

National Aeronautics and
Space Administration

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



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/

Yusef A. Johnson
Flight Design Analyst
a.i. solutions/KSC/AIS2

cc: VA-H/Mr. Carney
VA-H1/Mr. Beaver
VA-H1/Mr. Haddox
VA-C/Mr. Higginbotham
VA-C/Mrs. Nufer
VA-G2/Mr. Treptow
SA-D2/Mr. Frattin
SA-D2/Mr. Hale
SA-D2/Mr. Henry
Analex-3/Mr. Davis
Analex-22/Ms. Ramos

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Appendix A. Updated ELaNa-23 Component List by CubeSat: SORTIE

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 | 2700° | 0 |
| 4 | Antennae Structure | 1 | DELTRIN 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