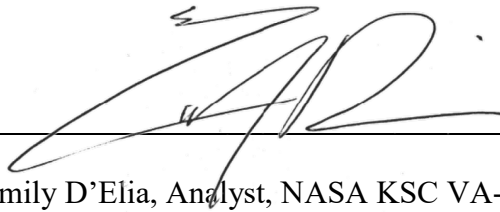


ELVL-2021-0046035
May 18, 2021

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

Signature Page



Emily D'Elia, Analyst, NASA KSC VA-H1



Liam Cheney, Mission Manager, NASA KSC VA-C

National Aeronautics and
Space Administration



John F. Kennedy Space Center, Florida
Kennedy Space Center, FL 32899

ELVL-2021-0046035
May 18, 2021

Reply to Attn of: VA-H1

TO: Liam Cheney, LSP Mission Manager, NASA/KSC/VA-C
FROM: Emily D'Elia, 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-8719.14B, 25 April 2019
- C. International Space Station Reference Trajectory, delivered December 2019
- 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 ELaN4 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. Debris Assessment Software User's Guide: Version 3.1, NASA/TP-2019-220300
- K. Blue Canyon Technologies Memo to UC Berkeley: Proprietary Material for ODAR, Rahul Chakravorty to David Sundkvist, 29 March 2021

The intent of this report is to satisfy the orbital debris requirements listed in ref. (a) for the CURIE CubeSat launching on the VCLS Demo 2 Astra Mission. 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 report 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 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

Section 1: Program Management and Mission Overview

CURIE is sponsored by the Human Exploration and Operations Mission Directorate at NASA Headquarters. The Program Executive is Sam Fonder. 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 VCLS Demo 2 Astra mission. The current launch date is planned for December 15, 2021. DAS version 3.1.2 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 4.994 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	9.08
After CURIE A/B separation on orbit	2	366.0 x 100.0 x 100.0	4.54

The following pages describe the CURIE CubeSat.

CURIE – University of California, Berkeley – 6U

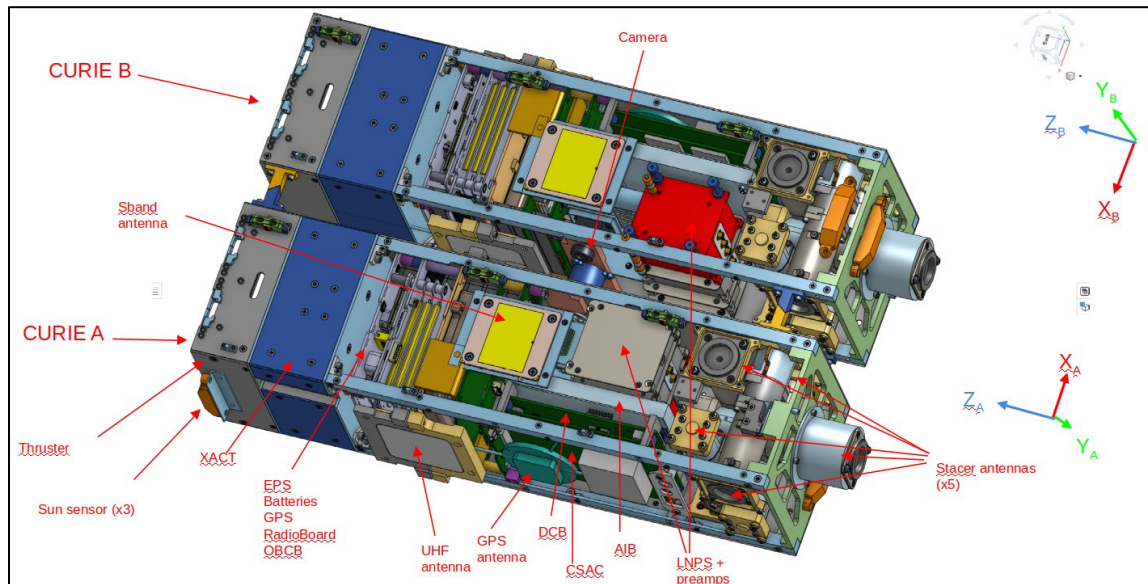


Figure 1: CURIE Component View

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 $\pm X$ 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 $\pm Y$ 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 CO₂ 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, with respect to 3U and smaller CubeSats, 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 CubeSat batteries still meet Req. 56450 (4.4-2) by virtue of the 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.” (ref. (h))

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 4.994 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.

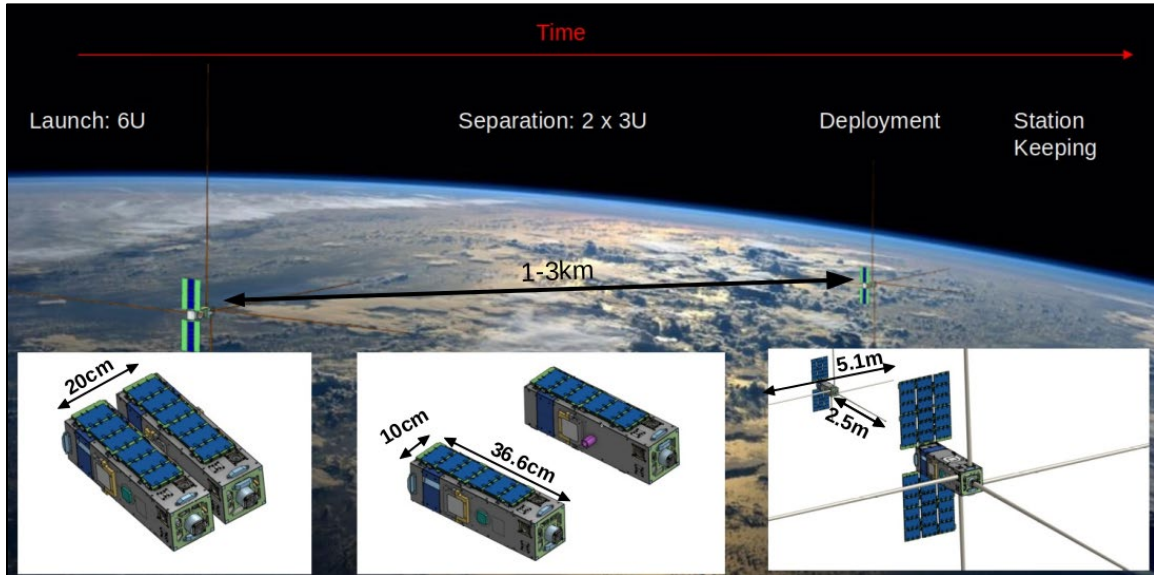


Figure 2: CURIE As-Deployed View

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

Equation 1: Mean Cross Sectional Area for Convex Objects

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

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 Equation 1. This configuration renders the longest orbital life times for all CubeSats.

Once a CubeSat is 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 500-km circular orbit at a 41° inclination. With an area to mass ratio of 0.0078 m²/kg, DAS yields 4.994 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)	9.08
Individual 3U Mass (kg)	4.54

6U Stowed	Mean C/S Area (m²)	0.0710
	Area-to Mass (m²/kg)	0.0078
	Orbital Lifetime (yrs)	4.994
	Probability of collision (10^X)	0.0000

3U Stowed	Mean C/S Area (m²)	0.0416
	Area-to Mass (m²/kg)	0.0092
	Orbital Lifetime (yrs)	4.402
	Probability of collision (10^X)	0.0000

Deployed**	Mean C/S Area (m²)	0.1154
	Area-to Mass (m²/kg)	0.0254
	Orbital Lifetime (yrs)	2.360
	Probability of collision (10^X)	0.0000

Solar Flux Table Dated 03/30/2021

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

Table 3: CubeSat Orbital Lifetime & Collision Probability

The probability of CURIE colliding with debris or meteoroids greater than 10 cm in diameter that are capable of preventing post-mission disposal is less than 0.00000, for any configuration. 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:

$$\frac{\text{Mean } C/S \text{ Area } (m^2)}{\text{Mass } (kg)} = \text{Area} - \text{to} - \text{Mass} \left(\frac{m^2}{kg} \right)$$

Equation 3: Area to Mass

$$\frac{0.0710 \text{ m}^2}{9.08 \text{ kg}} = 0.0078 \frac{\text{m}^2}{\text{kg}}$$

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: 500-km circular orbit with a 41° inclination at deployment no earlier than December 2021. An area to mass ratio of ~0.0078 m²/kg for the CURIE CubeSat was used. DAS yields a 4.994 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	0.00	0.04
UHF Patch Antenna	Ceramic, Acetal	0.110	0.00	11.76
GPS Antenna	Ceramic	0.023	0.00	5.40
XACT, RWA, Magnets	Proprietary Material #1**	0.019	76.10	-
XACT, RW DAMPER, ASY	Ti-6Al-4V	0.010	77.80	-
XACT, RW3 DAMPER, ASY	Ti-6Al-4V	0.007	77.80	-
Photodiode	Ceramic	0.004	0.00	0.33
STAR TRACKER LENSES	Fused Silica	0.025	75.2	-

** 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	1:0

*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. This is why CURIE has a 1:0 probability, as none of its components have more than 15J of energy.

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. D'Elia
Flight Design Analyst
NASA/KSC/VA-H1

cc: VA-H/Mr. Carney
VA-H1/Mr. Beaver
VA-H1/Mr. Haddox
VA-C/Mr. Higginbotham
VA-C/Mr. Cheney
AIS2/Mrs. Pariso
SA-D2/Mr. Frattin
SA-D2/Mr. Hale
SA-D2/Mr. Henry
Analex-3/Mr. Davis
Analex-22/Ms. Ramos

Appendix Index:

Appendix A. CURIE Component List

Appendix A. CURIE Component List

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		Al-6061-T6	Box	9080	226.3	366	100	No	-	Demise
	CURIE as 3U		Al-6061-T6	Box	4540	100	366	100	No	-	Demise
2	Chassis Walls	1	Al-6061-T6	Box	290	100	280	100	No	-	Demise
3	Chassis Rails	4	Al-6061-T6	Box	400	11	280	11	No	-	Demise
4	Chassi End Plate	2	Al-6061-T6	Plate	140	98	98	2.5	No	-	Demise
5	XACT Interface Plate	1	Al-6061-T6	Plate	70	98	98	2.5	No	-	Demise
6	Cubesat Separation Mechanism	1	Al-6061-T6 + stainless steel hardware	Box	40	30	94	16	No	-	Demise
7	Separation Frangibolt	1	Ti-6Al-4V	Cylinder	1	3	35	3	Yes	3045	0.04 J
8	Avionics Stack	1	FR4, Aluminum, Stainless Steel Li Ion batteries	Box	670	95	88	95	No	-	Demise
9	Instrument Stack	1	FR4, Aluminum, Stainless Steel	Box	280	98.0	102.0	41.0	No	-	Demise
10	Preamplifier Stack	1	FR4, Aluminum, Stainless Steel	Box	160	48.0	69.0	98.0	No	-	Demise
11	Solar Panels	6	FR4, silicon, bronze, Stainless Steel	Plate	2160	236	287	15	No	-	Demise
12	Stacer Enclosure	5	Aluminum, PEEK, Stainless Steel	Cylinder	685	41	98	33	No	-	Demise
13	Stacer Boom	5	BeCu	Tube	375	6	2600	6	No	-	Demise
14	Stacer Frangibolt	10	Ti-6Al-4V	Cylinder	5	4	15	4	No	-	Demise
15	UHF patch antenna	2	Ceramic, Acetal	Plate	110	60	70	9	Yes	3632	11.76 J
16	S-band patch antenna	2	FR4, Aluminum	Plate	32	63	45	2.6	No	-	Demise
17	GPS antenna	1	Ceramic	Plate	23	36	36	7	Yes	3632	5.40 J
18	Cameras	2	Aluminum, Plastic	Box	20	45	30	30	No	-	Demise
19	Thruster Frame	1	Aluminum	Box	150	100	35	100	No	-	Demise
20	CO2 canister	1	Steel	Cylinder	44	18	75	18	No	-	Demise

21	Pressure regulator	1	Steel	Cylinder	90	26	28	26	No	-	Demise
22	Canister Piercing Motor	1	Steel, Copper	Cylinder	160	22	74	22	No	-	Demise
23	Gears	1	Stainless Steel, Aluminum	Cylinder	10	30	10	30	No	-	Demise
24	XACT, HOUSING	1	Aluminum 6061-T6	Box	228	100	100	50	No	-	Demise
25	XACT, HOUSING COVER	1	Aluminum 6061-T6	Box	25	55	55	55	No	-	Demise
26	PWA, XACT Controller	1	G10/FR4	Box	53	77	77	77	No	-	Demise
27	XACT, RWA, Wheel	3	416 SS	Box	198	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	27.75	28	28	28	No	-	Demise
30	XACT, RWA, Motor	3	Copper	Box	60	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	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	37	37	37	No	-	Demise
35	STAR TRACKER LENSES	1	Fused Silica	Box	25	25	25	25	Yes	3119	Demise
36	STAR TRACKER FOCAL PLANE	1	Aluminum 6061-T6	Box	10	29	29	29	No	-	Demise
37	XACT, CSS, Housing	1	Aluminum 6061-T6	Box	4	19	19	19	No	-	Demise
38	Photodiode	4	Ceramic	Box	4	6	6	6	Yes	-	0.33 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	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	79	79	79	No	-	Demise
43	XACT, RW3 DAMPER, CLAMP	1	Aluminum 6061-T6	Box	6	28	28	28	No	-	Demise
44	XACT, CSS2, BLANKOFF	1	Aluminum 6061-T6	Box	4	19	19	19	No	-	Demise
45	XACT, CSS1, BLANKOFF	1	Aluminum 6061-T6	Box	4	27	27	27	No	-	Demise
46	0-80 SHCS .313L	2	A286	Box	0.32	3	3	3	No	-	Demise

47	0-80 FLTHD 0.500L	4	A286	Box	0.64	3	3	3	No	-	Demise
48	2-56 FLTHD 100 deg 0.125L	8	A286	Box	1.28	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	1.89	3	3	3	No	-	Demise
52	2-56 FLTHD 100 deg 0.438L	4	A286	Box	0.88	3	3	3	No	-	Demise
53	2-56 FLTHD 100 deg 0.625L	8	A286	Box	1.84	3	3	3	No	-	Demise
54	#2 Washer, 0.149 OD, 0.016 THK	21	A286	Box	3.36	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	16	16	16	No	-	Demise