Attributes

CubeSat Names	CubeSat Quantity	CubeSat size (mm)	CubeSat Mass (kg)
CURIE at ejection	1	366.0 x 226.3 x 100.0	10.39
After CURIE A/B separation on orbit	2	366.0 x 100.0 x 100.0	5.20

The following pages describe the CURIE CubeSat.

CURIE – University of California, Berkeley – 6U

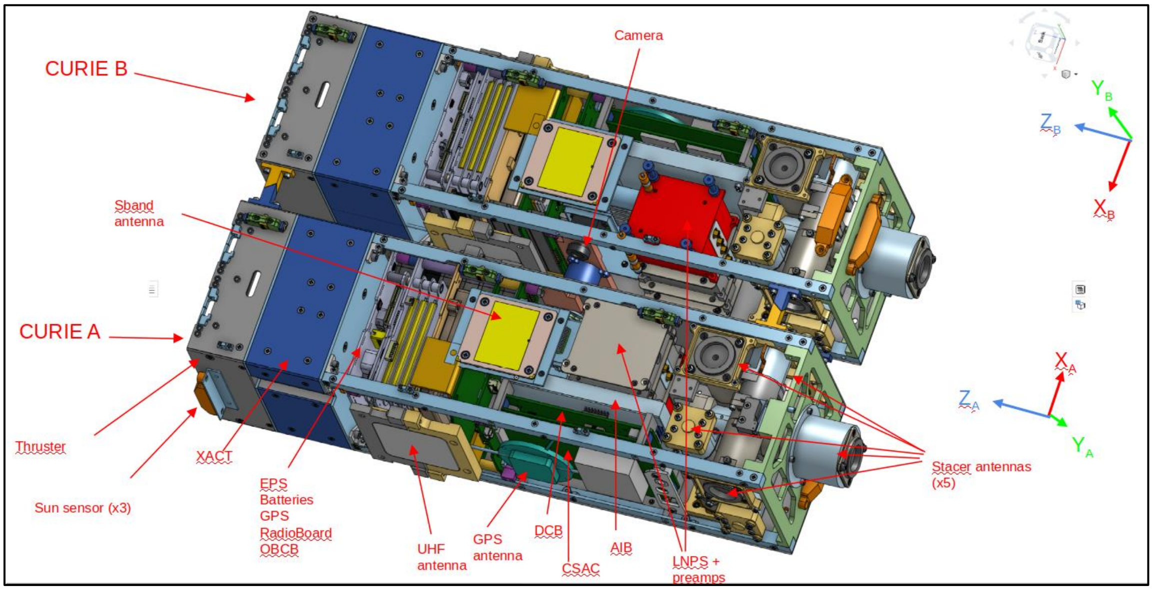

Figure 1: CURIE Component View

Overview

The CUbesat Radio Interferometry Experiment (CURIE) is a two-element radio interferometer. CURIE will launch as a 6U CubeSat and then separate into two 3U CubeSats once in orbit. CURIE measures radio waves from 0.1-19MHz, which must be measured from space, as those frequencies fall below the cutoff imposed by Earth’s ionosphere.

The principal science objective for CURIE is to use radio interferometry to study radio burst emissions from solar eruptive events such as flares and coronal mass ejections (CMEs) in the inner heliosphere, providing observations important for our understanding of the heliospheric space weather environment.

CONOPS

After deployment from the launch vehicle as a 6U CubeSat, CURIE will power up and remain in its first on-orbit boot-up mode for 45 minutes. Shortly after that, the UHF beacon will start to transmit for 3 seconds every 2 minutes. Shortly after, CURIE will separate into its two 3U components. After spacecraft separation, solar panel deployment will be actuated, followed by science stacer antenna deployment. This is the CURIE final configuration.

In its final mission operations configuration, CURIE consists of two 3U CubeSats. The body frame X-Y-Z coordinate system is defined in Figure 1.

Each CubeSat has trifold solar arrays (SAs) which deploy into the X-Y plane that is perpendicular to the long (Z) axis of the spacecraft.

Each CubeSat has five deployable stacer boom antennas that are each ~2.5m in length. Four are arranged in a cross dipole format in the X-Y plane. The fifth is a monopole aligned with the Z-axis.

Each 3U CubeSat is equipped with two Ultra High Frequency (UHF) patch antennas and two GPS patch antennas on the ± X faces of the spacecraft. These are unobstructed, regardless of the deployment state of the SAs or the stacers. Each CubeSat also has two higher data rate S-Band patch antennas on the ± Y faces of the CubeSats. These become unobstructed after deployment of the solar arrays.

The separation actuation will be aligned with the orbital velocity vector and impart a relative velocity of 2 cm/s between the two 3U satellites causing a slow, passive, secular growth of their separation along-track. During this period, the thrusters will be commissioned and then formation-flying control established to keep the two satellites with an along-track separation 1-3 km to begin science activities. The orbital elements of the two satellites will be near identical but with a differential true anomaly corresponding to 1-3 km separation.

Ground station TT&C two-way communication will be on UHF, while high rate science data is downlinked on S-band. CURIE has a 12-month nominal mission lifetime.

Materials

CURIE chassi structure is made of Aluminum 6061-T6. The science stacer antennas are made of Be-Cu (Beryllium-Copper alloy). There are small parts made of Titanium Ti-6Al-4V in the frangibolt actuators. The rest of the materials are standard off-the-shelf components, FR4 PCBs and solar cells.

Hazards

Each 3U CubeSat contains a cold gas thrusters system comprising a single canister containing, at launch, 12g of CO_2 at 850-psi pressure, a motor to puncture the sealed canister in orbit after spacecraft separation and deployment, a valve, a regulator, harnessing and a nozzle aligned with the spacecraft -Z-axis. The DOT certified pressure vessel has a burst pressure > 6800psi (a safety factor of 9). CURIE carries no radioactive materials onboard.

Batteries

CURIE's power generation and storage system comprises symmetric deployable trifold solar arrays (SAs, see fig 1. above), an electric power supply (EPS) unit from Clyde Space (Starbuck Nano), which includes battery charge regulators (BCR) and switches, current limiters and power distribution modules (PCM). The solar arrays consist of six 3U panels each with six cells, providing a nominal total input power after deployment of 36 Watts. Additionally, the central panel is doubled sided such that power generation still occurs pre-deployment of the tri-fold solar arrays, albeit at a reduced rate (6 Watts). The lithium-ion battery (OPTIMUS-30) is purchased from Clyde Space with a capacity of 30Whrs and has a large track record of flight, particularly on CubeSat platforms and is qualified to NASA Standard EP-Wi-032.

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 on the CURIE CubeSat 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 for CURIE.

As discussed in Reference H, the probability of battery explosion is very low, and, due to the very small mass of the satellites and their short orbital lifetimes the effect of an explosion on the far-term LEO environment is negligible. The CURIE battery cells are certified using UL 1642 testing standards for lithium batteries, which addresses various concerns, including overcharge/overdischarge, temperature cycling, shock, vibration, low pressure, overheating, and other concerns.

Limitations in space and mass prevent the inclusion of the necessary resources to disconnect the battery or the solar arrays at EOM. However, the low charges and small battery cells on the CubeSat’s power system prevent 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 with a maximum lifetime of 20.539 years maximum, CURIE is compliant.

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

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 and orbital lifetime.

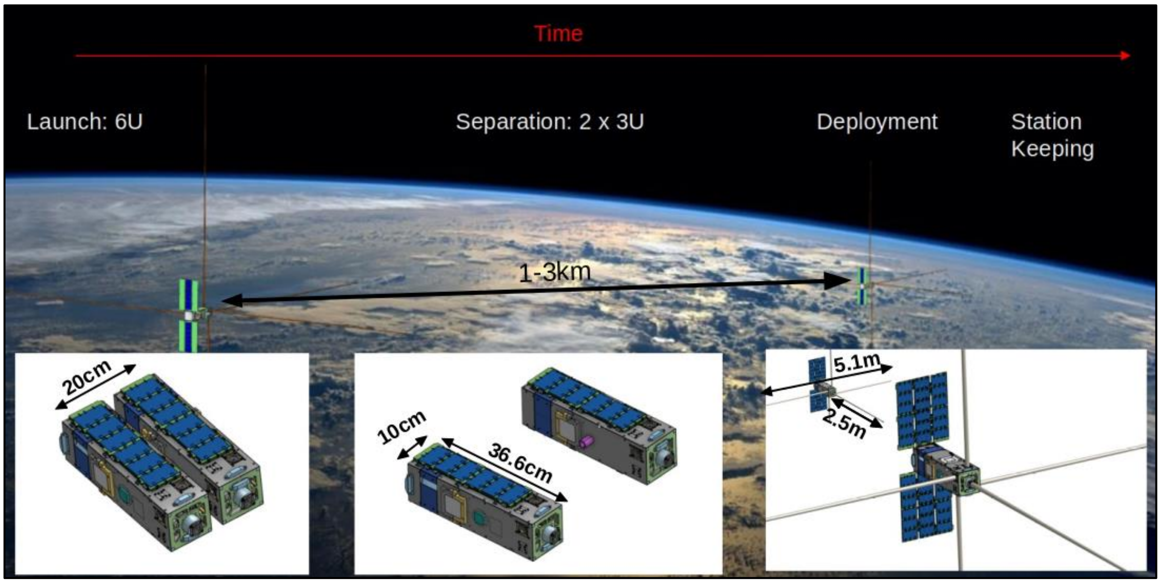

Figure 2: CURIE As-Deployed View

$$\boldsymbol{Mean\ CSA} = \frac{\sum \boldsymbol{Surface\ Area}}{\boldsymbol{4}} = \frac{\boldsymbol{2} * [(\boldsymbol{w} * \boldsymbol{l}) + (\boldsymbol{w} * \boldsymbol{h}) + (\boldsymbol{l} * \boldsymbol{h})]}{\boldsymbol{4}}$$

Equation 1: Mean Cross Sectional Area for Convex Objects

$$\boldsymbol{Mean\ CSA} = \frac{(\boldsymbol{A_{max}} + \boldsymbol{A_1} + \boldsymbol{A_1})}{\boldsymbol{2}}$$

Equation 2: Mean Cross Sectional Area for Complex Objects

The CubeSat evaluated for this ODAR is stowed in a convex configuration, indicating there are no elements of the CubeSat obscuring another element of the same CubeSat from view. Thus, the mean CSA for the stowed CubeSat was calculated using $\boldsymbol{Mean\ CSA} = \frac{\sum \boldsymbol{Surface\ Area}}{\boldsymbol{4}} = \frac{\boldsymbol{2} * [(\boldsymbol{w} * \boldsymbol{l}) + (\boldsymbol{w} * \boldsymbol{h}) + (\boldsymbol{l} * \boldsymbol{h})]}{\boldsymbol{4}}$ Equation 1. This configuration renders the longest orbital life times for all CubeSats.

Once a CubeSat has been ejected from the CubeSat dispenser and deployables have been extended, Equation 2 is utilized to determine the mean CSA. A_{max} is identified as the view that yields the maximum cross-sectional area. A_1 and A_2 are the two cross-sectional areas orthogonal to A_{max}. Refer to Appendix A for component dimensions used in these calculations

CURIE’s expected orbit at deployment is a 580-km circular orbit at a 62° inclination. With an area to mass ratio of 0.0078 m^2/kg, DAS yields 20.539 years for orbit lifetime for its as-ejected state, which in turn is used to obtain the collision probability. CURIE is calculated to have a probability of collision of 0.0. Table 3 below provides complete results.

CubeSat	**CURIE**
6U Mass (kg)	10.39
Individual 3U Mass (kg)	5.20

6U Stowed	**Mean C/S Area (m^2)**	0.0710
	Area-to Mass (m^2/kg)	0.0068
	Orbital Lifetime (yrs)	**20.539**
	Probability of collision	**4.8428E-06**

3U Stowed	**Mean C/S Area (m^2)**	0.0416
	Area-to Mass (m^2/kg)	0.0080
	Orbital Lifetime (yrs)	**14.623**
	Probability of collision	**1.6230E-06**

Deployed**	**Mean C/S Area (m^2)**	0.1154
	Area-to Mass (m^2/kg)	0.0222
	Orbital Lifetime (yrs)	**7.075**
	Probability of collision	**1.4493E-06**

Solar Flux Table Dated 12/19/2022

** Deployed calculations were taken of a single CURIE 3U CubeSat after solar panel deployment

Table 3: CubeSat Orbital Lifetime & Collision Probability

The worst-case probability of CURIE colliding with debris or meteoroids greater than 10 cm in diameter that are capable of preventing post-mission disposal is 1.4493E-06. This satisfies the 0.001 maximum probability requirement 4.5-1.

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

This ODAR also serves as the EOMP (End of Mission Plan).

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

CURIE will naturally decay from orbit within 25 years after end of the mission, satisfying requirement 4.6-1a detailing the spacecraft disposal option.

Planning for spacecraft maneuvers to accomplish post-mission disposal is not applicable. Disposal will be achieved via passive atmospheric reentry.

Calculating the area-to-mass ratio for the worst-case (smallest Area-to-Mass) post-mission disposal finds CURIE in its 6U stowed configuration as the worst case. The area-to-mass is calculated as follows:

$$\frac{\boldsymbol{Mean\ {}^{C}\!/_{S}\,Area\ (m^2)}}{\boldsymbol{Mass\ (kg)}} = \boldsymbol{Area - to - Mass\ (\frac{m^2}{kg})}$$

Equation 3: Area to Mass

$$\frac{0.0710\,m^2}{10.39\,kg} = 0.0068\,\frac{m^2}{kg}$$

The assessment of the spacecraft illustrates it is compliant with Requirements 4.6-1 through 4.6-5.

DAS Orbital Lifetime Calculations:

DAS inputs are: 580-km circular orbit with a 62° inclination at deployment no earlier than October 2023. An area to mass ratio of ~0.0068 m^2/kg for the CURIE CubeSat was used. DAS yields a 20.539 years orbit lifetime for CURIE in its 6U stowed state.

This meets requirement 4.6-1.

Section 7: Assessment of Spacecraft Reentry Hazards

A detailed assessment of the components to be flown on CURIE was performed. The assessment used DAS, a conservative tool used by the NASA Orbital Debris Office to verify Requirement 4.7-1. The analysis is intended to provide a bounding analysis for characterizing the survivability of a CubeSat's component during re-entry. For example, when DAS shows a component surviving reentry, it is not taking into account the material ablating away or charring due to oxidative heating. Both physical effects are experienced upon reentry and will decrease the mass and size of the real-life components as they reenter the atmosphere, reducing the risk they pose still further.

The following steps are used to identify and evaluate a component's potential reentry risk relative to the 4.7-1 requirement of having less than 15 J of kinetic energy and a 1:10,000 probability of a human casualty in the event it survives reentry.

1. Low melting temperature (less than 1000 °C) components are identified as materials that would never survive reentry and pose no risk of human casualty. This is confirmed through DAS analysis that showed materials with melting temperatures equal to or below that of copper (1080 °C) will always demise upon reentry for any size component up to the dimensions of a 1U CubeSat.

2. The remaining high temperature materials are shown to pose negligible risk of human casualty through a bounding DAS analysis of the highest temperature components, stainless steel (1500°C). If a component has a melting temperature between 1000 °C and 1500°C, it can be expected to possess the same negligible risk as a stainless steel component of similar dimensions.

3. Fasteners and similar materials that are composed of stainless steel or a lower melting point material will not be input into DAS, as suggested by guidance from the Orbital Debris Project Office (Reference I)

Table 4: CURIE High Melting Temperature Material Analysis

Name	Material	Total Mass (kg)	Demise Alt (km)	Kinetic Energy (J)
Separation Frangibolt	Ti-6Al-4V	0.005	70.7	-
UHF Patch Antenna	Ceramic, Acetal	0.110	0.0	6.46
GPS Antenna	Ceramic	0.023	0.0	3.66
XACT, RWA, Magnets	Proprietary Material #1**	0.019	76.10	-
XACT, RW DAMPER, ASY	Ti-6Al-4V	0.010	77.1	-
XACT, RW3 DAMPER, ASY	Ti-6Al-4V	0.007	75.3	-
Photodiode	Ceramic	0.004	0.0	0.15
STAR TRACKER LENSES	Fused Silica	0.025	76.4	-

** This material is proprietary to Blue Canyon Technologies. Additional information can be found in Memo #1, which can be made available upon request.

The majority of high melting point components demise upon reentry and CURIE complies with the 1:10,000 probability of Human Casualty Requirement 4.7-1. A breakdown of the determined probabilities follows:

Table 5: Requirement 4.7-1 Compliance by CubeSat

Name	Status	Risk of Human Casualty
CURIE	Compliant	1:100,000,000

*Requirement 4.7-1 Probability of Human Casualty > 1:10,000

If a component survives to the ground but has less than 15 Joules of kinetic energy, it is not included in the Debris Casualty Area that inputs into the Probability of Human Casualty calculation.

CURIE is compliant with Requirement 4.7-1 of NASA-STD-8719.14A.

Section 8: Assessment for Tether Missions

CURIE will not be deploying any tethers.

Section 9-14

ODAR sections 9 through 14 pertain to the launch vehicle, and are not covered here. Launch vehicle sections of the ODAR are the responsibility of the launch service provider.

If you have any questions, please contact the undersigned at 321-867-1367.

/original signed by/

Emily S. Boehmer
Flight Design Analyst
NASA/KSC/VA-H1

cc: VA-C/Liam J. Cheney
VA-C/Norman L. Phelps
AIS2/ Jennifer A. Snyder
SA-D1/Kevin R. Villa
SA-D2/Homero Hidalgo

Appendix Index:

Appendix A. CURIE Component List

NOTE: After integration, the CURIE team discovered that the total mass of each 3U spacecraft was approximately 304g heavier than the original itemized mass estimate. Due to the Spacecraft's integration timeline, CURIE could not supply updated individual masses for each component. NASA LSP and the CURIE team concluded that all components with high-temperature materials (highlighted below) are COTS items; therefore, these components are unlikely to drive the mass discrepancy. With concurrence from the spacecraft team, NASA LSP agreed to split the additional 304g of mass evenly amongst all remaining items below.

Item Number	Name	Qty	Material	Body Type	Mass (g) (total)	Diameter / Width (mm)	Length (mm)	Height (mm)	High Temp	Melting Temp (F°)	Survivability
1	CURIE as 6U (Launched as 6U, later 2x 3U). Below listed components is for one 3U	1	Al-6061-T6	Box	10393.0	226.3	366	100	No	-	Demise
	CURIE as 3U	2	Al-6061-T6	Box	5196.0	100	366	100	No	-	Demise
2	Chassis Walls	1	Al-6061-T6	Box	290.0	100	280	100	No	-	Demise
3	Chassis Rails	4	Al-6061-T6	Box	230.0	11	280	11	No	-	Demise
4	Chassi End Plate	2	Al-6061-T6	Plate	63.0	98	98	2.5	No	-	Demise
5	XACT Interface Plate	1	Al-6061-T6	Plate	70.0	98	98	2.5	No	-	Demise
6	Cubesat Separation Mechanism	1	Al-6061-T6 + stainless steel hardware	Box	40.0	30	94	16	No	-	Demise
7	Separation Frangibolt	1	Ti-6Al-4V	Cylinder	50.0	3	35	3	Yes	3045	Demise
8	Avionics Stack	1	FR4, Aluminum, Stainless Steel Li Ion batteries	Box	770.0	95	88	95	No	-	Demise
9	Instrument Stack	1	FR4, Aluminum, Stainless Steel	Box	380.0	98.0	102.0	41.0	No	-	Demise
10	Preamp Stack	1	FR4, Aluminum, Stainless Steel	Box	260.0	48.0	69.0	98.0	No	-	Demise
11	Solar Panels	6	FR4, silicon, bronze, Stainless Steel	Plate	350.0	236	287	15	No	-	Demise
12	Stacer Enclosure	5	Aluminum,PEEK, Stainless Steel	Cylinder	350.0	41	98	33	No	-	Demise
13	Stacer Boom	5	BeCu	Tube	120.0	6	2600	6	No	-	Demise
14	Stacer Frangibolt	10	Ti-6Al-4V	Cylinder	50.0	4	15	4	No	-	Demise
15	UHF patch antenna	2	Ceramic, Acetal	Plate	110.0	60	70	9	Yes	3632	6.46 J

16	S-band patch antenna	2	FR4, Aluminum	Plate	32.0	63	45	2.6	No	-	Demise
17	GPS antenna	1	Ceramic	Plate	23.0	36	36	7	Yes	3632	3.66 J
18	Cameras	2	Aluminum, Plastic	Box	20.0	45	30	30	No	-	Demise
19	Thruster Frame	1	Aluminum	Box	150.0	100	35	100	No	-	Demise
20	CO2 canister	1	Steel	Cylinder	44.0	18	75	18	No	-	Demise
21	Pressure regulator	1	Steel	Cylinder	90.0	26	28	26	No	-	Demise
22	Canister Piercing Motor	1	Steel, Copper	Cylinder	260.0	22	74	22	No	-	Demise
23	Gears	1	Stainless Steel, Aluminum	Cylinder	10.0	30	10	30	No	-	Demise
24	XACT, HOUSING	1	Aluminum 6061-T6	Box	228.0	100	100	50	No	-	Demise
25	XACT, HOUSING COVER	1	Aluminum 6061-T6	Box	25.0	55	55	55	No	-	Demise
26	PWA, XACT Controller	1	G10/FR4	Box	53.0	77	77	77	No	-	Demise
27	XACT, RWA, Wheel	3	416 SS	Box	198.0	33	33	33	No	-	Demise
28	XACT, RWA, Baseplate	3	Aluminum 6061-T6	Box	22.5	29	29	29	No	-	Demise
29	XACT, RWA, Housing	3	Aluminum 6061-T6	Box	27.8	28	28	28	No	-	Demise
30	XACT, RWA, Motor	3	Copper	Box	60.0	34	34	34	No	-	Demise
31	XACT, RWA, Magnets	3	Proprietary Material #1 (See Memo #1)	Box	19.2	15	15	15	Yes	See Memo #1	Demise
32	XACT, RW DAMPER, ASY	2	Ti 6Al-4V	Box	10.0	22	22	22	Yes	3045	Demise
33	XACT, RW3 DAMPER, ASY	1	Ti 6Al-4V	Box	7.5	27	27	27	Yes	3045	Demise
34	STAR TRACKER, LENS BARREL	1	Aluminum 6061-T6	Box	31.0	37	37	37	No	-	Demise
35	STAR TRACKER LENSES	1	Fused Silica	Box	25.0	25	25	25	Yes	3119	Demise
36	STAR TRACKER FOCAL PLANE	1	Aluminum 6061-T6	Box	10.0	29	29	29	No	-	Demise
37	XAXT, CSS, Housing	1	Aluminum 6061-T6	Box	4.0	19	19	19	No	-	Demise
38	Photodiode	4	Ceramic	Box	4.0	6	6	6	Yes	-	0.15 J
39	XACT, Torque Rod Bracket	3	Aluminum 6061-T6	Box	7.8	17	17	17	No	-	Demise
40	Ferrite Rod	3	Ferrite	Box	15.0	13	13	13	No	-	Demise
41	36AWG Magnet Wire	3	Copper	Box	7.5	18	18	18	No	-	Demise
42	XACT, BAFFLES	1	Aluminum 6061-T6	Box	51.0	79	79	79	No	-	Demise

43	XACT, RW3 DAMPER, CLAMP	1	Aluminum 6061-T6	Box	6.0	28	28	28	No	-	Demise
44	XACT, CSS2, BLANKOFF	1	Aluminum 6061-T6	Box	4.0	19	19	19	No	-	Demise
45	XACT, CSS1, BLANKOFF	1	Aluminum 6061-T6	Box	4.0	27	27	27	No	-	Demise
46	0-80 SHCS .313L	2	A286	Box	0.3	3	3	3	No	-	Demise
47	0-80 FLTHD 0.500L	4	A286	Box	0.6	3	3	3	No	-	Demise
48	2-56 FLTHD 100 deg 0.125L	8	A286	Box	1.3	3	3	3	No	-	Demise
49	2-56 FLTHD 100 deg 0.188L	20	A286	Box	3.2	3	3	3	No	-	Demise
50	2-56 FLATHD 100 deg 0.25L	18	A286	Box	3.6	3	3	3	No	-	Demise
51	2-56 FLTHD 100 deg .313L	9	A286	Box	1.9	3	3	3	No	-	Demise
52	2-56 FLTHD 100 deg 0.438L	4	A286	Box	0.9	3	3	3	No	-	Demise
53	2-56 FLTHD 100 deg 0.625L	8	A286	Box	1.8	3	3	3	No	-	Demise
54	#2 Washer, 0.149 OD, 0.016 THK	21	A286	Box	3.4	3	3	3	No	-	Demise
55	2-56 JACKPOST .060" PANEL THICKNESS	2	18-8 Stainless	Box	0.8	4	4	4	No	-	Demise
56	XACT, Sun Sensor PWA	1	G10/FR4	Box	2.0	16	16	16	No	-	Demise
57	Spacecraft Harness	2	Copper	Wire	290.0	10	200	-	No	-	Demise