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Overview One

Orbital Debris Assessment Report

Revision C • 1 May 2016

Prepared for SpaceVR, Inc. in compliance with NASA-STD-8719.14 by Southern Stars Group, LLC. This document contains no proprietary, ITAR, or export control restrictions. NASA Debris Analysis Software (DAS) version 2.02 was used in preparing this report.

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Record of Revisions

Revision	Date	Affected Pages	Description of Change	Authors
A	25 Apr 2016	All	Initial Revision.	TCD
B	27 Apr 2016	All	Blaze edits; added DAS results and graphs	TCD, BDS
C	1 May 2016	All	Recomputed surface area and orbit lifetime.	TCD

Self-Assessment and OSMA Assessment of the ODAR

A self assessment is provided below, in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14. In the final ODAR document, this assessment will reflect any inputs received from OSMA as well.

Req. #	Launch Vehicle				Spacecraft		
	Compliant	Not Compliant	Incomplete	Standard Non Compliant	Compliant	Not Compliant	Incomplete
4.3-1.a			x		x		
4.3-1.b			x		x		
4.3-2			x		x		
4.4-1			x		x		
4.4-2			x		x		
4.4-3			x		x		
4.4-4			x		x		
4.5-1			x		x		
4.5-2			x		x		
4.6-1(a)			x		x		
4.6-1(b)			x		x		
4.6-1(c)			x		x		
4.6-2			x		x		
4.6-3			x		x		
4.6-4			x		x		
4.6-5			x		x		
4.7-1			x		x		
4.8-1			x		x		

Note:

The primary payload belongs to SpaceX. This is not a SpaceVR, Inc. primary mission. All of the other portions of the launch stack are non-SpaceVR, and Overview One is not the lead.

Assessment Report Format

ODAR Technical Sections Format Requiremnents:

- This ODAR follows the format in NASA-STD-8719.14, Appendix A.1, and include the content indicated at a minimum in each section 2 through 8 below for the Overview One satellite. Sections 9 through 14 apply to the launch vehicle ODAR, and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Overview One is a privately funded mission owned and operated by SpaceVR, Inc., a California corporation with its principal place of business at 45 Lansing St. #2105, San Francisco, CA 94105.

Senior Manager and Program Management:

- Ryan Holmes, ryan@spacevr.co, +1 (415) 570-3691
- Blaze Sanders, blaze@spacevr.co, +1 (650) 384-9377

The mission point-of-contact for JSpoC collision/conjunction warnings is Blaze Sanders, above.

Key engineering personnel:

- Blaze Sanders, blaze@spacevr.co, +1 (650) 384-9377
- Varun Vruddhula, varun@spacevr.co, +1 (415) 570-3691

Foreign government or space agency participation:

- No foreign agency is participating in this mission. All managing personnel are United States citizens.

Summary of NASA's responsibility under the governing agreement(s):

- Not Applicable.

Schedule of upcoming mission milestones:

1 December 2016	Spacecraft delivery to Launch Service Provider.
1 February 2017	Earliest possible launch.
1 March 2017	Earliest possible deployment from ISS.

Mission Overview

Overview 1 Alpha and Beta are 3U CubeSats that will be launched to the International Space Station (ISS) on a SpaceX ISS commercial resupply mission, then later deployed from the International Space Station into a 409 km orbit at 51.6° inclination. Their mission is a space test flight of SpaceVR's Overview series of Virtual Reality 360° video recording CubeSats.

The O1 Alpha and Beta satellites are identical, but are expected to launch to ISS on separate vehicles, and to be deployed at separate times. This document describes the mission profile of the first O1 CubeSat. The second O1 CubeSat will follow an indentical mission profile, but at a later date (not yet determined at the time of this writing.)

Launch Vehicle and Launch Site:

- The launch vehicle is a SpaceX Falcon 9, scheduled for launch from the Kennedy Space Center, Florida, USA. The mission is an unmanned ISS commerical resupply mission.

Proposed Launch Date:

- No earlier than 1 February 2017.

Mission Duration:

- Six to nine months in LEO operation, until atmospheric reentry via orbital decay.

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination:

- The SpaceX Falcon 9 is a two-stage, liquid fuel vehicle. The primary payload is the Dragon cargo carrier. The Overview One is carried as cargo inside the Dragon and transferred to ISS inside a soft carry bag. It is released between 30 and 90 days after transfer to ISS by the Nanoracks CubeSat deployer at a relative velocity of approximately 1 meter/sec with respect to ISS, in a direction opposite the ISS's orbital motion.

- The CubeSat has a higher ballistic coefficient than ISS, and lacks re-boost or propulsion capability. It is expected to remain in approximately the same 51.6° orbital plane as ISS during its operational lifetime. There are no parking or transfer orbits; rather, the CubeSat's altitude will gradually decrease due to atmospheric drag. The CubeSat will never pass above ISS, and it will rapidly move ahead of and "lap" the ISS over many orbits due to its shorter orbital period. The CubeSat will re-enter the atmosphere destructively after its altitude decays to approximately 200 km.

At this time, we know of no potential interaction or physical interference between the Overview 1 CubeSats and any other spacecraft. If given sufficient warning time, collision avoidance could possibly be accomplished by re-orienting the spacecraft to alter its cross-sectional area in the direciton of motion, thereby increasing (or decreasing) atmospheric drag. However, as of this writing, this capability is only theoretical, has not yet been studied or tested in practice, and should not be relied on operationally.

- The mission point-of-contact for JSpOC collision warnings is Blaze Sanders, blaze@spacevr.co, +1 (650) 384-9377

ODAR Section 2: Spacecraft Description

Overview One is a 3U CubeSat, 10 x 10 x 30 cm on a side, with four solar panel "wings" that fold out to a length of 10 x 30 cm after deployment. Overview One is a proof-of-concept flight for SpaceVR that will also test two new imaging systems and communication architectures.

The primary CubeSat structure is made of Aluminum Alloy 6051. It contains all standard commercial off the shelf (COTS) materials, electrical components, PCBs and solar cells. There are no pressure vessels, hazardous or exotic materials. The ClydeSpace electrical power storage system contains lithium polymer batteries with over-charge/current protection circuitry.

Overview One is built to conform to the overall constraints of the Nanoracks CubeSat Dispenser (NRCSD).

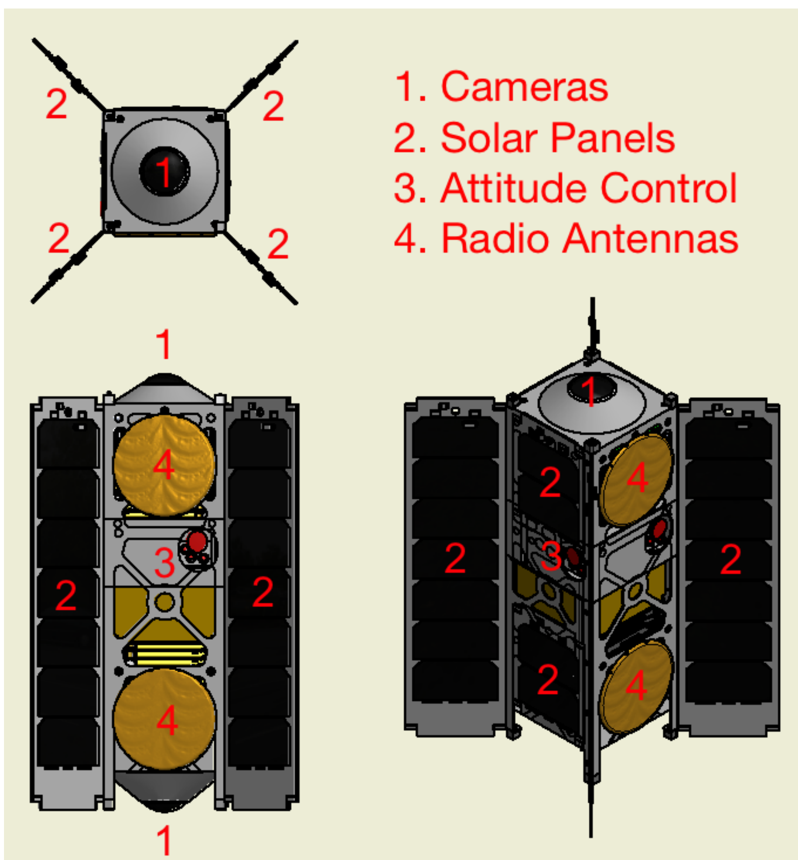


Figure 1. Three views of Overview One 3U CubeSat in deployed configuration.

Total spacecraft mass at launch:

- 6 kg

Dry mass of spacecraft at launch:

- 6 kg

Propulsion systems:

- None.

On-board fluids:

- None.

Attitude control:

- Active attitude will be provided by a Blue Canyon Technologies, Inc. XACT Attitude Determination and Control System. The XACT includes three reaction wheels, a three-axis magnetometer, three torque rods, a two-camera Earth Horizon Sensor, and a stand-alone ADACS computer.

Range safety or other pyrotechnic devices:

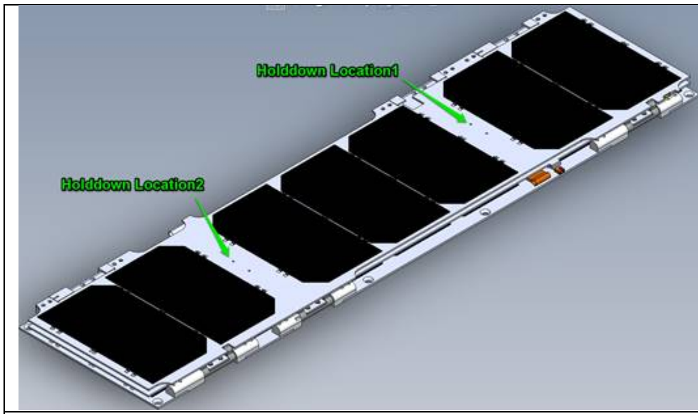
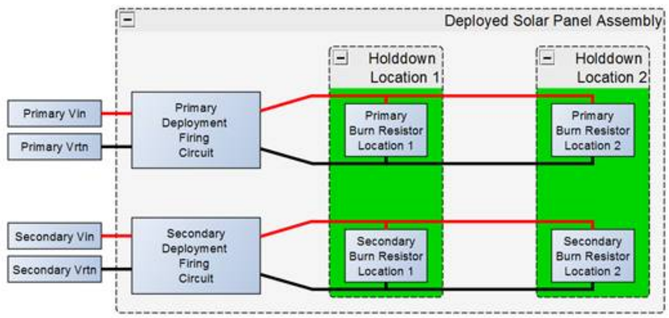
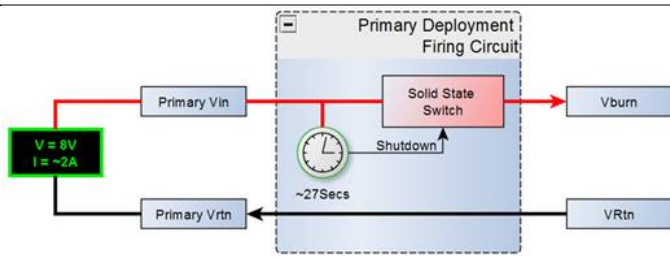
- None.

Electrical generation and storage system:

- Solar cells charging a 120 Watt-Hour Li-Ion battery pack. The battery pack has been pre-qualified by ClydeSpace for use in spaceflight applications. An extensive discussion of the battery system follows in section 4.4.

Other sources of stored energy:

- Clyde Space deployable panels use a “hold-down and release” mechanism with spring-loaded hinges providing the motive force and Dynema cord holding the panels in the stowed configuration. The thermal knife circuitry detailed below then severs this cord once the spacecraft has been released from the NRCSD, allowing the panels to spring open.

	• Each Assembly has two holddown locations. • In order to deploy, both holddown locations must be released
	• Each Assembly has identical redundant primary and secondary deployment firing circuits • Either circuit will release Hold-down Location1 and 2 simultaneously, deploying the assembly
	Each Deployment Firing Circuit: • operates at 7-8.2V (Battery bus voltage) • draws ~2A @ 8V • will deploy after ~2.5 seconds @25˚C • has a timed shutdown of ~27secs after power is applied

Radioactive materials:

- None.

ODAR Section 3: Assessment of Spacecraft Debris Released during Normal Operations

No objects (>1 mm) are expected to be released from the spacecraft any time after launch. Therefore Overview One is COMPLIANT with requirements 4.3-1 and 4.3-2.

Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material:

- None.

Rationale/necessity for release of each object:

- N/A.

Time of release of each object, relative to launch time:

- N/A.

Release velocity of each object with respect to spacecraft:

- N/A.

Expected orbital parameters (apogee, perigee, and inclination) of each object after release:

- N/A.

Calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO):

- N/A.

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v2.0.2):

- 4.3-1, Mission Related Debris Passing Through LEO: COMPLIANT
- 4.3-2, Mission Related Debris Passing Near GEO: COMPLIANT

ODAR Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions

There are no intentional breakups scheduled during on orbit operations. We are aware of no known potential causes of spacecraft breakup during deployment and mission operations.

Potential causes of spacecraft breakup during deployment and mission operations:

- There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.

Summary of failure modes and effects analyses of all credible failure modes which may lead to an accidental explosion:

- The battery safety systems are discussed in requirement 4.4-1 below. If the Li-Po batteries fail, they are expected to vent gas, rather than explode.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:

- There are no plans for any intentional spacecraft breakup by explosion, collision, nor by any other means.

List of components which shall be passivated at End of Mission (EOM) including method of passivation and amount which cannot be passivated:

- Overview One contains no components which are passivated at EOM. The spacecraft will be destroyed by atmospheric reentry. There is no plan to passivate the batteries, but even in the event of mechanical damage or short-circuit they will not explode.

Rationale for all items which are required to be passivated, but cannot be due to their design:

- N/A.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:

- *Requirement 4.4-1:* Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon:

  For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).

  Compliance statement:

  Required Probability: 0.001.
  Expected probability: 0.000.

  Supporting Rationale:

  The primary electrical energy storage system aboard Overview One is a 120 Watt-hour Lithium polymer battery module supplied by Clyde Space, Ltd. of Glasgow, Scotland, UK. Clyde Space has performed analysis and qualification of our battery under an ESA contract. In addition, NASA Goddard has tested and passed our battery for manned space flight on the shuttle. These tests include:

  - Capacity at C/10 under vacuum
  - Radiation testing to 500 kRad following ECSS guidelines.
  - Capacity at -10°C, 0°C, 20°C and 40°C
  - Cycling Tests at reduced pressure (15-20mbars) - 30% DoD, C/2 Charge/Discharge >5000 cycles
  - Vibration and shock to NASA GEVS.

  All batteries have an integrated, thermostatically controlled battery heater, and built-in over-charge, over-discharge, and over-current protection. There is no credible failure mode known which might result in battery explosion with possible orbital debris generation.

- ***Requirement 4.4-2:*** Design for passivation after completion of mission operations while in orbit about Earth or the Moon:

  Design of all spacecraft and launch vehicle orbital stages shall include the ability to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or postmission disposal or control to a level which can not cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).

  Compliance statement:

  Overview One's battery charge circuits include overcharge protection to limit the risk of battery failure. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

- ***Requirement 4.4-3.*** Limiting the long-term risk to other space systems from planned breakups:

  Compliance statement:

  This requirement is not applicable. There are no planned breakups.

- ***Requirement 4.4-4:*** Limiting the short-term risk to other space systems from planned breakups:

  Compliance statement:

  This requirement is not applicable. There are no planned breakups.

ODAR 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. A summary of the cross sectional area computation follows.

Overview One is stowed in a convex configuration, meaning that no element of the CubeSat obscures another element of the same CubeSat from view. Thus, the stowed mean CSA was calculated using Equation 1. Once Overview One has been ejected from the dispenser, and solar panels have been deployed, Equation 2 is utilized to determine the mean CSA. A_{max} is the view that yields the maximum cross-sectional area. A_1 and A_2 are the two cross-sectional areas orthogonal to A_{max}.

$$MeanCSA = \frac{\sum SurfaceArea}{4} = \frac{2 \cdot \left[\left(w \cdot l \right) + \left(w \cdot h \right) + \left(l \cdot h \right) \right]}{4}$$

Equation 1: Mean Cross Sectional Area for Convex Objects

$$MeanCSA = \frac{\left(A_{\max} + A_1 + A_2 \right)}{2}$$

Equation 2: Mean Cross Sectional Area for Complex Objects

In a stowed configuration, Overview One is 10 x 10 x 34 cm. With solar panels deployed, the dimensions are approximately 24 x 24 x 34 cm. Thus, the convex mean CSA for Overview One is 390 cm^2. The complex mean CSA is 866 cm^2.

$$MeanCSA = \frac{2 \cdot [(10 \cdot 10) + (10 \cdot 34) + (10 \cdot 34)]}{4}$$

Equation 3: Mean Cross Sectional Area for Stowed Spacecraft

$$MeanCSA = \frac{(24 \cdot 34) + (24 \cdot 34) + (10 \cdot 10)}{2}$$

Equation 4: Mean Cross Sectional Area for Deployed Spacecraft

Requirement 4.5-1 asks to compute probability of collision with large space objects (> 10 cm diameter). Using DAS 2.0.2 sofware, we computed the probability of spacecraft collision with space objects larger than 10 cm in diameter during the orbital lifetime of the spacecraft (assumptions: 409 x 416 km altitude, 51.6° inclination, X m^2 area), as 0.00000.

Requirement 4.5-2 asks to compute probability of collision with space objects, including orbital debris and meteoroids, of sufficient size to prevent postmission disposal. However, as there is no post-mission disposal operation, requirement 4.5-2 is not applicable to this mission.

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v2.0, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):

- *Requirement 4.5-1. Limiting debris generated by collisions with large objects when operating in Earth orbit:* For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001 (Requirement 56506).

  Large Object Impact and Debris Generation Probability: 0.00000; COMPLIANT.

- *Requirement 4.5-2. Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit:* For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable postmission disposal requirements is less than 0.01 (Requirement 56507).

  Small Object Impact and Debris Generation Probability: NOT APPLICABLE.

ODAR Section 6: Assessment of Spacecraft Postmission Disposal Plans and Procedures

Disposal is achieved via passive atmospheric reentry. There will be no post-mission disposal operation. The spacecraft will naturally decay from orbit within 25 years after end of the mission, satisfying requirement 4.6-1a (spacecraft disposal option).

6.1 Description of spacecraft disposal option selected:

- The spacecraft has no capability or plan for end-of-mission disposal. Any discussion of systems and components required to accomplish post-mission disposal operation, including passivation and maneuvering, is not applicable.

6.2 Plan for any spacecraft maneuvers required to accomplish postmission disposal:

- Not applicable.

6.3 Calculation of area-to-mass ratio after postmission disposal, if the controlled reentry option is not selected:

- **Spacecraft Mass:** 6 kg
  Cross-sectional Area: 0.0866 m^2 (see calculation in section 5)
  Area to mass ratio: 0.0866/6 = 0.0144 m^2/kg

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v 2.0 .2 and NASA-STD-8719.14 section):

- *Requirement 4.6-1. Disposal for space structures passing through LEO:* A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods:

  a) Atmospheric reentry option:
     Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.
  b) Storage orbit option:
     Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.

c) Direct retrieval:
Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

Analysis: The Overview One satellite reentry is COMPLIANT using Method "a." Overview One will re-enter approximately 1.8 years after deployment, with orbit history as shown in Figure 3 (analysis assumes an approximate random tumbling behavior).

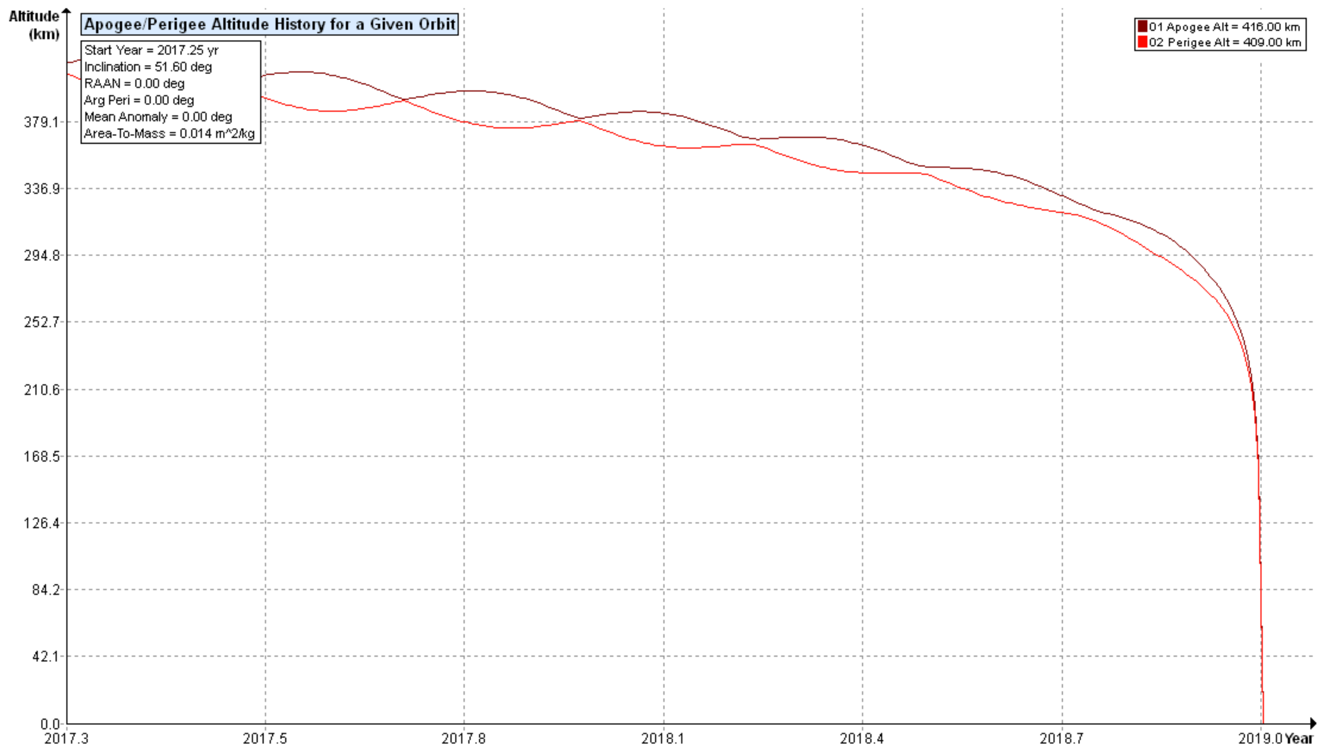


Figure 3. Overview One orbit history, assuming successful solar panel deployment immediately upon release from ISS at T=2017.25

Requirement 4.6-2. Disposal for space structures near GEO.

- **Analysis:** Not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO.

- **Analysis:** Not applicable.

Requirement 4.6-4. Reliability of Postmission Disposal Operations

- **Analysis:** Overview One does not rely on solar panel deployment to ensure post mission disposal within the allowed 25-year timeframe. Even if the solar panel deployment mechanism fails, the satellite will reenter passively approximately 4.1 years after launch, as shown in Figure 4, below.

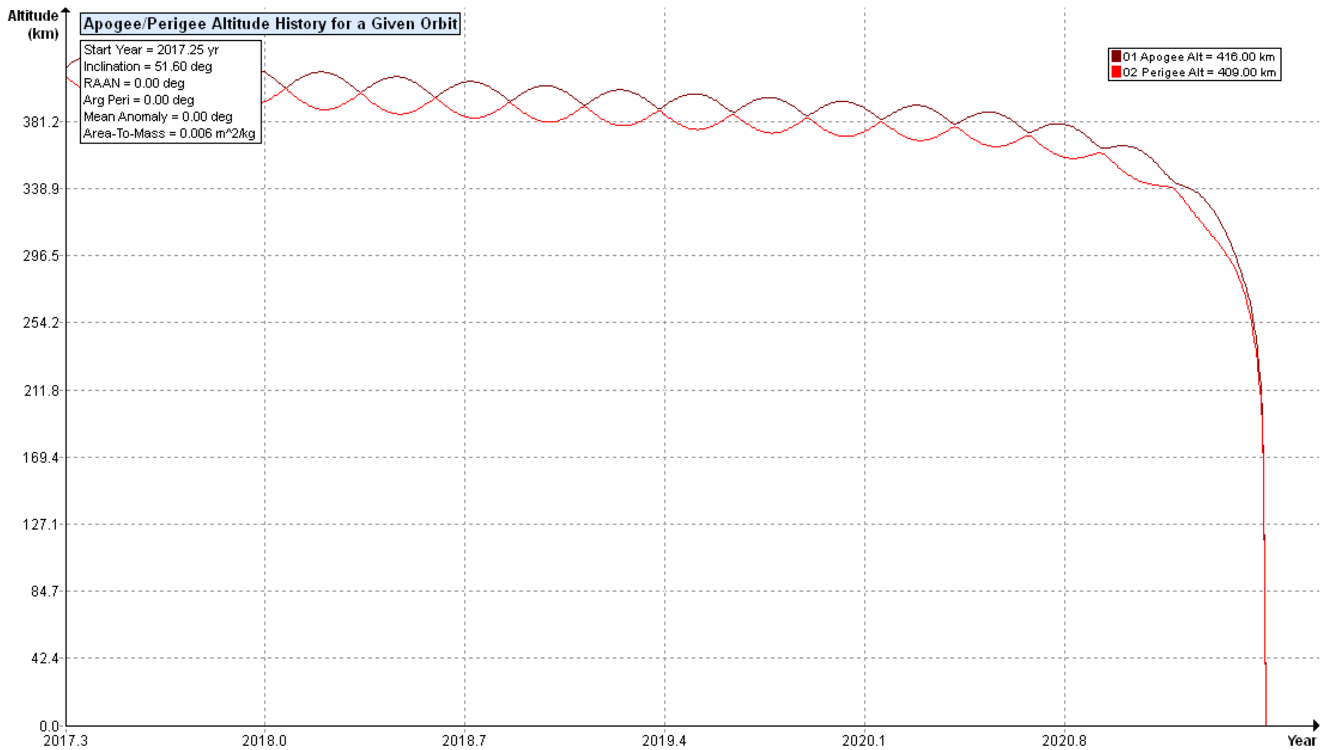


Figure 4. Overview One orbit history, assuming solar panel non-deployment after ISS release at T=2017.25.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

A detailed description of spacecraft components includes small Li-ion batteries; an aluminum framework; cameras and other circuitry; solar cells. All components will vaporize on re-entry.

Assessment of spacecraft compliance with Requirement 4.7-1:

- ***Requirement 4.7-1. Limit the risk of human casualty:*** The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules:

  For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

  Summary Analysis Results: DAS v2.0.2 reports that Supernova-Beta is COMPLIANT with the requirement. No components are predicted by NASA DAS software to survive re-entry. The probability of human casualty due to uncontrolled reentry is 0.000000.

  Analysis (per DAS v2.0.2):

```
04 27 2016; 16:56:33PM  DAS Application Started
04 27 2016; 16:56:33PM  Opened Project C:\Users\Tim DeBenedictis\Desktop\DAS-
OVERVIEW-ONE\
04 27 2016; 16:56:49PM  Processing Requirement 4.6    Return Status :  Passed

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

**INPUT**

      Space Structure Name = Overview One
      Space Structure Type = Payload

      Perigee Altitude = 409.000000 (km)
      Apogee Altitude = 416.000000 (km)
      Inclination = 51.600000 (deg)
      RAAN = 0.000000 (deg)
      Argument of Perigee = 0.000000 (deg)
      Mean Anomaly = 0.000000 (deg)
      Area-To-Mass Ratio = 0.012800 (m^2/kg)
      Start Year = 2017.250000 (yr)
      Initial Mass = 6.000000 (kg)
      Final Mass = 6.000000 (kg)
      Duration = 0.500000 (yr)
      Station Kept = False
```

```
      Abandoned = True
      PMD Perigee Altitude = 394.494588 (km)
      PMD Apogee Altitude = 396.111287 (km)
      PMD Inclination = 51.596598 (deg)
      PMD RAAN = 167.684744 (deg)
      PMD Argument of Perigee = 163.700249 (deg)
      PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

      Suggested Perigee Altitude = 394.494588 (km)
      Suggested Apogee Altitude = 396.111287 (km)
      Returned Error Message = Passes LEO reentry orbit criteria.

      Released Year = 2019 (yr)
      Requirement = 61
      Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
04 27 2016; 16:56:49PM  *********Processing Requirement 4.7-1
      Return Status :  Passed

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

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quantity = 1
parent = 0
materialID = 8
type = Box
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Thermal Mass = 6.000000
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Length = 0.300000
Height = 0.100000

name = Chassis
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 5.756000
Thermal Mass = 0.390000
Diameter/Width = 0.100000
Length = 0.300000
Height = 0.100000

name = Batteries
quantity = 4
parent = 2
materialID = 5
type = Box
Aero Mass = 0.312000
Thermal Mass = 0.312000
Diameter/Width = 0.090000
Length = 0.950000
```

```
Height = 0.022000

name = EPS
quantity = 2
parent = 2
materialID = 23
type = Box
Aero Mass = 0.148000
Thermal Mass = 0.148000
Diameter/Width = 0.090000
Length = 0.095000
Height = 0.022000

name = 3U Solar Panels
quantity = 10
parent = 2
materialID = 23
type = Flat Plate
Aero Mass = 0.190000
Thermal Mass = 0.190000
Diameter/Width = 0.100000
Length = 0.200000

name = Radio
quantity = 1
parent = 2
materialID = 5
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.086000
Length = 0.088000
Height = 0.045000

name = ADACS
quantity = 1
parent = 2
materialID = 5
type = Box
Aero Mass = 0.910000
Thermal Mass = 0.910000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.050000

name = Patch Antenna
quantity = 2
parent = 2
materialID = 40
type = Cylinder
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.100000
Length = 10.000000

name = Camera Assembly
quantity = 2
parent = 2
```

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materialID = 23
type = Box
Aero Mass = 0.014000
Thermal Mass = 0.014000
Diameter/Width = 0.030000
Length = 0.030000
Height = 0.030000

name = Jetson Flight Computer
quantity = 1
parent = 2
materialID = 5
type = Box
Aero Mass = 0.134000
Thermal Mass = 0.134000
Diameter/Width = 0.055000
Length = 0.084000
Height = 0.025000

name = 1U Solar Panel
quantity = 2
parent = 2
materialID = 23
type = Flat Plate
Aero Mass = 0.063000
Thermal Mass = 0.063000
Diameter/Width = 0.100000
Length = 0.100000

name = Lens
quantity = 2
parent = 2
materialID = 23
type = Cylinder
Aero Mass = 0.052000
Thermal Mass = 0.052000
Diameter/Width = 0.040000
Length = 0.033000

name = Jetson Carrier Board Assy
quantity = 2
parent = 2
materialID = 23
type = Flat Plate
Aero Mass = 0.010000
Thermal Mass = 0.010000
Diameter/Width = 0.055000
Length = 0.084000

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

name = Overview One
Demise Altitude = 77.994629
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
```

```
name = Chassis
Demise Altitude = 76.845113
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Batteries
Demise Altitude = 76.035793
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = EPS
Demise Altitude = 75.268050
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 3U Solar Panels
Demise Altitude = 75.584293
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Radio
Demise Altitude = 69.859160
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = ADACS
Demise Altitude = 66.598073
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Patch Antenna
Demise Altitude = 76.845113
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Camera Assembly
Demise Altitude = 76.305785
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Jetson Flight Computer
Demise Altitude = 74.021066
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = 1U Solar Panel
Demise Altitude = 76.038746
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
```

```
************************************
name = Lens
Demise Altitude = 74.768308
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Jetson Carrier Board Assy
Demise Altitude = 76.637707
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************

=============== End of Requirement 4.7-1 ===============
```

Appendix A: Acronyms

Al	Aluminum
cm	Centimeter
COTS	Commercial Off-The-Shelf
CSD	Cannisterized Satellite Dispenser
DAS	Debris Assessment Software
EOM	End Of Mission
GEO	Geosynchronous Earth Orbit
ITAR	International Traffic In Arms Regulations
ISS	International Space Station
kg	Kilogram
km	Kilometer
LEO	Low Earth Orbit
Li-Ion	Lithium Ion
m^2	meters squared
Ml	Milliliter
Mm	Millimeter
N/A	Not Applicable
NRCSD	NanoRacks CubeSat Dispenser
ODAR	Orbital Debris Assessment Report
OSMA	Office of Safety and Mission Assurance
Ti	Titanium
yr	Year