National Aeronautics and
Space Administration

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Reply to Attn of: VA-H1

May 23, 2018

TO: Scott Higginbotham, LSP Mission Manager, NASA/KSC/VA-C

FROM: Yusef Johnson, a.i. solutions/KSC/AIS2

SUBJECT: Analysis of Updated Mass Properties of the SORTIE CubeSat

REFERENCES:

A. *NASA Procedural Requirements for Limiting Orbital Debris Generation*, NPR 8715.6A, 5 February 2008
B. *Orbital Debris Assessment for the CubeSats on the CRS OA-9/ELaNa-23 Mission*, ELVL-2018-0045208 Rev 0, 16 November 2017

The intent of this memo is to show that updated mass properties for the SORTIE cubesat, still satisfies the orbital debris requirements listed in ref. (b) for the ELaNa-23 auxiliary mission launching on the CRS OA-9 vehicle.

This memo only contains updates to that section with respect to the changes in the SORTIE cubesat. These changes only affect Section 7 of the previously submitted ELaNa-23 ODAR. The CubeSat component which effected the change, is a more detailed accounting of the materials used for the antennae and their supporting structure. In the previously submitted ELaNa-23 ODAR, the antennae and their supporting structure was analyzed as a single structure with a total mass of 150 g. The spacecraft submitted updated information which presented the antennae and their supporting structure as separate entities, made of separate materials with different masses.

The result is that the antennae is now analyzed as a separate entity made of 410 Steel, weighing 25 g, and the antennae support structure is analyzed as a DELRIN 150 structure, weighing 125 g. This lower mass for the antennae leads to a lower kinetic energy on ground impact.

Section 7: Assessment of Spacecraft Reentry Hazards

A detailed re-assessment of SORTIE's components to be flown on ELaNa-23 was performed. The assessment used DAS 2.1.1, 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 the 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. Low melting temperature (less than 1000 °C) components are identified as materials that would never survive reentry and pose no risk to 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 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: ELaNa-21 High Melting Temperature Material Analysis

CubeSat	Name	Material	Total Mass (kg)	Demise Alt (km)	Kenetic Energy (J)
SORTIE	Antennae	Steel AISI 410	25	0	7
SORTIE	Separation Switches	Steel AISI 410	1.95	0	0
SORTIE	Fasteners	Steel AISI 316	125.86	77.3	0

The majority of stainless steel components demise upon reentry. And all CubeSats comply 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
SORTIE	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 SORTIE has a 1:0 probability as none of its surviving components have more than 15J of energy.

If you have any questions, please contact the undersigned at 321-867-2098.

/original signed by/

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Appendix A. ELaNa-21 Component List by CubeSat: SORTIE

Item Number	Name	Qty	Material	Body Type	Mass (g) (total)	Diameter / Width (mm)	Length (mm)	Height (mm)	High Temp	Melting Temp (F°)	Survivability
1	SORTIE	-	-	-	-	-	-	-	-	-	Demise
2	CubeSat Structure	1	Aluminum 6061	Box	3000	239.19	365	115.37	No		Demise
3	Antennae	1	Steel 410	whip	25	12.7	165	0.3	Yes	2700º	0
4	Antennae Structure	1	DELRIN 150	Box	125	38.6	67.95	43.18	No	-	Demise
5	Solar Panels	3	Aluminum honeycomb structure	plate	500	7.26	309.88	200	No	-	Demise
6	Sep Springs*	0	-	-	-	-	-	-	Yes	2500˚	Demise
7	Sep Switches	3	aluminum 6061 : steel 316 stainless	box	1.95	6.25	22.565	24.546	Yes	2500˚	Demise
8	Payload mIVM	1	Copper Alloy ;Aluminum 6061: FR-4	box	800	97.23	94.183	63.42	No	-	Demise
9	Payload uPLP	1	Copper Alloy ;Aluminum 6061: FR-4	box	300	82.55	100	2.68	No	-	Demise
10	Batteries	2 Packs	Lithium-Ion	box	1850	41.22	76.38	64.27	No	-	Demise
11	ADCS Components	1	PCB FR-4 ; FR-4 PCB ;	box	825	100	100	50	No	-	Demise
12	Comm Board	1	PCB FR-4 ;Aluminum 6061	box	350	82.5	82.5	17	No	-	Demise
13	Battery Board	1	PCB FR-4	PCB board	400	91.1	97.7	25.7	No	-	Demise
14	C&DH Board	1	PCB FR-4	PCB board	200	96	90	20	No	-	Demise
15	Fasteners*	203	18-8 Stainless Steel	Fastener	125.86	6.16	8.92	6.16	Yes		Demise
16	Cabling	-	Teflon insulated Copper alloy	-	-	-	-	-	No	-	Demise
17											Demise

*sep springs are part of sep switch assembly