SILVERSAT Orbital Debris Assessment Report (ODAR)

per NASA-STD 8719.14C

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Revision 0

Date 11/26/2024

SilverSat Limited
David J Copeland
2017 Luzerne Ave
Silver Spring, Md 20910

Required Signatures

Title: President David J Copeland	
Date 12/2/2024	

Title: Telecom Lead	
Date 12/2/2024	

Title: Author Michael L. Miller	
Date 12/2/2024	

Version History

Version	Date	Change Author	Change Summary
Rev 0	December 2, 2024	Michael L. Miller	Initial Release

1. Self Assessment

A self-assessment against NASA-STD-8719.14C spacecraft mission requirements is shown below for SILVERSAT.

Requirement	Resolution	Remarks
4.3-1.a MRD 25-year limit	N/A	No separating objects
4.3-1.b MRD<100 object x year limit	N/A	No separating objects
4.3-2 GEO MRD	N/A	No separating objects
4.4-1 <0.001 Explosion Risk	COMPLIANT	
4.4-2 Passivate Energy Sources	COMPLIANT	
4.4-3 Limit Intentional BU, Long Term	N/A	No planned breakups
4.4-4 Limit Intentional BU, Short Term	N/A	No planned breakups
4.5-1 <0.001 10cm Impact Risk	COMPLIANT	

Requirement	Resolution	Remarks
4.5-2 <0.01 Small MMOD Impacts	N/A	No planned controlled reentry, no critical subsystems to protect
4.6-1a-c LEO Disposal	COMPLIANT	
4.6-2 Storage or Earth-escape	N/A	
4.6-3 Long-term Reentry	N/A	
4.6-4 Disposal Reliability	COMPLIANT	
4.7-1 Reentry Risk	COMPLIANT	
4.8-1 Special Classes	N/A	Not considered a special class of space mission

Table 1-1: Self-Assessment of SILVERSAT

Debris Assessment Software (DAS) version 3.2.6 was used for evaluation of the SilverSat against requirements.

2. ODAR Section 1: Program Management and Mission Overview

a. Identification of the Company and Program Executive

Company: SilverSat Limited

Program Executive: David J Copeland (President)

Telecom Lead: Thomas K. Conrad

Address: 2017 Luzerne Ave, Silver Spring, Md 20910

b. Identification of any foreign government or space agency participation in the mission and a summary of NASA's responsibility under the governing agreement(s)

None

c. Brief description of the mission

SilverSat is an educational mission for middle- and high-school students. The satellite is designed and built by student members of the SilverSat club, with adult mentors. It is a technology demonstration, using emerging Improved Layer 2 Protocol (IL2P) data over amateur UHF frequency to and from the satellite. This extends work that has been done by others with using this protocol for amateur packet radio.

d. Identification of the anticipated launch vehicle and launch site

The spacecraft will be launched aboard CRS NG-22 ISS cargo re-supply mission, from Cape Canaveral, Florida to be deployed from the ISS

e. Identification of the proposed launch date and mission duration

The spacecraft will be launched NET June 7 2025, and the mission duration will be about 1 year.

f. Description of the launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination

The spacecraft will be inserted into a circular orbit at 400 km altitude, on an inclination from the equator of 51.6 degrees.

g. Description of the spacecraft's maneuver capability, including both attitude and orbit control. Give the time period during which the capabilities will be exercised.

There is no orbit control. The attitude control system consists of permanent magnets aligned with the Z axis of the spacecraft, and hysteresis material to dampen tumble.

The spacecraft has no maneuver capability. There is no propulsion.

h. Reason for selection of operational orbit(s) (such as ground track, SSO, GEO sync, instrument resolution, co-locate with other spacecraft, …)

The orbit was selected for launch availability.

There is no planned co-location with any other spacecraft.

i. Identification of any interaction or potential physical interference with other operational spacecraft (Note: This does not include potential for RF interaction unless it affects the risk of generating orbital debris.)

There is no expected interference with other operational spacecraft.

3. ODAR Section 2: Spacecraft Description

a. Physical description of the spacecraft, including spacecraft bus, payload instrumentation, and all appendages, such as solar arrays, antennas, and instrument or attitude control booms

The spacecraft is a single unit (1U) CubeSat with the dimensions of 10x10x10cm. The total mass is 0.883 kg. It contains the following systems:

Avionics Subsystem: The Avionics subsystem consists of a single board computer based on the ATSAMD21G18A microcontroller. This board also contains a real-time clock, 6 degree-of-freedom inertial measurement unit (IMU), 32k-byte FRAM, external watchdog timer and e-Fuse. Data communications between Avionics, Payload and the Comms use RS-422. The operations of the Payload (power enable and mode) is signaled between the boards using triple-voted open-drain general-purpose I/O. The IMU is a COTS Adafruit MPU 6050 module, and it detects translational and rotational acceleration to identify whether the satellite is tumbling.

Communications Subsystem (Comms): The Comms subsystem includes one radio and one antenna. The radio is designed and manufactured by SilverSat specifically for this mission. The antenna is manufactured by EnduroSat, model UHF Type III. The ground station is installed at the Goddard Amateur Radio Club. The ground station radio is also manufactured by SilverSat and is a copy of the satellite's radio with outboard amplifiers and filtering. In conformance with § 5.107 Transmitter control requirements, all transmissions (data and beacon) from the satellite can be terminated by ground command.

Electrical Power Subsystem (EPS): The EPS consists of the EnduroSat EPS 1 module and five EnduroSat solar panels. The EPS 1 module contains two Lithium-Polymer batteries, maximum power point tracking circuitry for each axis of the satellite, and switchable 5V and 3.3V regulators providing power to the bus. The EPS contains battery heaters which are internally controlled, and will provide heat when the batteries are between 0 deg C and 4 deg C. The batteries are Varta 1/LPP503759 8HH cells. Three safety-inhibit roller switches are in series with the batteries. The solar panels are EnduroSat model 1U and each contain 2 Azur Space triple-junction cells. The Avionics board is powered from the raw battery voltage and controls the operation of the EPS.

Attitude Control Subsystem (ADS): The ADS consists of permanent magnets aligned with the Z axis of the spacecraft, and hysteresis material to dampen tumble. The magnets are 11 Standex Meder - Alnico500 rods, 2.5 mm diameter by 12.7 mm long, glued to the inside of the frame. The hysteresis material is 8 strips of 0.152mm thick Co-NETIC material, each strip measuring approximately 6mm by 25mm. These strips are glued to the inside of the +Z closeout panel, symmetric about the camera opening.

Structure Subsystem: The structure is an EnduroSat 1U frame with an additional aluminum panel for the +Z surface. The frame is 6082 aluminum with a hard anodized finish. The +Z closeout panel is 6061-T6 aluminum with a hard anodized finish.

Payload Subsystem: The Payload subsystem is responsible for taking pictures and sending those pictures to the ground, either as an SSDV stream or a tweet to X (formerly Twitter). The subsystem consists of a single board that contains a Raspberry Pi Zero and a 4D Systems UCamIII camera. The Raspberry Pi Zero is responsible for controlling the camera to take pictures, storing the pictures, and generating the data stream for the downlink and sending it to the radio. In 'Tweet from space' mode, the Raspberry Pi also implements the TCP/IP stack. The camera is mounted to the bottom of the board and protrudes through a hole in the Avionics board. The Payload is powered only when needed, as controlled by the Avionics board.

b. Detailed illustration of the entire spacecraft in the mission operation configuration with clear overall dimensional markings and marked internal component locations

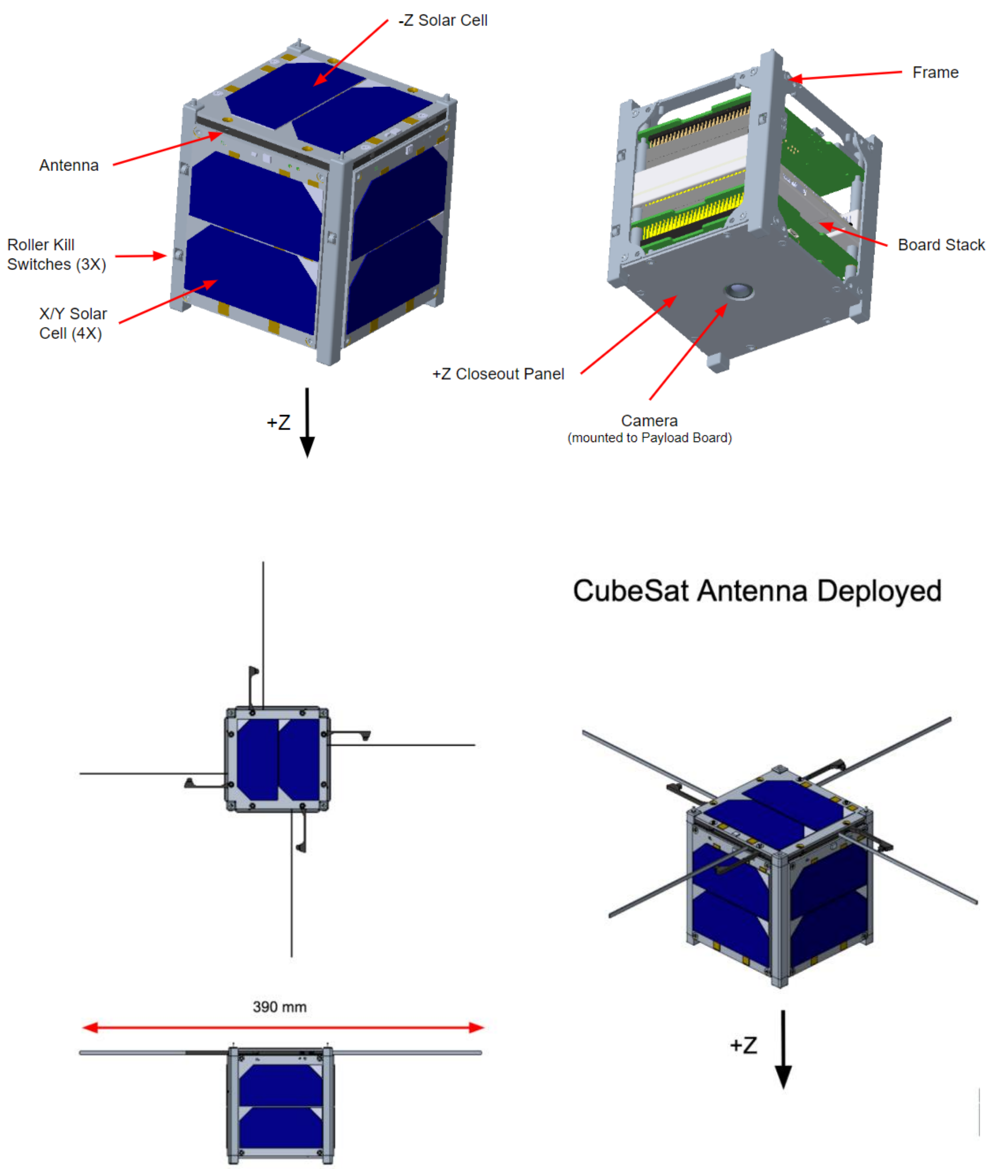

Figure 3-1: SILVERSAT Spacecraft with Overall Dimensions

c. Total spacecraft mass at launch, including all propellants and fluids

The total mass is 0.883 kg.

d. Dry mass of spacecraft at launch, excluding solid rocket motor propellants

The dry mass is 0883 kg. There are no propellants or other consumables.

e. Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear)

N/A There is no propulsion system.

f. Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes. Description of all fluid systems, including size, type, and qualifications of fluid containers such as propellant and pressurization tanks, including pressurized batteries

N/A No fluids will be on board.

g. Description of all active and/or passive attitude control systems with an indication of the normal attitude of the spacecraft with respect to the velocity vector

The ADCS consists of permanent magnets aligned with the Z axis of the spacecraft, and hysteresis material to dampen tumble.

The nominal attitude is shown in Figure 3-1. The Z axis of the spacecraft will generally align with the field lines of the Earths' magnetic field.

h. Description of any range safety or other pyrotechnic devices

There are no range safety or pyrotechnic devices on the spacecraft.

i. Description of the electrical generation and storage system

The electrical generation and storage system consists of the EnduroSat EPS 1 module and five EnduroSat solar panels. The EPS 1 module contains two Lithium-Polymer batteries, maximum power point tracking circuitry for each axis of the satellite, and switchable 5V and 3.3V regulators providing power to the bus. The EPS contains battery heaters which are internally controlled, and will provide heat when the batteries are between 0 deg C and 4 deg C. The batteries are Varta 1/LPP503759 8HH cells.

The solar panels are EnduroSat model 1U and each contain 2 Azur Space triple-junction cells. The Avionics board is powered from the raw battery voltage and controls the operation of the EPS.

j. Identification of any other sources of stored energy not noted above

There are no other sources of energy storage on the spacecraft

k. Identification of any radioactive materials on board or make a positive statement that there are no radioactive materials onboard

There are no radioactive materials on spacecraft.

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

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

There are no separating objects from the spacecraft during any phase of the SilverSat mission.

b. Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 ‘

4.3-1a/b, Mission Related Debris Passing Through LEO: **N/A**

There are no planned separating objects from the spacecraft.

4.3-2, Mission Related Debris Passing Near GEO: **N/A**

There are no planned separating objects from the spacecraft.

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

a. Identification of all potential causes of spacecraft breakup during deployment and mission operations

During nominal deployment and mission operations, there are no credible scenarios that result in spacecraft breakup.

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

The spacecraft contains lithium-ion batteries as the only source of stored energy. Protections are in place to prevent on-orbit explosions.

Lithium-Polymer Batteries

SilverSat utilizes two unpressurized UL-Listed Varta 1/LPP503759 8HH lithium-polymer cells. These cells include mitigations against elevated temperatures, over-charge, over-discharge and over-current. These mitigations prevent any catastrophic failure mode and potential for on-orbit explosion to occur.

The cells undergo UN38.3 and IEC62133-2 safety testing to further ensure battery integrity, including charge and discharge testing, internal resistance characterization, and cycle performance. Furthermore, the cells are tested by the EPS manufacturer for suitability to deployment to the International Space Station based on NASA document JSC 20793 'Crewed Space Vehicle Battery Safety Requirements'.

Cell Safety Devices

The cells include a set of standard safety features described below. These features provide mitigation against elevated temperatures, over-charge, over-discharge and over-current, and allow the EPS to maintain battery temperature:

- Positive Temperature Coefficient Device (PTC): The resistance of the PTC is low during normal operation and increases when the temperature rises above a critical level to reduce current flow and acts as a thermal fuse.
- Protection Circuit Module (PCM): The PCM is protection circuitry internal to each battery that disconnects the battery from the EPS in the event of over-current, over-charge, or over-discharge.
- Negative Temperature Coefficient Device (NTC): The NTC is a temperature monitor internal to each battery which is used by the EPS to control battery heaters, to maintain battery temperature above 0 deg C.

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

the spacecraft is not designed for breakup and the mission does not include any planned explosions or collisions.

d. List of components which are passivated at EOM. List includes method of passivation and amount which cannot be passivated.

Batteries will not be passivated. The spacecraft will operate until demise.

e. Rationale for all items which are required to be passivated but cannot be due to their design.

Within 4 months of deploy, the spacecraft will demise, and we plan to operate until then.

<u>Requirement 4.4-1: Limiting probability of accidental explosions</u>: **COMPLIANT**

"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)."

The only stored energy is in the battery cells, and there is no credible scenario in which energy release in the batteries causes an explosion.

Therefore, the expected probability of accidental explosions is under 0.001 and is Compliant to this requirement.

Requirement 4.4-2: Passivate to limit probability of accidental explosions: **COMPLIANT**

Requirement 4.4-3: Limit the long-term risk to other space systems from planned breakups: **N/A**

There are no planned breakups.

Requirement 4.4-4: Limit the long-term risk to other space systems from planned breakups: **N/A**

There are no planned breakups.

6. ODAR Section 5: Assessment of Spacecraft Potential for On-Orbit Collisions

a. Calculation of spacecraft probability of collision with space objects larger than 10 cm in diameter during the orbital lifetime of the spacecraft Calculation of spacecraft probability of collision with space objects, including orbital debris and meteoroids, of sufficient size to prevent post mission disposal

The probability of accidental collision with space objects larger than 10 cm in diameter was estimated using DAS.

Effective cross sectional area is calculated based on random tumbling, as the orientation of the orbiting spacecraft to the Earths magnetic field lines will result in a random orientation over the lifetime of the satellite.

The effective cross section is calculated as (A + B + C)/2, where A, B and C are the orthogonal cross sectional areas. For a 10 cm cube this results in an effective cross section of 0.015 m^2.

The mass of 0.883 kg remains constant throughout the orbit lifetime. So the Area to mass ratio is 0.015/0.883, or 0.0170 m^2/kg

Area to Mass Ratio, m2/kg	Orbit Lifetime, Years	Large Object Collision Risk from DAS
0.0170	0.293	7.2473E-09

Table 6-1 Lifetime, and Large Object Collision Risk

Table 6-1 shows the probability of Large object collision to be 7.2473E-09, which is less than the required 0.001 probability.

b. Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2

Requirement 4.5-1: Limit debris generated by collisions with large objects when operating in Earth orbit: **Compliant**

Requirement 4.5-2: Limit debris generated by collisions with small objects when operating in Earth orbit: **N/A post mission disposal by passive demise does not require any systems to be functional.**

7. ODAR Section 6: Assessment of Spacecraft Post Mission Disposal Plans and Procedures

a. Description of spacecraft disposal option selected

Post mission disposal will be achieved by passive demise. Per DAS, this will occur 0.293 years after deploy, and demise will define the end of the mission. See Figure 7-1.

No systems or components are required to accomplish post mission disposal by passive demise.

No maneuvering of the vehicle is needed to accomplish a post mission disposal by passive demise.

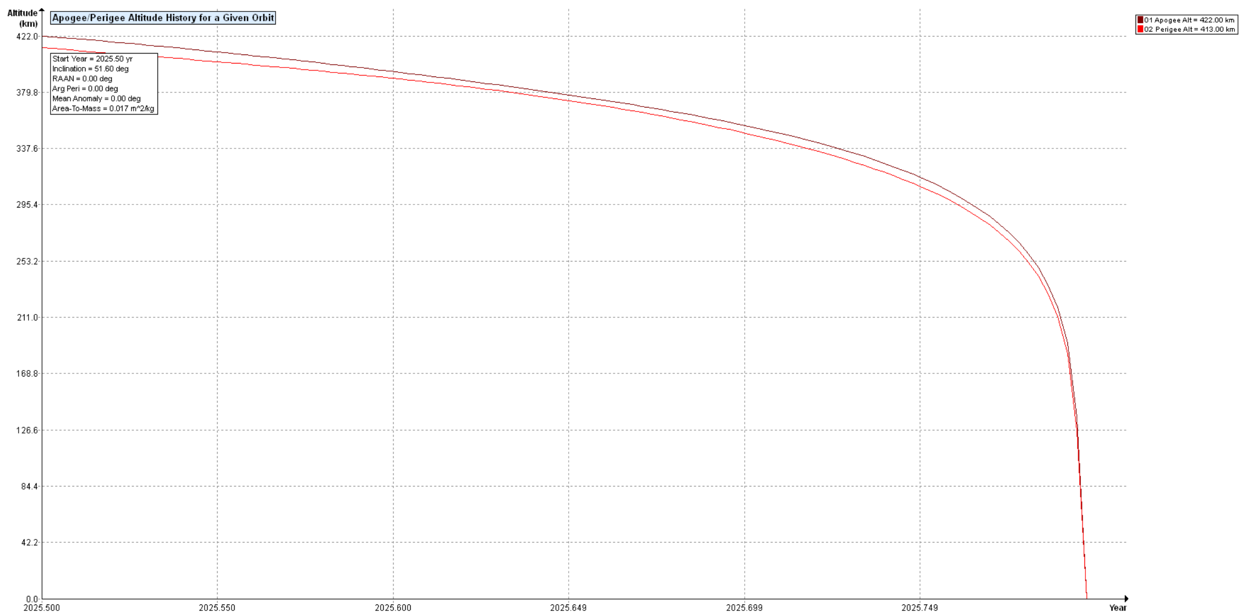

Figure 7-1 Altitude vs Time, SilverSat

b. Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-4

Requirement 4.6-1, Disposal for space structures passing through LEO: **Compliant**

Per DAS, the passive demise occurs 0.293 years after deploy which is less than the limit of 5 years after the end of the mission set by FCC.

Requirement 4.6-2, Disposal for space structures near GEO: **N/A**

Requirement 4.6-3, Disposal for space structures between LEO and GEO: **N/A**

Requirement 4.6-4, Reliability of post-mission disposal operations: **N/A**

8. <u>ODAR Section 7</u>: Assessment of Spacecraft Reentry Hazards

a. Detailed description of spacecraft components by size, mass, material, shape, and original location on the space vehicle, if the atmospheric reentry option is selected

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Name	Parent	Qty	Material	Shape	Mass	Width	Length	Height
Structure 1U without Stacking Rods	1	1	Aluminum (generic)	Box	0.097	0.1	0.113	0.1
Magnets Alnico500	2	11	Iron	Cylinder	0.00048	0.0025	0.0127	
Coax RG316	2	1	Copper Alloy	Cylinder	0.0063	0.0026	0.15	
Harnessing	2	1	Copper Alloy	Cylinder	0.01281	0.001	3.6	
Avionics Board Main Board IMU	2	1	Fiberglass	Box	0.051	0.09	0.096	0.004
Radio Board	2	1	Fiberglass	Box	0.0428	0.09	0.096	0.003
Payload Board Main Board Camera Raspberry Pi	2	1	Fiberglass	Box	0.073	0.09	0.096	0.005
EPS Housing	2	1	Aluminum (generic)	Box	0.0865	0.09	0.096	0.021
EPS PCB Batteries	9	1	Fiberglass	Box	0.164	0.09	0.096	0.011
Stacking Rods	2	4	Stainless Steel (generic)	Cylinder	0.004	0.0028	0.0953	
Minus Z Closeout Panel	1	1	Aluminum 6061-T6	Box	0.037	0.098	0.098	0.0015
Solar Panel 1U XY Substrate	1	2	Fiberglass	Box	0.0348	0.0826	0.098	0.0024
Solar Panel 1U XY RBF Substrate	1	2	Fiberglass	Box	0.03578	0.0826	0.098	0.0025
Solar Cells Azure Space 3G30A	1	10	Germanium	Box	0.00356	0.04015	0.085	0.00038
Solar Panel Antenna 1U Z Substrate	1	1	Fiberglass	Box	0.10148	0.098	0.098	0.007

Table 8-1: SILVERSAT Components List

b. Summary of objects expected to survive an uncontrolled reentry, using NASA Debris Assessment Software (DAS), NASA Object Reentry Survival Analysis Tool (ORSAT), or comparable software

Based on DAS, no components are expected to survive reentry.

c. Calculation of probability of human casualty for the expected year of uncontrolled reentry and the spacecraft orbital inclination

The risk of human casualty is 0.

d. Assessment of spacecraft compliance with Requirement 4.7-1

4.7-1, Limit the risk of human casualty: **Compliant**

9. ODAR Section 8: Assessment for Special Classes of Space Missions

Specify the special mission class(es) and detail how the ODAR addresses additional measures applied to the mission.

The requirements for special classes of space missions do not apply to the SilverSat mission.

Assessment of compliance with Requirement 4.8-1

Requirement 4.8-1, Assessment of compliance for special classes of space missions: **N/A**

SilverSat is not considered a special class of space mission, as described by the provided list.

10. ODAR Section 9-14: Launch Vehicle

Sections 9 through 14 pertain to the Launch Vehicle for SilverSat and are not covered in this document.

Appendix A – DAS Activity Log

```
12 01 2024; 16:59:31PM Activity Log Started
12 01 2024; 16:59:31PM Opened Project C:\Users\Mike\Documents\All
SatLicensing\SILVERSAT\ODAR\DAS SilverSat\
12 01 2024; 17:00:50PM Project Data Saved To File
12 01 2024; 17:00:56PM Project Data Saved To File
12 01 2024; 17:05:21PM Mission Editor Changes Applied
12 01 2024; 17:05:21PM Project Data Saved To File
12 01 2024; 17:05:21PM Project Data Saved To File
12 01 2024; 17:06:00PM Science and Engineering - Apogee/Perigee History
for a Given Orbit

**INPUT**

      Perigee Altitude = 413.000000 (km)
      Apogee Altitude = 422.000000 (km)
      Inclination = 51.600000 (deg)
      RAAN = 0.000000 (deg)
      Argument of Perigee = 0.000000 (deg)
      Mean Anomaly = 0.000000 (deg)
      Area-To-Mass Ratio = 0.017000 (m^2/kg)
      Start Year = 2025.500000 (yr)
      Integration Time = 1.000000 (yr)

**OUTPUT**

      Plot
12 01 2024; 17:06:55PM Science and Engineering - Orbit Lifetime/Dwell Time

**INPUT**

      Start Year = 2025.500000 (yr)
      Perigee Altitude = 413.000000 (km)
      Apogee Altitude = 422.000000 (km)
      Inclination = 51.600000 (deg)
      RAAN = 0.000000 (deg)
      Argument of Perigee = 0.000000 (deg)
      Area-To-Mass Ratio = 0.017000 (m^2/kg)

**OUTPUT**

      Orbital Lifetime from Startyr = 0.292956 (yr)
      Time Spent in LEO during Lifetime  = 0.292956 (yr)
      Last year of Propagation = 2025 (yr)
      Returned Error Message: Object reentered
12 01 2024; 17:07:39PM Processing Requirement 4.6   Return Status :
Passed

==============
Project Data
==============
```

```
**INPUT**

      Space Structure Name = SilverSat
      Space Structure Type = Payload

      Perigee Altitude = 413.000000 (km)
      Apogee Altitude = 422.000000 (km)
      Inclination = 51.600000 (deg)
      RAAN = 0.000000 (deg)
      Argument of Perigee = 0.000000 (deg)
      Mean Anomaly = 0.000000 (deg)
      Area-To-Mass Ratio = 0.017000 (m^2/kg)
      Start Year = 2025.500000 (yr)
      Initial Mass = 0.883000 (kg)
      Final Mass = 0.883000 (kg)
      Duration = 2.000000 (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)
      Long-Term Reentry = False

**OUTPUT**

      Suggested Perigee Altitude = 413.000000 (km)
      Suggested Apogee Altitude = 422.000000 (km)
      Returned Error Message = Reentry during mission (no PMD req.).

      Released Year = 2025 (yr)
      Requirement = 61
      Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
12 01 2024; 17:07:39PM *********Processing Requirement 4.7-1
      Return Status :  Passed

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

name = SilverSat
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 0.883000
Thermal Mass = 0.883000
Diameter/Width = 0.100000
```

```
Length = 0.113000
Height = 0.100000

name = Structure 1U without Stacking Rods
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.554690
Thermal Mass = 0.097000
Diameter/Width = 0.100000
Length = 0.113000
Height = 0.100000

name = Magnets Alnico500
quantity = 11
parent = 2
materialID = 38
type = Cylinder
Aero Mass = 0.000480
Thermal Mass = 0.000480
Diameter/Width = 0.002500
Length = 0.012700

name = Coax RG316
quantity = 1
parent = 2
materialID = 19
type = Cylinder
Aero Mass = 0.006300
Thermal Mass = 0.006300
Diameter/Width = 0.002600
Length = 0.150000

name = Harnessing
quantity = 1
parent = 2
materialID = 19
type = Cylinder
Aero Mass = 0.012810
Thermal Mass = 0.012810
Diameter/Width = 0.001000
Length = 3.600000

name = Avionics Board  Main Board IMU
quantity = 1
parent = 2
materialID = 23
type = Box
Aero Mass = 0.051000
Thermal Mass = 0.051000
Diameter/Width = 0.090000
Length = 0.096000
```

```
Height = 0.004000

name = Radio Board
quantity = 1
parent = 2
materialID = 23
type = Box
Aero Mass = 0.042800
Thermal Mass = 0.042800
Diameter/Width = 0.090000
Length = 0.096000
Height = 0.003000

name = Payload Board Main Board Camera Raspberry Pi
quantity = 1
parent = 2
materialID = 23
type = Box
Aero Mass = 0.073000
Thermal Mass = 0.073000
Diameter/Width = 0.090000
Length = 0.096000
Height = 0.005000

name = EPS Housing
quantity = 1
parent = 2
materialID = 5
type = Box
Aero Mass = 0.250500
Thermal Mass = 0.086500
Diameter/Width = 0.090000
Length = 0.096000
Height = 0.021000

name = EPS PCB Batteries
quantity = 1
parent = 9
materialID = 23
type = Box
Aero Mass = 0.164000
Thermal Mass = 0.164000
Diameter/Width = 0.090000
Length = 0.096000
Height = 0.011000

name = Stacking Rods
quantity = 4
parent = 2
materialID = 54
type = Cylinder
Aero Mass = 0.004000
Thermal Mass = 0.004000
```

```
Diameter/Width = 0.002800
Length = 0.095300

name = Minus Z Closeout Panel
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.037000
Thermal Mass = 0.037000
Diameter/Width = 0.098000
Length = 0.098000
Height = 0.001500

name = Solar Panel 1U XY Substrate
quantity = 2
parent = 1
materialID = 23
type = Box
Aero Mass = 0.034800
Thermal Mass = 0.034800
Diameter/Width = 0.082600
Length = 0.098000
Height = 0.002400

name = Solar Panel 1U XY RBF Substrate
quantity = 2
parent = 1
materialID = 23
type = Box
Aero Mass = 0.035780
Thermal Mass = 0.035780
Diameter/Width = 0.082600
Length = 0.098000
Height = 0.002500

name = Solar Cells Azure Space 3G30A
quantity = 10
parent = 1
materialID = 25
type = Box
Aero Mass = 0.003560
Thermal Mass = 0.003560
Diameter/Width = 0.040150
Length = 0.085000
Height = 0.000380

name = Solar Panel  Antenna 1U Z Substrate
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.101480
```

```
Thermal Mass = 0.101480
Diameter/Width = 0.098000
Length = 0.098000
Height = 0.007000

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

name = SilverSat
Demise Altitude = 77.992939
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Structure 1U without Stacking Rods
Demise Altitude = 77.208751
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Magnets Alnico500
Demise Altitude = 75.842933
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Coax RG316
Demise Altitude = 76.511962
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Harnessing
Demise Altitude = 77.063966
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Avionics Board  Main Board IMU
Demise Altitude = 75.977196
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Radio Board
Demise Altitude = 76.156607
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Payload Board Main Board Camera Raspberry Pi
Demise Altitude = 75.486364
Debris Casualty Area = 0.000000
```

```
Impact Kinetic Energy = 0.000000

*************************************
name = EPS Housing
Demise Altitude = 75.663763
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = EPS PCB Batteries
Demise Altitude = 72.100661
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Stacking Rods
Demise Altitude = 76.052750
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Minus Z Closeout Panel
Demise Altitude = 77.657678
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Solar Panel 1U XY Substrate
Demise Altitude = 77.105951
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Solar Panel 1U XY RBF Substrate
Demise Altitude = 77.078953
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Solar Cells Azure Space 3G30A
Demise Altitude = 77.907419
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Solar Panel  Antenna 1U Z Substrate
Demise Altitude = 75.807026
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

12 01 2024; 17:07:39PM Project Data Saved To File
12 01 2024; 17:13:28PM Processing Requirement 4.5-1:   Return Status : Passed

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

INPUT

Space Structure Name = SilverSat
Space Structure Type = Payload
Perigee Altitude = 413.000 (km)
Apogee Altitude = 422.000 (km)
Inclination = 51.600 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0170 (m^2/kg)
Start Year = 2025.500 (yr)
Initial Mass = 0.883 (kg)
Final Mass = 0.883 (kg)
Duration = 2.000 (yr)
Station-Kept = False
Abandoned = True
Long-Term Reentry = False

OUTPUT

Collision Probability = 7.2473E-09
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

12 01 2024; 17:14:05PM Project Data Saved To File