Orbital Debris Assessment Report

Produced by Care Weather Technologies for the Hatchling Canary 1 Mission

In Accordance with NASA-STD 8719.14A

Revision History and Signatures

Revision	Notes	Produced By	Checked By	Date
A	First Revision	Patrick Walton CEO, Care Weather Technologies Hatchling Mission Manager	Alex Laraway CTO, Care Weather Technologies Hatchling System Engineer	8/8/2020
B	Added 550 km orbit possibility.	Patrick Walton CEO, Care Weather Technologies Hatchling Mission Manager	Alex Laraway CTO, Care Weather Technologies Hatchling System Engineer	8/11/2020

CAREWEATHER

Summary of Compliance

Sections 1 through 8 of Process for Limiting Orbital Debris, NASA-STD-8719.14A, 25 May 2012, are addressed in this document; sections 9 through 14 are in the domain of the launch provider and are addressed by others.

The following table summarizes the compliance status of the Hatchling Canary 1 spacecraft. It is fully compliant with all applicable requirements.

Table 1. Compliance Assessment Per Requirement

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	Batteries incapable of debris-producing failure
4.4-2	Compliant	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	

This report is intended to satisfy the orbital debris requirements listed in NASA Procedural Requirements for Limiting Orbital Debris Generation, NPR 8715.6A, 5 February 2008, for the Hatchling Canary 1 mission.

Section 1: Mission Overview

The primary objective of the Hatchling Canary 1 Mission is to test the performance of Care Weather's nanosatellite bus technologies, including power, computing, communications, structures, deployment mechanisms, and attitude determination and stabilization. Instrumentation on board the satellite will measure the performance of these systems. Performance data will be relayed to the ground over the communications link. Hatchling Canary (or Hatchling) is a forerunner to the Canary satellite system, which will add a wind-sensing radar, called a scatterometer, to fill critical gaps in U.S. weather monitoring capacity, provide unprecedented insight into tropical convection, and enable next-generation forecasts and advance warnings for our nation's most costly disasters.

Section 2: Spacecraft Description

Hatchling Canary 1 uses a 1p pocketqube platform with deployable solar arrays. In the stowed configuration, depicted in Fig. 1, Hatchling measures 5.2 cm x 5.8 cm x 6.4 cm. In the deployed configuration, Hatchling measures 40.6 x 40.6 x 22.9 cm. Hatchling's shuttlecock shape in the deployed configuration, depicted in Fig. 2, gives it a range of visible surface area between 0.011 m^2 and 0.038 m^2, depending on the viewing angle. This is greater than the range of visible surface area of a 3U CubeSat (0.01 m^2 to 0.03 m^2). To illustrate this, Figs. 3-6 depict Hatchling from a variety of viewing angles. The minimum visible surface area of Hatchling (0.011 m^2) corresponds to the side view shown in Fig. 4. The maximum surface area of Hatchling (0.038 m^2) corresponds to the top view shown in Fig. 3. All other viewing angles correspond to visible surface areas between these minimum and maximum bounds. This makes Hatchling Canary as trackable as a 3U CubeSat.

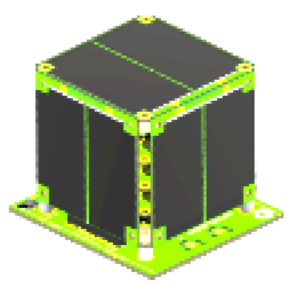

Figure 1. Hatchling Canary in the Stowed Configuration

Figure 2. Hatchling Canary in the Deployed Shuttlecock Configuration With Visible Surface Area Between 0.011 m^2 and 0.038 m^2.

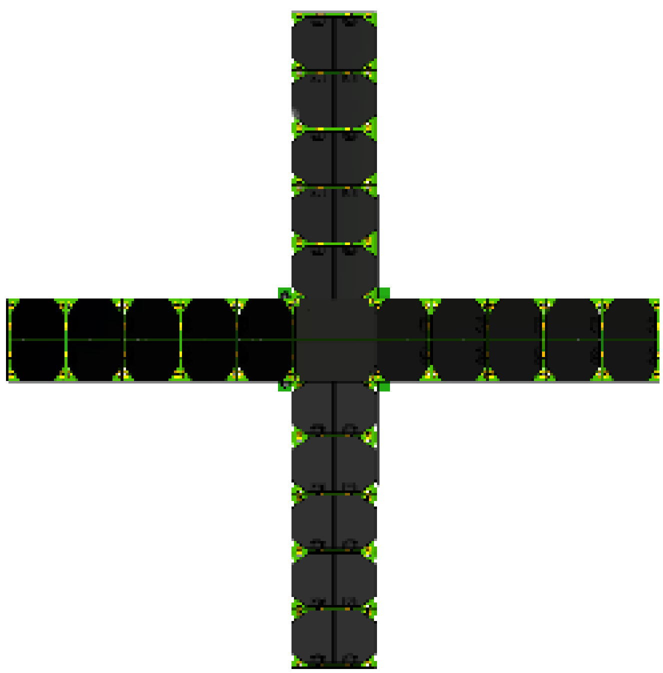

Figure 3. Top View of the Hatchling Canary Shuttlecock Corresponding to Maximum Visible Surface Area of 0.038 m^2 Equivalent to the Long Side of a 3U CubeSat.

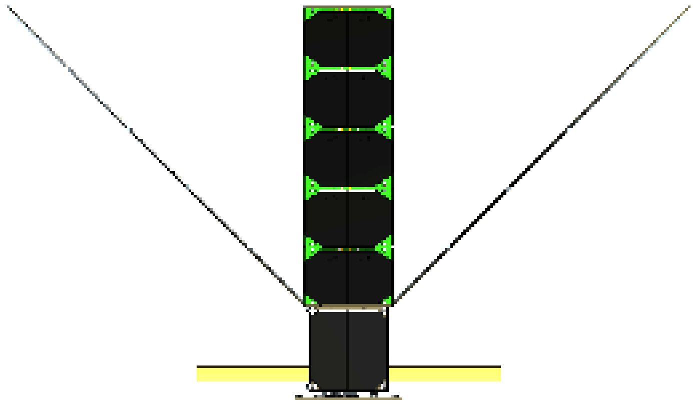

Figure 4. Side View of the Hatchling Canary Shuttlecock Corresponding to Minimum Surface Area of 0.011 m^2 Equivalent to the Small End of a 3U CubeSat.

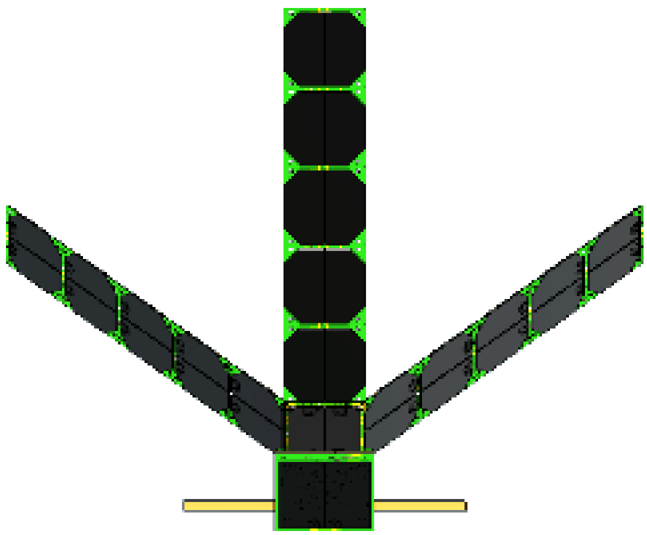

Figure 5. Lower Slant View of the Hatchling Canary Shuttlecock With Visible Surface Area Between 0.011 m^2 and 0.038 m^2.

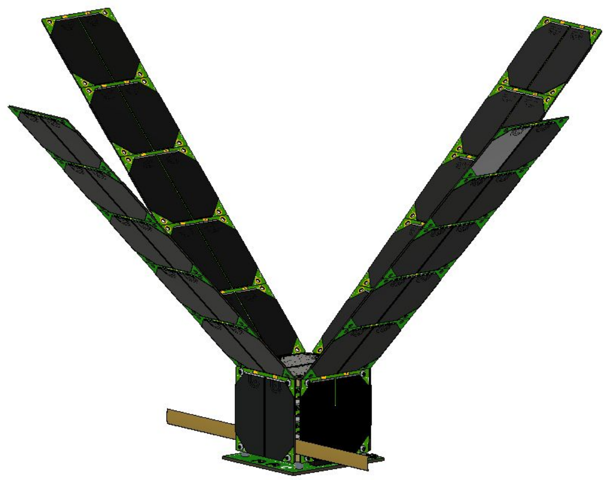

Figure 6. Side Slant View of the Hatchling Canary Shuttlecock With Visible Surface Area Between 0.011 m^2 and 0.038 m^2.

The Hatchling deployable solar array system builds on the Care Weather team's extensive experience in deployable space mechanisms, including hundreds of hours of environmental and fatigue testing and flight-qualified deployable panels and deployment mechanisms. Hatchling uses a burn wire mechanism to release the solar panels. During launch, the solar panels are restrained using nylon wires with knots that have been vibration qualified to the NASA GEVS 10grms specification. These nylon wires are tensioned against a nichrome wire. After Hatchling is released into orbit, a delay is initiated. After this delay, the command and computing subsystem engages a switch which allows high current to pass through the nichrome wire. This burns the nylon wires, which break and allow the spring-loaded panels to release into their deployed position.

Hazards

Hatchling Canary has no pressure vessels, hazardous materials, or exotic materials.

Batteries

Hatchling Canary has two Lithium-polymer (LiPo) batteries. The batteries are manufactured by Markyn and have model number GMB553448. Their characteristics are: 950 mAh and 3.7 V nominal. The manufacturer tests batteries for explosive failure under all protection methods and ensures batteries cannot fail in a way that would damage surrounding components.

The battery control circuitry has an extensive suite of protections that have been demonstrated through hundreds of hours of ground testing in hot and cool environments. Each battery has at least two methods of protection against each possible method of Lipo failure. These protections include:

1. Protection from over-charge voltage (in excess of 4.5V): The battery charger is set to output a max of 4.2V. When the battery reaches this float voltage, the charger directs current to the satellite system, bypassing the batteries and preventing over-charging. The microcontroller also continuously monitors charge current and can disable charging if an error condition is met.

2. Protection from over-charge current (in excess of 1000mA): The battery charger is set to charge at a maximum of 500mA, half the maximum charge current for these batteries. The microcontroller also supervises this current and can disable charging from individual batteries as needed.

3. Protection from over-discharge current (discharge over 1000mA) or short circuits: The high-side enable switch limits current draw to 900mA. In addition to this, a low side protection circuit disables the battery instantly if a current draw of above 2A is reached.

4. Protection from under-voltage (below 2.8V): The low side circuit protection disables batteries when voltage drops below 3.0V. Hysteresis is implemented to not release this error state until the battery reaches 3.2V. In addition to this, the microcontroller puts the system to sleep during this time, enabling the batteries to charge without load.

5. Protection from over-temperature (above 50°C): A temperature sensing circuit internal to the charger disables charging at above 50°C. In order to prevent discharge during this time, the microcontroller puts the entire system to "sleep" for approximately 8 minutes to limit current draw.

6. Protection from under-temperature (below 0°C): The microcontroller enables resistance heaters when battery temperature drops below 5°C. These heaters are powered until the batteries reach at least 15°C at which time they are powered off.

Section 3: Assessment of Spacecraft Debris Released During Normal Operations
No releases are planned, therefore this section is not applicable.

Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions
There are <u>no</u> plans for designed spacecraft breakups, explosions, or intentional collisions.

The probability of battery explosion is very low, and, due to the very small mass of the satellite the effect of an explosion on the far-term LEO environment is negligible, per HQ OSMA Policy Memo/Email to 8719.14: CubeSat Battery Non-Passivation, Suzanne Aleman to Justin Treptow, 10, March 2014

The batteries meet Reg. 56450 (4.4-2) in accordance with HQ OSMA policy which states that "CubeSats [3U or smaller] as a satellite class need not disconnect their batteries if flown in LEO with orbital lifetimes less than 25 years."

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4 shows that the satellite is compliant.

Section 5: Assessment of Spacecraft Potential for On Orbit Collisions

NASA Debris Assessment software was used to evaluate the probability of collision with large objects. See Appendix A for the DAS activity log, which shows that the probability of an on orbit collision is, in the worst case "6.26E-09", where the worst case corresponds to the fully deployed configuration. This satisfies the 0.001 maximum probability requirement 4.5-l.

The spacecraft has no capability nor plans for end-of-mission disposal, therefore requirement 4.5-2 is not applicable.

Assessment of spacecraft compliance with Requirements 4.5-1 shows it to be compliant.
Requirement 4.5-2 is not applicable to this mission.

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

The planned orbit is 450 km circular, sun-synchronous, but our integrator, Momentus, operates a spacecraft tub and they may elect to raise the orbit to 550 km before releasing Hatchling. Planning for spacecraft maneuvers to accomplish post-mission disposal is not applicable. Disposal is achieved via passive atmospheric reentry.

Nominally, in the 450 km orbit, the spacecraft will naturally decay from orbit in 5 months from release on orbit. If solar panels do not deploy, the spacecraft will naturally decay from orbit in 14 months after release into orbit. Both scenarios are well under the 25-year rule of requirement 4.6-l.

In the 550 km orbit, in the nominal scenario, spacecraft will naturally decay from orbit in 15 months from release on orbit. If solar panels do not deploy, the spacecraft will naturally decay from orbit in 4 years after release into orbit. Both of these scenarios are also well under the 25-year rule of requirement 4.6- l.

Summary of DAS 3.1.0 Orbital Lifetime Calculations

DAS inputs are: 450-550 km circular orbit, with an inclination of 97° at deployment no earlier than February 1, 2021. In the nominal, 450 km operation case, the lifetime of the spacecraft is estimated to be approximately 5 months until demise, as shown in Fig. 4, and 14 months in the stowed case, as shown in Fig. 5. In the 550 km case, nominal spacecraft operation is expected to result in a spacecraft orbital lifetime of 15 months, as shown in Fig. 6, and not-nominal operation with stowed panels is expected to result in a spacecraft orbital lifetime of 4 years, as shown in Fig. 7.

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

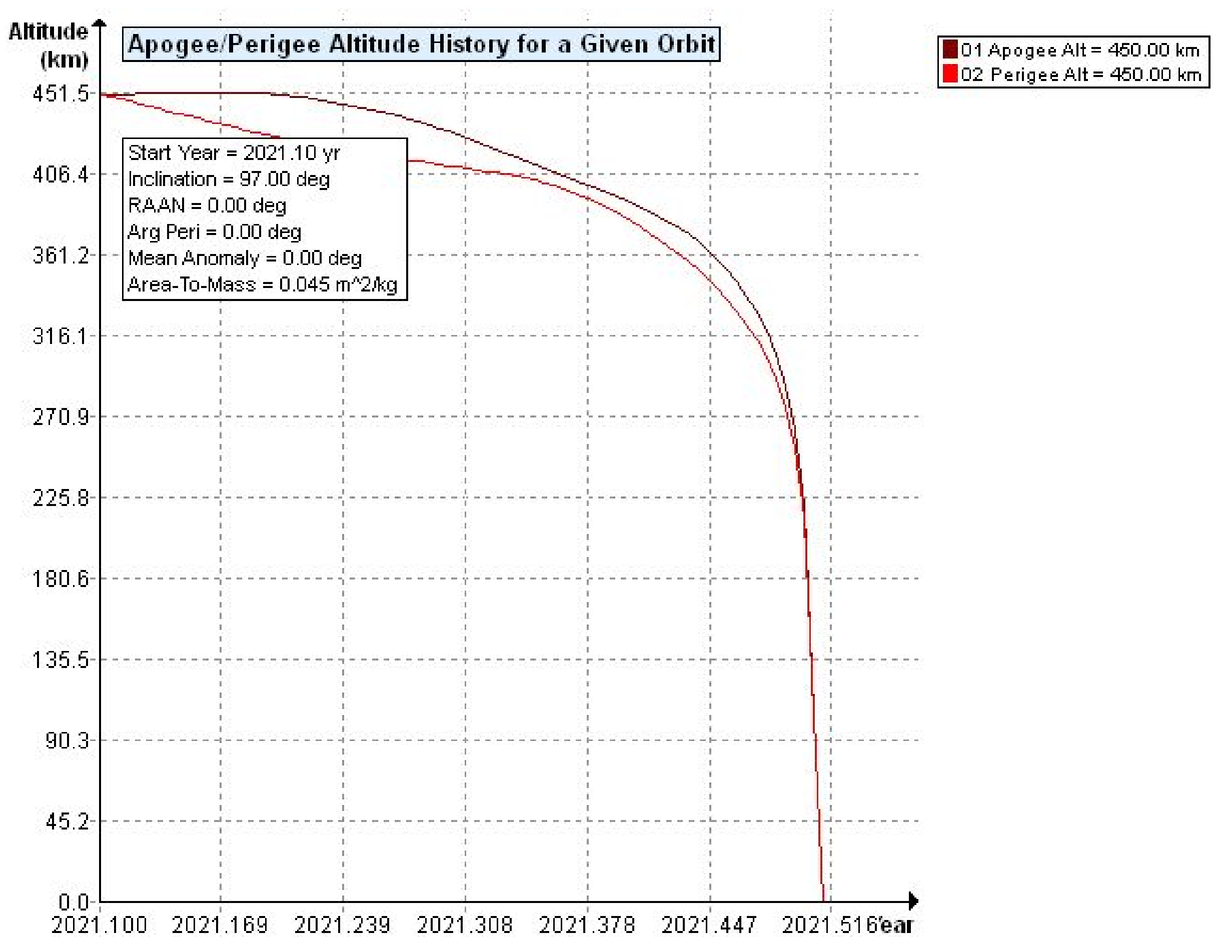

Figure 4. Altitude vs. Time For Hatchling Canary 1 Spacecraft in the Deployed Configuration Starting at 450 km Orbit. Obtained Using NASA DAS 3.1.0. See Appendix A for More Details.

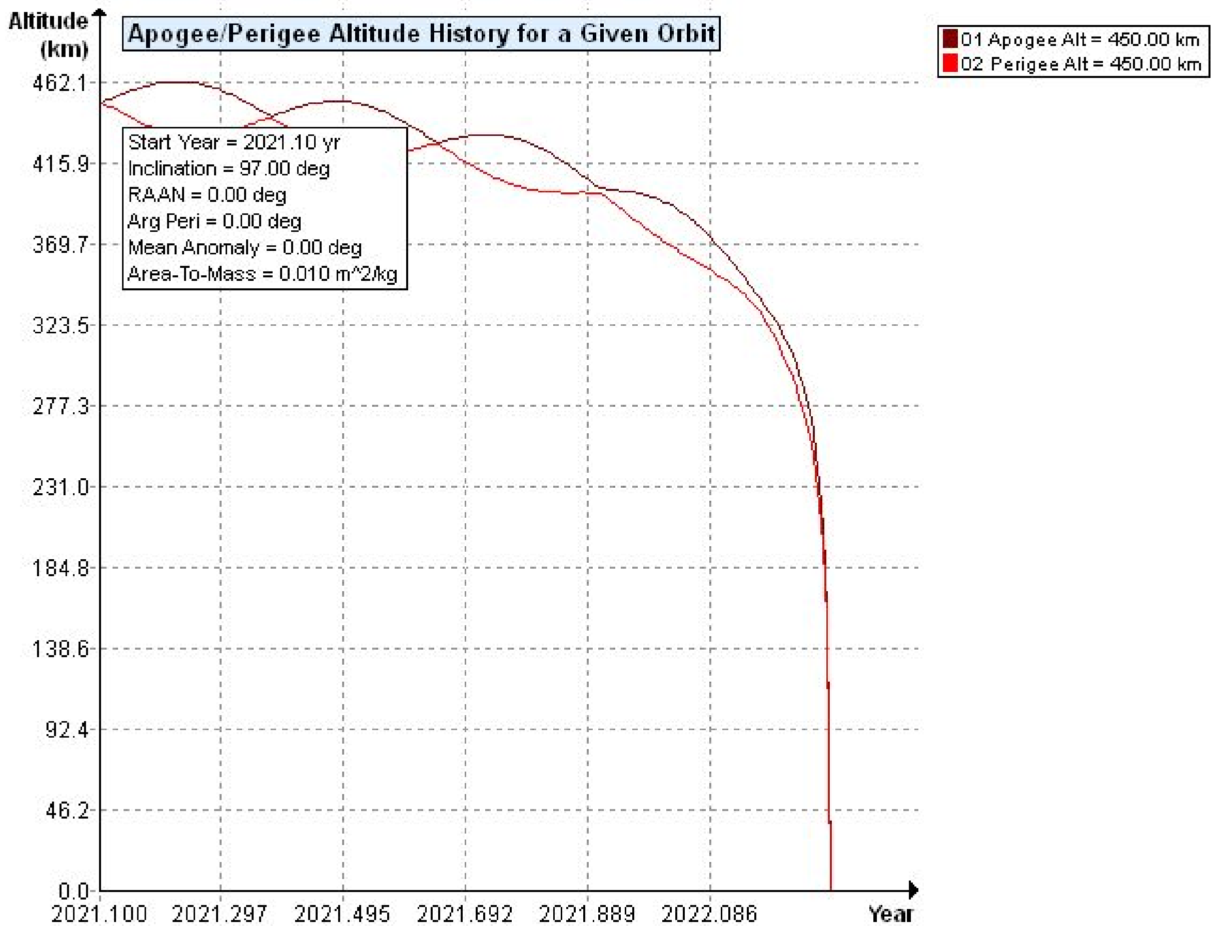

Figure 5. Altitude vs. Time For Hatchling Canary 1 Spacecraft in the Stowed Configuration Starting at 450 km Orbit. Obtained Using NASA DAS 3.1.0. See Appendix A for More Details.

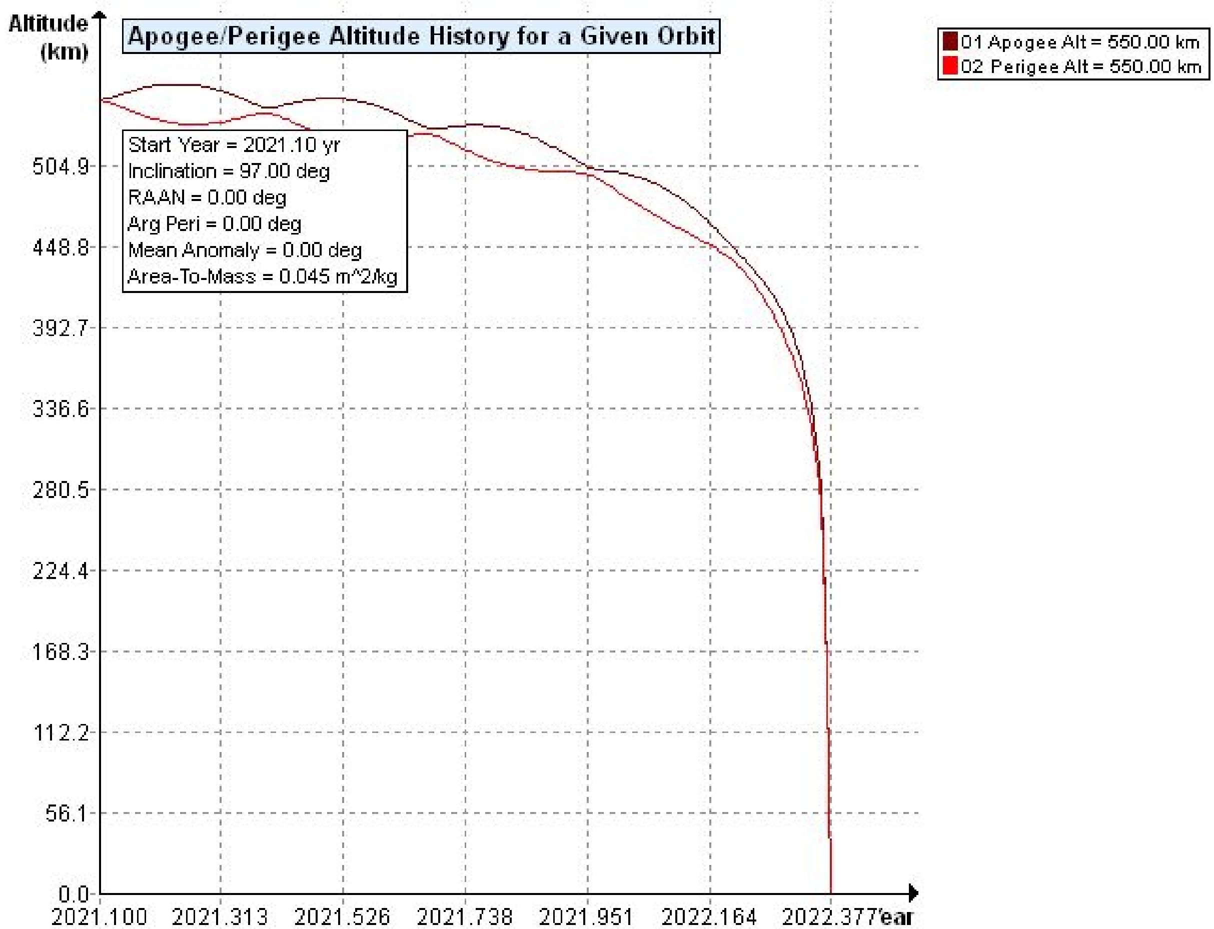

Figure 6. Altitude vs. Time For Hatchling Canary 1 Spacecraft in the Deployed Configuration Starting at 550 km Orbit. Obtained Using NASA DAS 3.1.0. See Appendix B for More Details.

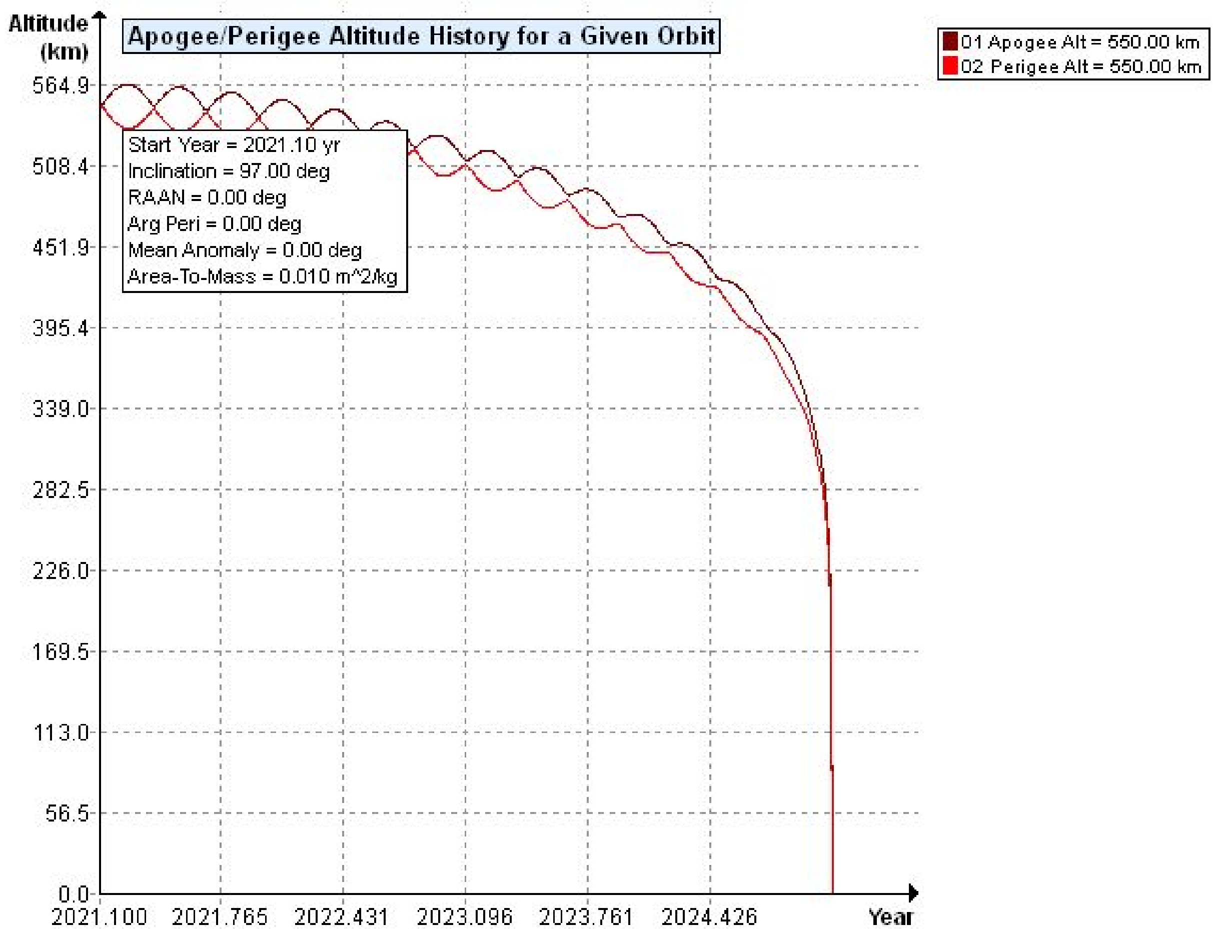

Figure 7. Altitude vs. Time For Hatchling Canary 1 Spacecraft in the Stowed Configuration Starting at 550 km Orbit. Obtained Using NASA DAS 3.1.0. See Appendix B for More Details.

Section 7: Assessment of Spacecraft Re-entry Hazards

A detailed assessment of the components of the spacecraft was performed using DAS 3.1.0, to verify Requirement 4.7-1. See Appendix A, the DAS Activity Log, for more details. All components are demised above 77 km and the probability of human casualty is 1:100,000,000, thus Hatchling Canary 1 complies with the less than 1:10,000 probability of Human Casualty Requirement 4.7-1.

The satellites are thus in compliance with Requirement 4.7-1 of NASA-STD-8719.14A.

Section 8: Assessment for Tether Missions

No tethers are used. Requirement 4.8-1 is satisfied.

Sections 9-14:
ODAR sections 9-14 pertain to the launch vehicle and are not covered here.

References

A. NASA Procedural Requirements for Limiting Orbital Debris Generation, NPR 8715.6A, 5 February 2008

B. Process for Limiting Orbital Debris, NASA-STD-8719.14A, 25 May 2012

C. GSFC, NASA. General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects. GSFC-STD-7000A), NASA Goddard Space Flight Center, Greenbelt, MD, USA, 2013.

D. Markyn GMB, "Product Specification for Li-Ion Polymer Battery, Model 553448," 27 October 2016.

E. HQ OSMA Policy Memo/Email to 8719.14: CubeSat Battery Non-Passivation, Suzanne Aleman to Justin Treptow, 10, March 2014

F. HQ OSMA Email:6U CubeSat Battery Non Passivation Suzanne Aleman to Justin Treptow, 8 August 2017

Appendix A: Activity Log From NASA Debris Assessment Software (DAS 3.1.0)

08 06 2020; 22:34:04PM Activity Log Started
08 06 2020; 22:36:50PM Processing Requirement 4.3-1: Return Status : Not Run

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-1 ===============
08 06 2020; 22:39:42PM Processing Requirement 4.5-1: Return Status : Passed

==============
Run Data
==============

INPUT

Space Structure Name = Hatchling Canary 1
Space Structure Type = Payload
Perigee Altitude = 450.000 (km)
Apogee Altitude = 450.000 (km)
Inclination = 97.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0450 (m^2/kg)
Start Year = 2021.100 (yr)
Initial Mass = 0.250 (kg)
Final Mass = 0.250 (kg)
Duration = 0.500 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 6.2583E-09
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==============

=============== End of Requirement 4.5-1 ===============

08 06 2020; 22:39:58PM Project Data Saved To File
08 06 2020; 22:41:51PM Processing Requirement 4.6 Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = Hatchling Canary 1
Space Structure Type = Payload

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Initial Mass = 0.250000 (kg)
Final Mass = 0.250000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)
PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)

PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 450.000000 (km)
Suggested Apogee Altitude = 450.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2021 (yr)
Requirement = 61
Compliance Status = Pass

==============

=============== End of Requirement 4.6 ===============
08 06 2020; 22:42:14PM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 1

name = Hatchling Canary 1
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 0.250000
Thermal Mass = 0.250000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.050000

name = New Component (solar panel)
quantity = 22
parent = 1
materialID = 23
type = Box

Aero Mass = 0.008000
Thermal Mass = 0.007000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.005000

name = New Component3 (solar cell)
quantity = 22
parent = 2
materialID = 24
type = Flat Plate
Aero Mass = 0.001000
Thermal Mass = 0.001000
Diameter/Width = 0.050000
Length = 0.050000

name = New Component1 (LiPo Battery)
quantity = 3
parent = 1
materialID = 5
type = Box
Aero Mass = 0.010000
Thermal Mass = 0.010000
Diameter/Width = 0.035000
Length = 0.050000
Height = 0.015000

name = New Component2 (Nichrome burn wire)
quantity = 5
parent = 1
materialID = 46
type = Cylinder
Aero Mass = 0.000800
Thermal Mass = 0.000800
Diameter/Width = 0.010000
Length = 0.010000

name = New Component4 (PCB)

quantity = 5
parent = 1
materialID = 23
type = Box
Aero Mass = 0.008000
Thermal Mass = 0.008000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.005000

*************OUTPUT****
Item Number = 1

name = Hatchling Canary 1
Demise Altitude = 77.996208
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = New Component
Demise Altitude = 77.628571
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = New Component3
Demise Altitude = 77.603004
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = New Component1
Demise Altitude = 77.208862
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = New Component2

Demise Altitude = 77.044754
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = New Component4
Demise Altitude = 77.569717
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

=============== End of Requirement 4.7-1 ===============
08 06 2020; 22:42:14PM Project Data Saved To File

Appendix B: Activity Log From NASA Debris Assessment Software (DAS 3.1.0) for ODAR Rev B Evaluating 550 km Orbit

08 06 2020; 22:43:22PM Activity Log Started
08 06 2020; 22:46:54PM Processing Requirement 4.3-2: Return Status : Passed

=====================
No Project Data Available
=====================

=============== End of Requirement 4.3-2 ===============
08 06 2020; 23:35:04PM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2021.100000 (yr)
Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 0.405202 (yr)
Time Spent in LEO during Lifetime = 0.405202 (yr)
Last year of Propagation = 2021 (yr)
Returned Error Message: Object reentered

08 06 2020; 23:38:14PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2020.100000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:38:28PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:38:43PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:39:08PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 575.000000 (km)
Apogee Altitude = 425.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:39:34PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 575.000000 (km)
Apogee Altitude = 575.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:39:49PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 575.000000 (km)
Apogee Altitude = 575.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 4.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:40:12PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 4.000000 (yr)

OUTPUT

Plot

08 06 2020; 23:41:30PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.010000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 4.000000 (yr)

OUTPUT

Plot

08 07 2020; 01:16:53AM Project Data Saved To File

08 11 2020; 14:49:00PM Activity Log Started

08 11 2020; 14:49:00PM Opened Project
C:\Users\mpatwal\AppData\Local\NASA\DAS3.1.0\
08 11 2020; 14:49:20PM Processing Requirement 4.6 Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = Hatchling Canary 1
Space Structure Type = Payload

Perigee Altitude = 450.000000 (km)
Apogee Altitude = 450.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Initial Mass = 0.250000 (kg)
Final Mass = 0.250000 (kg)
Duration = 0.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)
PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 450.000000 (km)
Suggested Apogee Altitude = 450.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2021 (yr)
Requirement = 61
Compliance Status = Pass

==============

=============== End of Requirement 4.6 ===============

08 11 2020; 14:50:22PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 4.000000 (yr)

OUTPUT

Plot

08 11 2020; 14:53:58PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.045000 (m^2/kg)

Start Year = 2021.100000 (yr)
Integration Time = 4.000000 (yr)

OUTPUT

Plot

08 11 2020; 14:54:19PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.010000 (m^2/kg)
Start Year = 2021.100000 (yr)
Integration Time = 4.000000 (yr)

OUTPUT

Plot