Orbital Debris Assessment for
The Multiview Onboard Computational Imager (MOCI) CubeSat
per NASA-STD 8719.14B

RECORD OF REVISIONS		
REV	**Description**	**Date**
0	Original	**2/1/2021**

Table: 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 incapable of debris-producing failure.
4.4-2	Compliant	On board energy source 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	
4.6-1a	Compliant	Worst case lifetime 1.9 years
4.6-1b	Not applicable	
4.6-1c	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	MOCI has no planned tether release.

Section 1: Program Management and Mission Overview

MOCI is sponsored by the University Nanosatellite Program, which is administered by the Air Force Office of Scientific Research (AFOSR), the Air Force Research Laboratory (AFRL), the American Institute of Aeronautics and Astronautics (AIAA), the Space Development and Test Wing, and the AFRL Space Vehicles Directorate's Spacecraft Technology Division. The Program Manager is Jeff Ganley.

Responsible program/project manager and senior scientific and management personnel for MOCI are as follows:

Deepak Mishra, Principal Investigator, University of Georgia

Program Milestone Schedule	
Task	**Date**
CubeSat Selection	
CubeSat Delivery to VoxSpace	**September 2021**
Launch	**December 2021**

Figure 1: Program Milestone Schedule

MOCI will be launched as a secondary payload into ISS orbit. The launch vehicle and date are to be determined. The choice of ISS orbit is motivated by launch availability and the general adequacy of ISS orbit for this Earth-observation mission.

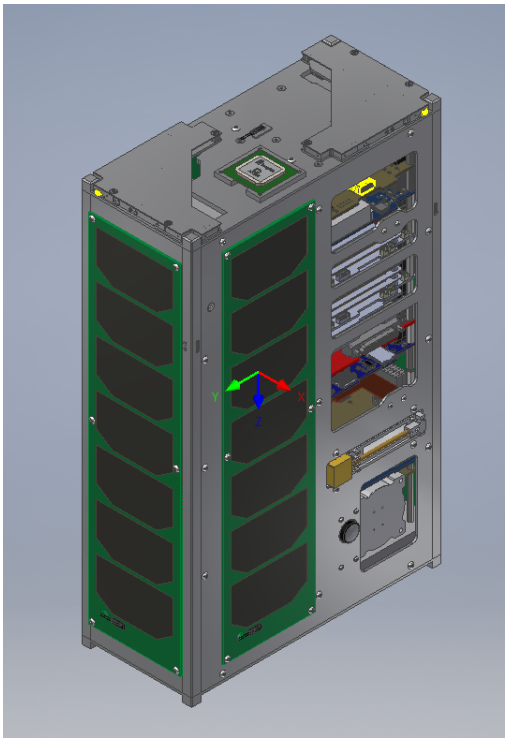
MOCI conforms to the 6U XL CubeSat form factor. The purpose of the mission is to demonstrate the in-orbit production of end-product data using Structure-from-Motion, as well as the use of a ground-trained neural network to perform object tracking.

Section 2: Spacecraft Description

Table 2 outlines the generic attributes for the MOCI CubeSat

CubeSat Name	Quantity	Size	Mass (kg)
MOCI	1	6U XL (36.6 x 22.6 x 11.0 cm^3)	7.5 +/- 2kg

Table 2: MOCI CubeSat form description



Overview: MOCI will gather image data of target objects on Earth (which may be landforms or certain moving objects) and then produce two types of end-product data: Digital Elevation Models (DEMs) and raw images. The mission will demonstrate the capabilities of on-orbit image processing using Structure-from-Motion, as well as object identification with a ground-trained neural network.

CONOPS: MOCI will deploy from the International Space Station, where it will wait 45 minutes before deploying one UHF antenna. It will go into a detumble submode, generate power, and perform initial health checks before entering a nominal cruising mode. MOCI will use a

camera with a low-power integrated circuit to take pictures of targets on the ground between latitudes -51.64 and 51.64.

Materials

The CubeSat structure is made of Aluminum 6061-T6. It contains all standard commercial off the shelf (COTS) materials, electrical components, PCBs and solar cells.

Hazards

There are no pressure vessels, hazardous or exotic materials.

Power System/Batteries

The electrical power storage system consists of 2 Clyde Space 40 Whr CubeSat Lithium ion Battery. Clyde Space will provide certification that the batteries have met testing levels required for manned space flight.

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.

The 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 and4.3-2.

No releases are planned on the MOCI CubeSat mission, 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 on the MOCI mission.

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 (ref (h)).

The CubeSats 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))

MOCI is a 6U XL CubeSat. Therefore, it is covered by the rationale concerning CubeSat batteries contained by 6U XL or smaller CubeSats mentioned in 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 prevents a catastrophic failure, so that passivation at EOM is not necessary to prevent an explosion or deflagration large enough to release orbital debris.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4 shows that with a maximum CubeSat lifetime of 1.9 years maximum, MOCI 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.

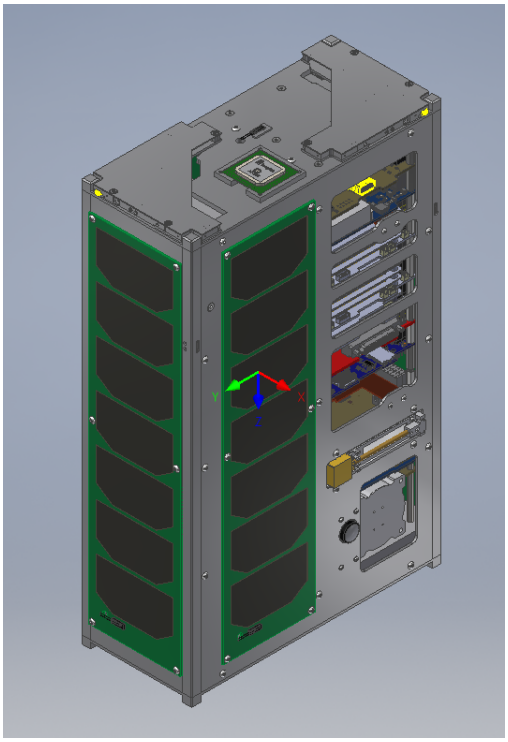


Figure 2: MOCI Isometric View

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

Equation 1: Mean Cross Sectional Area (CSA) for Convex Objects

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

Equation 2: Mean Cross Sectional Area for Complex Objects

MOCI is stowed in a convex configuration, indicating there are no elements of the CubeSat obscuring another element of the same CubeSat from view. Thus, mean CSA for stowed MOCI was calculated using Equation 1. This configuration renders the longest orbital life time for MOCI.

Once MOCI has been ejected from the NanoRacks dispenser and deployables have been extended, Equation 2 is utilized to determine the mean CSA. Amax is identified

as the view that yields the maximum cross-sectional area. A1 and A2 are the two cross-sectional areas orthogonal to A_{max}.- Refer to Appendix A for component dimensions used in these calculations. Given the negligible size of the MOCI antennae, Equation 1 and Equation 2 yield nearly the same result.

The MOCI (7.5 kg) orbit at deployment is projected to be 418 km apogee altitude by 418 km perigee altitude, with an inclination of 51.6 degrees. With an area to mass ratio of 0.041 m2/kg, DAS yields 1.9 years for orbit lifetime for its stowed state, which in turn is used to obtain the collision probability. MOCI shows a 0.0 probability of collision.

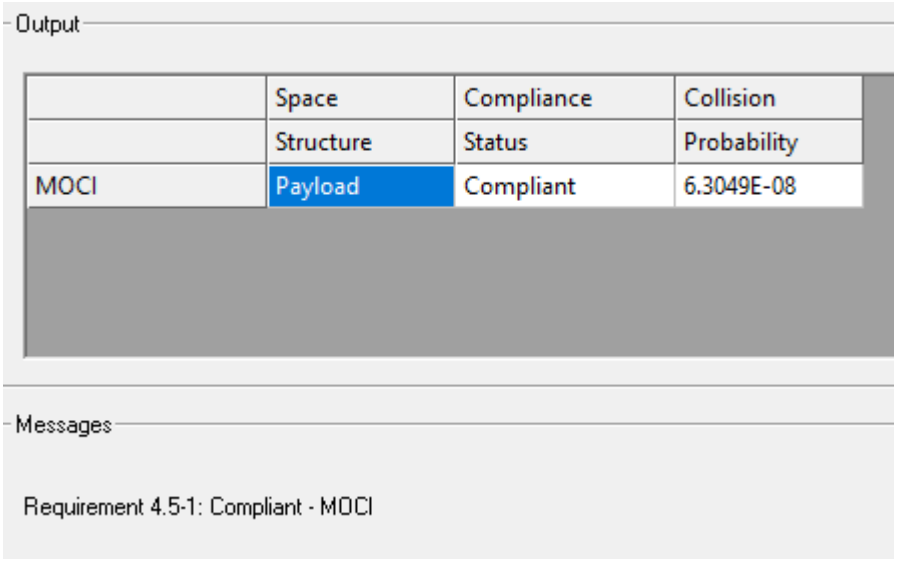
There will be no post-mission disposal operation. As such, the identification of all systems and components required to accomplish post-mission disposal operation, including passivation and maneuvering, is not applicable.

	CubeSat	**MOCI**
	Mass (kg)	**7.5 +/- 2kg**
	Mean C/S Area (m^2)	
	Area-to Mass (m^2/kg)	
	Orbital Lifetime (years)	**1.9**
	Probability of Collision	**0.0000**

*antenna area is negligible with respect to lifetime/collision risk calculations

Solar Flux Table Dated
12/16/2020

Table 3: CubeSat Orbital Lifetime & Collision Probability



The probability MOCI having a collision with debris and meteoroids greater than 10 cm in diameter and 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.

Since MOCI has no capability or plan for end-of-mission disposal, requirement 4.5-2 is not applicable.

Assessment of spacecraft compliance with Requirements 4.5-1 shows MOCI be Compliant.

MOCI has no capability or plans for end-of-mission disposal, therefore Requirement 4.5-2 is not applicable. MOCI will passively reenter and therefore this ODAR also serves as the EOMP (End of Mission Plan).

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

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

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

Calculating the area-to-mass ratio for the worst-case (smallest Area-to-Mass) postmission disposal among the CubeSats finds MOCI in its stowed configuration as the worst case. The area-to-mass is calculated as follows:

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

Equation 3: Area to Mass

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

DAS 2.1.1 Orbital Lifetime Calculations:
DAS inputs are: 410 km maximum apogee by 397 km maximum perigee altitudes with an inclination of 51.6° at deployment no earlier than December 2021. An area to mass ratio of 0.04 m2/kg for the MOCI CubeSat was used. DAS 2.1.1 yields a 1.9 years orbit lifetime for MOCI in its stowed state.
This meets requirement 4.6-1.

Section 7: Assessment of Spacecraft Reentry Hazards

A detailed assessment of the components of the MOCI CubeSat was performed. The assessment used DAS 3.1.0, 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 components 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 the survive reentry.

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

Table 4: MOCI High Melting Temperature / Large Component Analysis

Name	Material	Thermal Mass	Demise Alt	KE
305A-1W	Glass	0.0296	78	0
305A-2S	Glass	0.03369	78	0
305A-3S	Glass	0.05074	78	0
305S-4S	Glass	0.02952	78	0
305A-5S	Glass	0.02981	78	0
305A-6S	Glass	0.03984	78	0
305A-7S	Glass	0.02877	78	0
305A-8BS	Glass	0.065	78	0
305A-108 BARREL	Aluminum 6061-T6	0.40099	73.5	0
EM-PD-MT-003	Aluminum 6061-T6	0.135	74.9	0
EM-PD-MT-004	Aluminum 6061-T6	0.096	75.5	0
EPS Motherboard	Fiberglass	0.148	75.7	0
EPS 40Whr Batteries	Aluminum 6061-T6	0.335	71.6	0
Solar Panels	Fiberglass	0.54	74.1	0
S-Band Antenna	Aluminum 6061-T6	0.05	76.5	0
GPS Antenna	Copper Alloy	0.1	73.5	0
UHF Antenna	Silver Element	0.1	77.1	0
S-Band Transmitter	Fiberglass	0.095	76.3	0
UHF Transceiver	Fiberglass	0.085	76.5	0
CubeComputor	Fiberglass	0.1	76.2	0
CubeCoil	Copper Alloy	0.046	76.7	0
CubeConnect	Fiberglass	0.023	77.2	0
CubeTorquers	Aluminum 6061-T6	0.036	75.5	0
CubeControl	Fiberglass	0.145	75.5	0
CubeStar	Fiberglass	0.0555	76.4	0
Deployable Magnetometer	Aluminum (generic)	0.0091	77.1	0
Backup Magnetometer	Aluminum (generic)	0.0062	76.3	0
CubeSense V3	Fiberglass	0.03	76.2	0
CubeWheel	Aluminum 6061-T6	0.15	71	0
CSS	Copper Alloy	0.0003	77.6	0
OBC Motherboard	Fiberglass	0.0619	77	0
CAIB Board	Fiberglass	0.05847	76.8	0
Face X-	Aluminum 6061-T6	0.176	76.8	0
Face X+	Aluminum 6061-T6	0.187	76.8	0
Face Y-	Aluminum 6061-T6	0.059	77.3	0

Face Y+	Aluminum 6061-T6	0.069	77.2	0
Frame End Z-	Aluminum 6061-T6	0.265	74.7	0
Frame End Z+	Aluminum 6061-T6	0.203	75.4	0
Internal Structure	Aluminum 6061-T6	0.208	75.8	0
MOCI Rail X+Y-	Aluminum 6061-T6	0.055	77.2	0
MOCI Rail X-Y+	Aluminum 6061-T6	0.055	77.2	0
Magnetometer plate	Aluminum 6061-T6	0.185	73.2	0
Corgi Collar	Aluminum 6061-T6	0.143	73.9	0
CubeSense V2 Standoff	Aluminum 6061-T6	0.001	77.2	0

The majority of components demise upon reentry. This CubeSat 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
MOCI	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 CubeSats that have surviving components like MOCI have a 1:0 probability as none of its components have more than 15J of energy.

MOCI is shown to be in compliance with Requirement 4.7-1 of NASA-STD-8719.14A.

Section 8: Assessment for Tether Missions

MOCI will not be deploying any tethers.
MOCI satisfies Section 8's requirement 4.8-1.

Appendix Index:

Appendix A. MOCI Component List

Row Number	Name	Qty	Material	Body Type	Mass (g)	Diameter/ Width (mm)	Length (mm)	Height (mm)
1	Multiview Onboard Computational Imager (MOCI)	1		Cube	3.619826389	106.7	109.81	344
2	Ruda Optics	1		Cube	1.8112	93	93	130.5
2.1.1	Lenses				0			
2.1.2	305A-1W	1	Fused Silica BK7 glass	Cylinder	0.0296	50	50	4
2.1.3	305A-2S	1	N-LAK7	Cylinder	0.2103	47	47	6.45
2.1.4	305A-3S	1	N-KZFS4	Cylinder	0.1556	48	48	13.07
2.1.5	305S-4S	1	N-SK5	Cylinder	0.1259	47	47	10.391
2.1.6	305A-5S	1	N-SF10	Cylinder	0.1147	47	47	9.459
2.1.7	305A-6S	1	N-KZFS4	Cylinder	0.1127	47	47	10.719
2.1.8	305A-7S	1	S-BAL41	Cylinder	0.0297	47	47	9
2.1.9	305A-8BS	1	N-BK7	Cuboid	0.065	30	30	30
2.1.10	Camera Housing				0			
2.1.11	305A-101 LENS, RETAINER 1W	1		Cylinder	0.04273	67	67	11.25
2.1.12	305A-102 BOND RING, 2S	1		Cylinder	0.028477	67	67	7.25
2.1.13	305A-103 BOND RING, 3S	1		Cylinder	0.057762	72	72	11.6
2.1.14	305A-104 BONG RING, 4S	1		Cylinder	0.043082	72	72	8.5
2.1.15	305A-105 BOND RING, 5S	1		Cylinder	0.061634			
2.1.16	305A-106 BOND RING, 6S	1		Cylinder	0.053324			
2.1.17	305A-107 BOND RING, 7S	1		Cylinder	0.035895			
2.1.18	305A-108 BARREL	1		Cylinder	0.40099			
2.1.19	305A-109 RING, RETAINER, 1W	1		Cylinder	0.00497	52.07	52.07	4.75
2.1.20	305A-110 MOUNT, CAMERA, MONOCHROME	1		Box	0.04933	60	82	88.5
2.1.21	305A-113 BAFFLE, 35.4mm	1		Box	0.004687			
2.1.22	305A-114 BAFFLE, 32.8mm	1		Box	0.006738			
2.1.23	305A-115 BAFFLE, 29.6mm	1		Box	0.009407			
2.1.24	305A-116 BEAMSPLITTER, HOUSING	1		Box	0.07518			
2.1.25	305A-117 PLATE, MOUNTING, BEAMSLPITTER BARREL	1		Box	0.10243			
2.1.26	305A-119 BEAMSPLITTER, BACK, HOUSING	1		Box	0.00595			
2.1.27	305A-120 RING, TEFLON, 1W	1		Box	0.000125			
2.1.28	305A-121 SHIM, SPACER, MONOCHROME ESTIMATED	1		Box	0.005			
2.1.29	305A-122 CAP, LENS, UGA	1		Box	0.03458			
2.1.19	Camera Mounting Frame				0			

2.1.20	EM-PD-MT-003	1	AL 6061-T6	Cuboid	0.135	80	69.3	50
2.1.21	EM-PD-MT-004	1	AL 6061-T6	Cuboid	0.096	80	43.25	50
2.1.39	Fasteners				0			
2.1.40	Machine Screw Hex Flat M3x20	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.41	Machine Screw Hex Flat #4-40 x 3/8"	8	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.42	Machine Screw Hex Flat #4-40 x 1/2"	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.43	Machine Screw Button #2-56 x 3/16"	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.44	Machine Screw Hex Flat M3 x 14	2	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.45	Machine Screw Hex Button M1.6 x 4	2	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.46	Machine Screw Hex Button M2.0 x 5	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.47	Machine Screw Hex Button M3 x 20	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.48	Machine Screw Hex Button M2.0 x 10	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.49	Machine Screw Hex Button M2.0 x 4	8	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.50	Machine Screw Hex Flat #4-40 x 1/4"	35	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.51	Machine Screw Hex Button #4-40 x 3/16"	18	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.52	Hex Socket Flat Countersunk Screw 0-80 UNF x 0.25	6	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.53	Countersunk Screw w/ H Cross Recess M2 x 8	2	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.54	Machine Screw Hex Button #4-40 x 7/16"	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.55	Hex Nut #4-40	28	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.56	Hex Nut #2-56	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.57	Hex Nut #0-80	6	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.58	Machine Screw Hex Button #4-40 x 1/4"	12	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.59	Machine Screw Hex Button #4-40 x 5/16"	6	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.1.60	Machine Screw Hex Button #4-40 x 7/16"	4	18-8 Stainless Steel	Cylinder	0.1	-	-	-
2.2	Cameras				181.1			
2.2.1	ImperX	1			379	72	34.7	72

2.2.2	Flir Blackfly	1			0			
2.3	Jetson TX2i				131			
2.3.2	Heat Strap	1	Aluminium 6063 T5	Cuboid	5	0.5	35.325	54.5
2.3.5	PCB Board	2	PCB Material	Cuboid	0			
2.3.6	Electronic Connectors	1	Polyamide	Cuboid	0			
2.3.7	Electronic Connectors	1	Brass	Cuboid	0			
2.3.8	Electronic Connectors	1	Phosphor Copper	Cuboid	0			
3	EPS				0			
3.1	EPS Mother Board	1	-		0.148	90.17	95.9	27.86
3.1.1	Adhesive Fixing	-	Araldite 2014 Epoxy	Cuboid		-	-	-
3.1.2	Conformal Coating	-	1B31 Acrylic	-		-	-	-
3.1.3	Adhesive Fixing on Modifications	-	DC 6-1104	-		-	-	-
3.1.4	Adhesive Fixing	-	Stycast 2850	-		-	-	-
3.1.5	PCB Board	-	FR4	-		-	-	-
3.1.6	Low activity flux to avoid corrosion	-	Flux	-		-	-	-
3.1.7	PEMs	-	300 Series Stainless Steel	-		-	-	-
3.1.8	Expansion Header	-	Berylium Copper	-		-	-	-
3.1.9	Cubesat Header	-	Vectra E-130i	-		-	-	-
3.1.10	Cubesat Header	-	Crastin SK662FR	-		-	-	-
3.1.11	Cubesat Header	-	Phosphor Bronze	-		-	-	-
3.1.12	Cubesat Header	-	Nickel Underplating	-		-	-	-
3.1.13	Cubesat Header	-	Gold	-		-	-	-
3.1.14	Electronic Connectors	-	Polyamide	-		-	-	-
3.1.15	Electronic Connectors	-	Brass	-		-	-	-
3.1.16	Electronic Connectors	-	Phosphor Copper	-		-	-	-
3.1.17	M3 Fasteners	-	A4 Stainless Steel (316L)	-		-	-	-
3.1.18	Solder	-	Solder	-		-	-	-
3.1.19	Low activity flux to avoid corrosion	-	Flux	-		-	-	-
3.2	EPS 40Whr Batteries	2	-	Cuboid	0.335	90.17	95.89	27.35
3.2.1	Adhesive Fixing	-	Araldite 2014 Epoxy	-		-	-	-
3.2.2	Conformal Coating	-	Arathane 5750	-		-	-	-
3.2.3	Adhesive fixing on modifications	-	DC 6-1104	-		-	-	-
3.2.4	Thermally Conductive RTV	-	Stycast 5952	-		-	-	-
3.2.5	IP Protective Layer	-	Stycast 2850	-		-	-	-
3.2.6	PCB Board	-	PCB Material	-		-	-	-

3.2.7	Cubesat Header	-	Vectra E-130i	-		-	-	-
3.2.8	Cubesat Header	-	Crastin SK662FR	-		-	-	-
3.2.9	Cubesat Header	-	Phosphor Bronze	-		-	-	-
3.2.10	Cubesat Header	-	Nickel Underplating	-		-	-	-
3.2.11	Cubesat Header	-	Gold	-		-	-	-
3.2.12	Electronic Connectors	-	Polyamide	-		-	-	-
3.2.13	Electronic Connectors	-	Brass	-		-	-	-
3.2.14	Electronic Connectors	-	Phosphor Copper	-		-	-	-
3.2.15	Solder Resist	-	CARAPACE EMP110	-		-	-	-
3.2.16	Solder	-	Solder SN62	-		-	-	-
3.2.17	Flux	-	Alpha Rosin Flux, RF800, ROL 0	-		-	-	-
3.3	Solar Panels		-	Cuboid	0.54			
3.3.1	Full Panel	5	FR4 PCB	Cuboid	4.6	1.6	83	322
4	COMM				0			
4.1	Antenna			Cylinder	0			
4.1.1	S-Band Antenna	1	-	Cylinder	0.05	89	89	13.6
4.1.2	GPS Antenna	1	Composite	Cuboid	0.1	56	56	7.6
4.1.3	UHF Antenna	2	-	Cuboid	0.1	102	102	13
4.2	Communication Boards				0			
4.2.1	S-Band Transmitter	1	-	Cuboid	0.095	90.17	95.89	18.77
4.2.2	UHF Transceiver	1	-	Cuboid	0.085	90.17	95.89	18.09
5	ADCS				25.5			
5.1.1	CubeComputor	1		Cuboid	0			
5.1.2	CubeCoil	1		Cuboid	0.046	90	96	6
5.1.3	CubeConnect	1		Cuboid		-	-	-
5.1.4	CubeTorquers	2		Cuboid	0.036	18	14	77
5.1.5	CubeControl	1		Cuboid	0.145	90	96	19.5
5.1.6	CubeStar	1		Cuboid	0.0555	50	35	55
5.1.7	Deployable Magnetometer	1		Cuboid	0.0091	83.3	17.2	6.7
5.1.8	Backup Magnetometer	1		Cuboid	0.0062	23.4	16.8	8.1
5.1.9	CubeSense V3	2		Cuboid	0.03	41.7	17.7	26
5.1.10	CubeWheel	3	AL 6061-T6	Cuboid	0.15	46	46	31.5
5.1.11	CSS	10	PCB	Cuboid	0.0003	-	-	-
5.1.12	Magnetometer Mounting Bracket	1		Cuboid				
6	Command and Data Handling				0			
6.1	OBC Motherboard	1	-	Cuboid	0.0619	95.89	90.17	23.24
6.1.1	Adhesive Fixing	-	Araldite 2014 Epoxy	-		-	-	-
6.1.2	Conformal Coating	-	1B31 Acrylic	-		-	-	-

6.1.3	PCB Board	-	FR4	-		-	-	-
6.1.4	-	-	CARAPACE EMP110 or XV501T-4	-		-	-	-
6.1.6	Expansion Header	-	Berylium Copper	-		-	-	-
6.1.7	Cubesat Header	-	Vectra E-130i	-		-	-	-
6.1.8	Cubesat Header	-	Crastin SK662FR	-		-	-	-
6.1.9	Cubesat Header	-	Phosphor Bronze	-		-	-	-
6.1.10	Cubesat Header	-	Nickel Underplating	-		-	-	-
6.1.11	Cubesat Header	-	Gold	-		-	-	-
6.1.12	Electronic Connectors	-	Polyamide	-		-	-	-
6.1.13	Electronic Connectors	-	Brass	-		-	-	-
6.1.14	Electronic Connectors	-	Phosphor Copper	-		-	-	-
6.2	CAIB Board	1	-		0.05847	95.89	90.17	4.7
7	Structure				1.853388			
7.1	Frame				1.769	100	100	340.5
7.1.1	Face X-	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.176	2	209.3	349
7.1.2	Face X+	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.187	2	209.3	349
7.1.3	Face Y-	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.059	2	83	349
7.1.4	Face Y+	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.069	2	83	349
7.1.5	Frame End Z-	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.265	100	226.3	10.5
7.1.6	Frame End Z+	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.203	100	226.3	10.5
7.1.7	Internal Structure	1	Hard Anodized Aluminum 6061-T6	-	0.208	5.5	96	346
7.1.8	MOCI Rail X+Y-	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.055	18.75	18.75	366

7.1.9	MOCI Rail X-Y+	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.055	18.75	18.75	366
7.1.10	MOCI Rail with sep springs X+Y-	1	Hard Anodized Aluminum 6061-T6	-	0.055	18.75	18.75	366
7.1.11	MOCI Rail with sep springs X-Y+	1	Hard Anodized Aluminum 6061-T6	-	0.055	18.75	18.75	366
7.1.12	Magnetometer plate	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.185	104.5	96	7
7.1.13	Corgi Collar	1	Hard Anodized Aluminum 6061-T6	Cuboid	0.143	88.17	88.17	14.94
7.1.14	CubeSense V2 Standoff	2	Hard Anodized Aluminum 6061-T6	Cuboid	0.003	7.7	5.5	5
7.1.15	CubeStar Mounting Bracket	1	Hard Anodized Aluminum 6061-T7	-	0.048	-	-	-
7.1.16	Rail Deployment Switch	3	Generic	Cuboid	1	-	-	-
7.2	Heat Straps	-	-	-	0.0295			
7.1.23	Heat Strap UTRX	1	C10100 OFHC Copper	-	0.0235	-	-	-
7.1.24	Heat Strap STX	1	C10100 OFHC Copper	-	0.006	-	-	-
7.2	Standoffs				0.054888			
7.2.28	ADCS RWs to OBC 1	4	18-8 Stainless Steel	-	0.001376	6	17	-
7.2.29	ADCS RWs to OBC 2	4	18-8 Stainless Steel	-	0.001295	6	16	-
7.2.30	OBC to CAIB	4	18-8 Stainless Steel	-	0.000971	6	12	-
7.2.31	ADCS RW to ADCS mobo	4	18-8 Stainless Steel	-	0.000971	6	12	-
7.2.32	ADCS mobo to UHF	4	18-8 Stainless Steel	-	0.001295	6	16	-
7.2.33	UHF to S-Band	4	18-8 Stainless Steel	-	0.001295	6	16	-
7.2.34	Struct to EPS-MB	4	18-8 Stainless Steel	-	0.001016	6	12.55	-
7.2.35	Battery to EPS-MB	8	18-8 Stainless Steel	-	0.002	6	25	-
7.2.37	Caib to Payload standoff	4	18-8 Stainless Steel	-	0.001457	6	18	-
8	Miscellaneous Components				0			

8.1	Conformal Coating	1	-	-	0.02	-	-	-
8.2	Vibra-Tite Thread Adhesive	1	-	-	0.008	-	-	-
8.3	Wiring Harness	1	-		0.175	-	-	-