RBC Signals LLC
Application for 180-Day Special Temporary Authorization

Technical Appendix

I. Technical Description
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III. SteamSat Orbital Debris Assessment Report
IV. 400 MHz Yagi Radiation Hazard Analysis
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VI. Draft FCC Form 312 Schedule B

RBC Signals
180-Day STA Request

I. Technical Description

RBC Signals seeks to provide telemetry, tracking and command ("TT&C") in the 401-402 MHz band for two (2) cubesats operated by SatRevolution, as follows:

1. The SW1FT cubesat in 401.0375-401.0625 MHz (Earth-to-space) and 401.0125-401.0375 MHz (space-to-Earth) bands; and
2. The SteamSat cubesat in the 401.0-401.1 MHz (Earth-to-space) and 401.050-401.150 MHz (space-to-Earth) bands.

This Technical Description provides an operational overview of the SW1FT and SteamSat satellites in support of RBC Signals' request for a 180-day special temporary authorization ("STA") to provide TT&C support for the spacecraft from a facility in Deadhorse, Alaska, USA. With the launch of both satellites currently scheduled for mid- to late-December 2020, there should be sufficient time to place this application on public notice in anticipation of the start of the mission (*see* Narrative).

RBC Signals is requesting the STA to support SatRevolution in testing and demonstrating components, software, and operational concepts that are integral to the planned missions, and generally help establish space heritage for the satellite products being evaluated under this STA. SatRevolution seeks to operate the SteamSat to evaluate a low power, steam-based propellant system (the "TunaCan") that will assist cubesat operators with constellation management and orbit optimization. SatRevolution seeks to operate the SW1FT mission to demonstrate its next-generation Earth observation cameras (the "Vision300") and optical machine learning module (the "SpaceEdgeZero") and help make this novel technology more widely available.

The demonstrations planned for the SW1FT and SteamSat missions will be conducted intermittently over a three-year period commencing shortly after launch of the satellite. The frequencies, ground station location, and operational constraints have been carefully identified to avoid the potential for interference to other spectrum users.

RBC Signals notes that the expected launch window for the spacecraft is December 18, 2020 to December 31, 2020 on the same SpaceX Falcon 9 launch vehicle from Cape Canaveral, Florida. Therefore, RBC Signals respectfully requests that the Commission consider and authorize the proposed operations (as appropriately conditioned) as soon as practicable. RBC Signals will update the Commission with the final launch date once the launch schedule is finalized.

I. SW1FT

The SW1FT satellite conforms to the form factor of a 3U cubesat (340 mm X 116 mm X 109 mm in the stowed configuration and approximately 431.2 mm X 374.5 mm X 374.5 mm in the deployed configuration), with a total mass of approximately 3.0 kg, as indicated in Figure 1. The maximum power generated by the solar panels is approximately 22 W (18 W at end-of-life "EOL"), with a maximum transmitter output RF power of approximately 29 dBm in UHF frequencies.

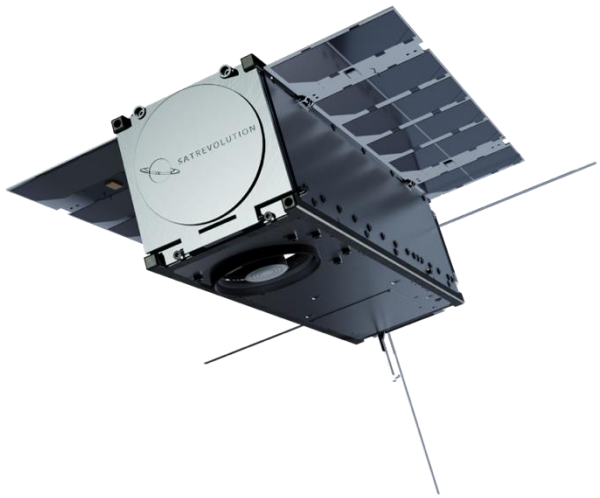

Figure 1. SW1FT Deployed Configuration

A. Orbit. The SW1FT satellite will be launched aboard a SpaceX Falcon 9 launch vehicle from the Cape Canaveral launch center in Florida in December 2020. The satellites will be launched into a nominal circular, sun-synchronous orbit at 525 km apogee and 525 km perigee with an inclination from the equator of 97.6°. An orbital lifetime calculation for this orbit estimates that the satellite will remain in orbit for approximately 2.97 years (under worst case conditions), well within the limits set by internationally accepted guidelines.[1]

B. TT&C Earth Station. RBC Signals will utilize a LimeSDR Mini radio transceiver and associated equipment, including an M2 Antenna Systems 400CP30A Yagi antenna (with an antenna gain of 16.2 dBi) to conduct TT&C operations. The earth station is located at an existing facility in Deadhorse, AK, and TT&C operations in the 401-402 MHz band will take place intermittently when the satellite is in view of the earth station site. RBC Signals will coordinate the TT&C operations to ensure compatibility with any other co-frequency operations in the area. The antenna patterns for the UHF transmit antenna at the earth station site is illustrated in Figure 2.

[1] *See* SW1FT Orbital Debris Assessment Report (attached).

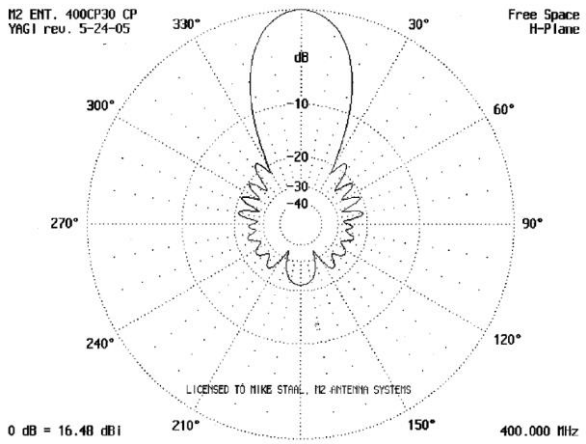

Figure 2. UHF Monopole Antenna Pattern

C. Operational Parameters. In addition to the draft FCC Form 312 Schedule B provided with this application, RBC Signals provides a summary of key technical parameters of the TT&C operations below:

UHF Band

- 0.2 W earth station transmitter output power, 9.2 dBW EIRP
- 0.8 W spacecraft transmitter output power, 2.0 dBW EIRP
- Tx (satellite uplink) from 401.0375-401.0625 MHz (Earth-to-space)
- Rx (satellite downlink) from 401.0125-401.0375 MHz (space-to-Earth)
- 2GFSK modulation
- 9.6 kbps uplink, 1.2/9.6 kbps downlink
- LHCP

D. Satellite Antenna Patterns. The satellite antenna patterns for the SW1FT UHF band antenna is illustrated in Figure 3.

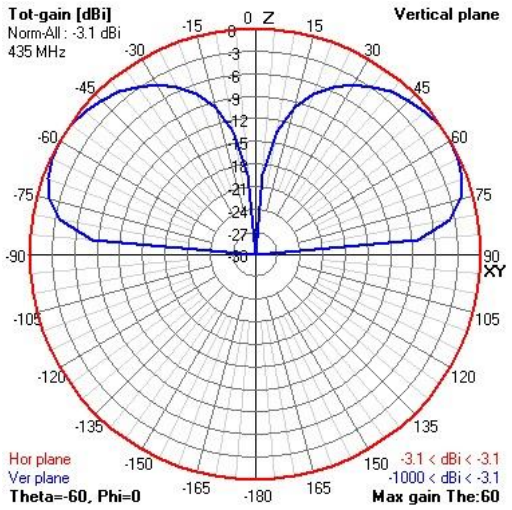

Figure 3. SW1FT UHF Satellite Antenna Pattern

II. SteamSat

The SteamSat satellite conforms to the form factor of a 1.5U cubesat (190.5 mm X 111 mm X 106.7 mm in the stowed configuration and approximately 374.5 mm X 374.5 mm X 190 mm in the deployed configuration), with a total mass of approximately 1.37 kg. The maximum power generated by the solar panels is approximately 8 W (6 W at EOL), with a maximum transmitter output RF power of approximately 29 dBm in UHF frequencies. The TT&C radio uses omnidirectional canted turnstile antennas, as indicated in Figure 6.

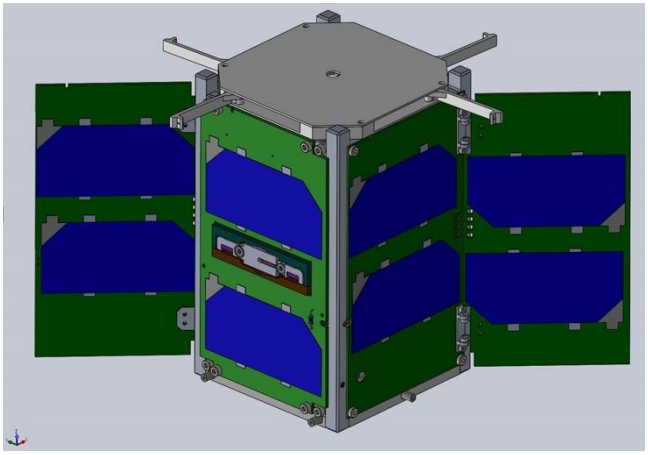

Figure 4. SteamSat Deployed Configuration

A. Orbit. The SteamSat satellite will be launched aboard a SpaceX Falcon 9 launch vehicle from the Cape Canaveral launch center in Florida in December 2020. The satellites will be launched into a nominal circular, sun-synchronous orbit at 525 km apogee and 525 km perigee with an inclination from the equator of 97.6°. An orbital lifetime calculation for this orbit estimates that the satellite will remain in orbit for approximately 2.513 years (under worst case conditions), well within the limits set by internationally accepted guidelines.[2]

B. TT&C Earth Station. RBC Signals will utilize a LimeSDR Mini radio transceiver and associated equipment, including an M2 Antenna Systems 400CP30A Yagi antenna (with an antenna gain of 16.2 dBi) to conduct TT&C operations. The earth station is located at RBC Signals' facility in Deadhorse, AK, and TT&C operations in the 401-402 MHz band will take place intermittently when the satellite is in view of the earth station site. RBC Signals will coordinate the TT&C operations to ensure compatibility with any other co-frequency operations in the area. The antenna patterns for the UHF transmit antenna at the earth station site is illustrated in Figure 2.

C. Operational Parameters. In addition to the draft FCC Form 312 Schedule B provided with this application, RBC Signals provides a summary of key technical parameters of the telemetry and tracking downlink operations and telecommand uplink operations include:

[2] *See* SteamSat Orbital Debris Assessment Report (attached).

UHF Band

- 0.2 W earth station transmitter output power, 9.2 dBW EIRP
- 0.8 W spacecraft transmitter output power, 2.0 dBW EIRP
- Tx (satellite uplink) from 401.0-401.1 MHz (Earth-to-space)
- Rx (satellite downlink) from 401.050-401.150 MHz (space-to-Earth)
- GFSK modulation
- 9.6 kbps uplink, 1.2/9.6 kbps downlink
- LHCP

D. Satellite Antenna Pattern. The antenna patterns for the SteamSat UHF transmit antenna is illustrated in Figure 7.

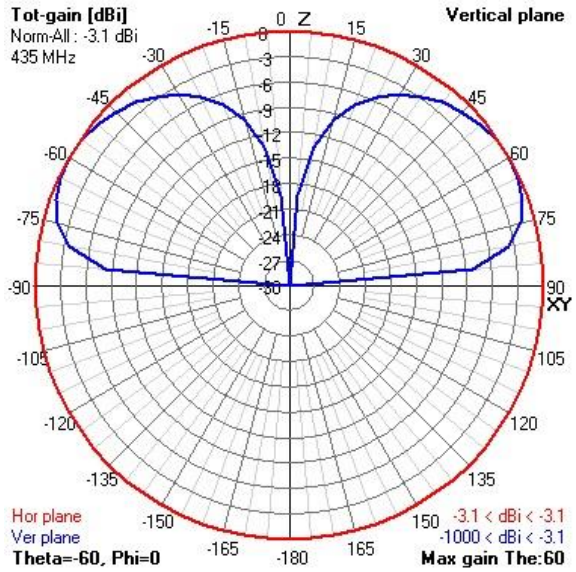

Figure 5. SteamSat UHF Satellite Antenna Pattern

SW1FT Orbital Debris Assessment Report (ODAR)

SW1FT-ODAR-1.0

This report is presented as compliance with NASA-STD-8719.14B, APPENDIX A, 4/25/2019

SatRevolution

POLAND OFFICE
Stabłowicka 147
54-066 Wrocław
Poland

U.S.A. OFFICE
388 Market Street (Suite 1300)
San Francisco, CA 94111
United States

DAS Software Version Used In Analysis: v3.1.0

Revision Record				
Revision:	Date:	Affected Pages:	Changes:	Author(s):
1.0	8/14/2020	All –Initial	DAS Software Results Orbit Lifetime Analysis	D. Morse

Contents

Self-assessment of the ODAR using the format in Appendix A.2 of NASA-STD-8719.14B:

A self-assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14B.

Section	Status	Comments
4.3-1, Mission-Related Debris Passing Through LEO	COMPLIANT	
4.3-2, Mission-Related Debris Passing Near GEO	COMPLIANT	
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	COMPLIANT	
4.4-2, Design for passivation after completion of mission operations while in orbit about Earth or the Moon	N/A	
4.4-3, Limiting the long-term risk to other space systems from planned breakups	COMPLIANT	
4.4-4, Limiting the short-term risk to other space systems from planned breakups	COMPLIANT	
4.5-1, Probability of Collision with Large Objects	COMPLIANT	
4.5-2, Probability of Damage from Small Objects	COMPLIANT	System will passively deorbit; therefore, no components are critical to deorbit.
4.6-1, Disposal for space structures passing through LEO	COMPLIANT	
4.6-2, Disposal for space structures passing through GEO	N/A	
4.6-3, Disposal for space structures between LEO and GEO	N/A	
4.6-4, Reliability of post-mission disposal operations	COMPLIANT	
4.8-1, Collision Hazards of Space Tethers	COMPLIANT	

Assessment Report Format:

ODAR Technical Sections Format Requirements:

SatRevolution is a Polish company with a US presence. This ODAR follows the format in NASA-STD-8719.14B, Appendix A.1 and includes the content indicated as a minimum, in each of sections 2 through 8 below for the SW1FT mission. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Program/project manager: Mateusz Kellar

Senior Management: Grzegorz Zwolinski (Chief Executive Officer, SatRevolution)

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination: The SW1FT mission will consist of a single satellite launched into sub-synchronous circular orbit with nominal orbit altitude of 525 km (based upon a range of SSO orbit altitudes from 500km to 550km).

Schedule of upcoming mission milestones:

- Scheduled Launch Date: December 16, 2020. SatRevolution has contracted SpaceX Rideshare to broker the SW1FT launch. SpaceX's most recent manifest indicates a launch window of December 1, 2020 – December 31, 2020.

Mission Overview: The SW1FT satellite will be launched into a sun-synchronous, Low Earth Orbit (LEO). The satellite bus will use magnetic torque coils, reaction wheel, star tracker cameras, sun sensor, GPS, and an IMU to enable 3-axis pointing control. The SW1FT mission will demonstrate an Earth Observation payload.

Launch Vehicle and Launch Site: Falcon 9 Launch Vehicle, Dedicated SSO Rideshare Mission #1. The launch site is Cape Canaveral, Florida. The Falcon-9 launch vehicle will transport multiple mission payloads to orbit.

SW1FT will be deployed into an approximately sun synchronous circular low Earth orbit. SW1FT will deploy solar panels and UHF antenna once deployed from the Momentus Vigoride deployer fitted with an ISIS Quadpack CubeSat deployer. The spacecraft is expected to be deployed with the following orbital parameters:[1]

Highest Apogee: 550 km

[1] The SW1FT satellite will be deployed between 500 km and 550 km at the discretion of the launch service provider. SatRevolution has assumed a 550 km orbital altitude for SW1FT for purposes of this orbital debris analysis report.

Highest Perigee: 550 km

Target Inclination: 97.6° ± 0.3°

SW1FT is demonstrating an Earth Observation payload.

Mission Duration: The anticipated lifetime of the spacecraft is 3 years in LEO.

ODAR Section 2: Spacecraft Description:

Physical description of the constellation: The SW1FT satellite is based on the SatRevolution NanoBus bus. Basic physical dimensions are 340.5 mm x 116 mm x 109 mm with a wet mass of approximately 3.0 kg. The satellite is composed of the NanoBus 3U bus, deployable solar panels, deployable UHF antenna and a water-based resisto-jet propulsion module. The solar panel generates up to 22 W of electric power which is stored in a 54.6 Wh COTS Li-Ion unpressurized 3-cell battery assembly. The bus is 3-axis stabilized, employing GPS, 9-DOF IMU, sun sensors, and star trackers for attitude knowledge and magnetic torque rods and reaction wheels for attitude control.

The SW1FT satellite will be separated from the Falcon 9 launch vehicle using the Momentus Vigoride deployer fitted with an ISIS CubeSat deployer which provide debris free actuation.

The SW1FT spacecraft is depicted in Figure 1 for the post-deployment configuration.

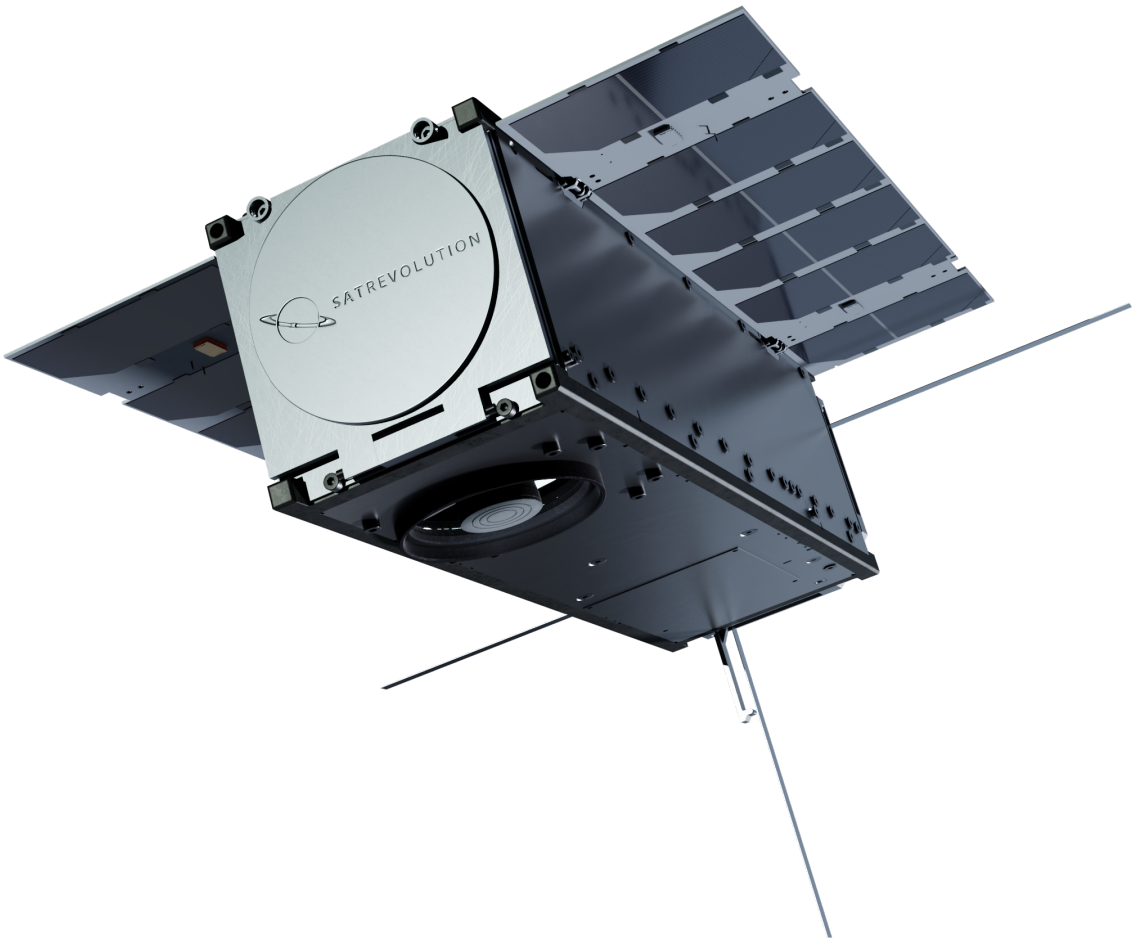

Figure 1 SW1FT Spacecraft Configuration

Total satellite mass at launch, including all propellants and fluids: 3.0 kg.

Dry mass of satellites at launch: 3.0 kg. (no propulsion)

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear): None

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: None

Fluids in Pressurized Batteries: None

The SW1FT satellite uses a 3-cell unpressurized standard COTS Lithium-Ion battery cells in each spacecraft. The total capacity energy capacity per spacecraft is 54.6 W-h.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector: The SW1FT spacecraft attitude will be controlled initially by torque rods, which will allow the satellite to be aligned relative to the Earth's magnetic field. These will allow the satellite to detumble and align with the magnetic field.

- A *safe mode* that is optimized for solar power generation from the satellite. The spacecraft's deployable panel will be oriented towards the sun.
- A *targeted tracking mode*, which will allow the satellite Nadir panel to be directed at any location on the Earth's surface.
- An *LVLH mode* that keeps the Nadir panel pointed towards the Earth's surface.

Description of any range safety or other pyrotechnic devices: None.

The SW1FT satellite will be released from the Falcon 9 launch vehicle using the Momentus Vigoride deployer fitted with an ISIS CubeSat deployer which provides debris-free actuation.

Description of the electrical generation and storage system: Standard COTS Lithium-Ion battery cells are charged before payload integration and provide 54.6 W-h of electrical energy during the eclipse portion of the satellite's orbit. The Solar Cells generate a maximum on-orbit power of approximately 22 W degrading down to 18 W at the end-of-life of the mission (3 years for calculation purposes).

Identification of any other sources of stored energy not noted above: None

Identification of any radioactive materials on board: None

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

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 v3.1.0)
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.

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 in-orbit failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell explosion.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions: There are no planned breakups.

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

- Three (3) Lithium Ion Battery Cells – configure spacecraft to prevent battery charging, let batteries deplete
- Propulsion – all propellant will be vented before passivation

Rationale for all items which are required to be passivated, but cannot be due to their design: None

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; COMPLIANT.

Supporting Rationale and FMEA details:

Battery explosion:

On-orbit failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell deflagration. Multiple independent failures must first occur for this effect. In the event of an unlikely explosion, the effect to the far-term LEO environment is considered negligible due to the following:

- SW1FT satellites have a short orbital life due to the low orbital altitude (<6 years under worst-case failure conditions)
- SW1FT satellites have very low mass
- SW1FT satellites have spacecraft structural covers will likely contain debris results from a battery rupturing, except for those that may be vented through small orifices

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 post-mission 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: At EOM, all propellant will be vented and the cubesat. In the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the spacecraft due to the lack of penetration energy to the multiple enclosures surrounding the batteries.

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

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v3.1.0, and calculation methods provided in NASA-STD-8719.14B, 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: 0.00000023; 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; the spacecraft is planned orbital disposal by atmospheric entry, and does not require a specific spacecraft orientation and drag state to meet the disposal requirements. Therefore, no element or component of the spacecraft system is required to complete post-mission operations.

Identification of all systems or components required to accomplish any post-mission disposal operation, including passivation and maneuvering: None

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

6.1 Description of spacecraft disposal option selected: The satellite includes a water-based propulsion demonstration that will be used to lower the orbit altitude by up to 70 km. In the case of propulsion demonstrator failure (or other general CubeSat failure), the satellite will still de-orbit naturally by atmospheric re-entry.

6.2 Plan for any spacecraft maneuvers required to accomplish post-mission disposal: None

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

Spacecraft Mass (Dry): 3.0 kg

Cross-sectional Area: 0.059607 m^2

(Calculated by DAS 3.1.0). Area to mass ratio: 059607/3.0 = 0.019869 m^2/kg

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v3.1.0 and NASA-STD-8719.14B 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: (Requirement 56557)*

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 SW1FT satellites' method of disposal is COMPLIANT using method "a." In the worst-case orbit altitude of 550 x 550 km near-circular orbit, the passive deorbit time is 4.156 years after launch with orbit history as shown in Figure 2 if the solar arrays do not deploy. It should be noted that this is assuming a launch date of December 2020. If the solar arrays do deploy, the passive deorbit time will be reduced to 2.973 yrs.

Under planned launch conditions, SW1FT will be deployed in a 525 x 525 km nominal near-circular orbit, reentering in approximately 2.973 years after launch. If the solar arrays deploy, the passive deorbit time will reduce to 1.84 years with orbit history as

shown in Figure 3 (analysis assumes a noon-midnight Sun synchronous orbit with solar array tracking).

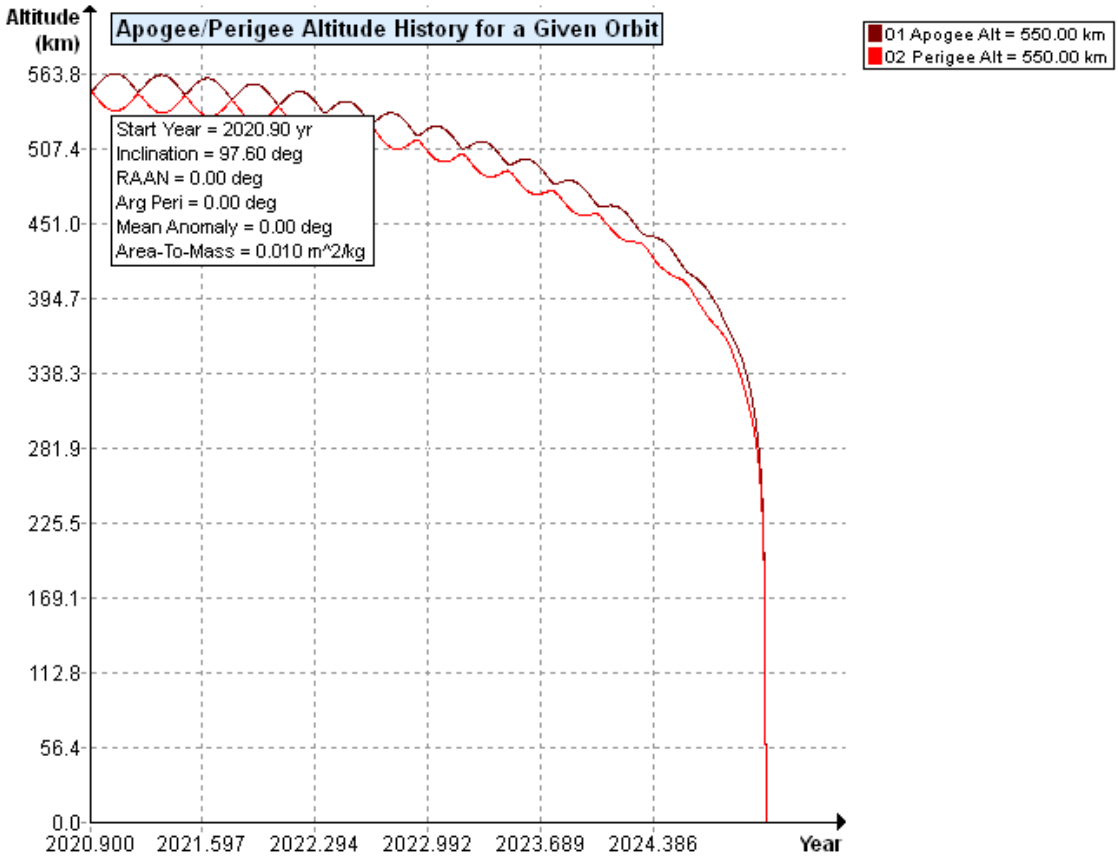

Figure 2 SW1FT Orbit History – at Maximum Orbit Altitude of 550 km x 550 km SSO in Stowed Configuration

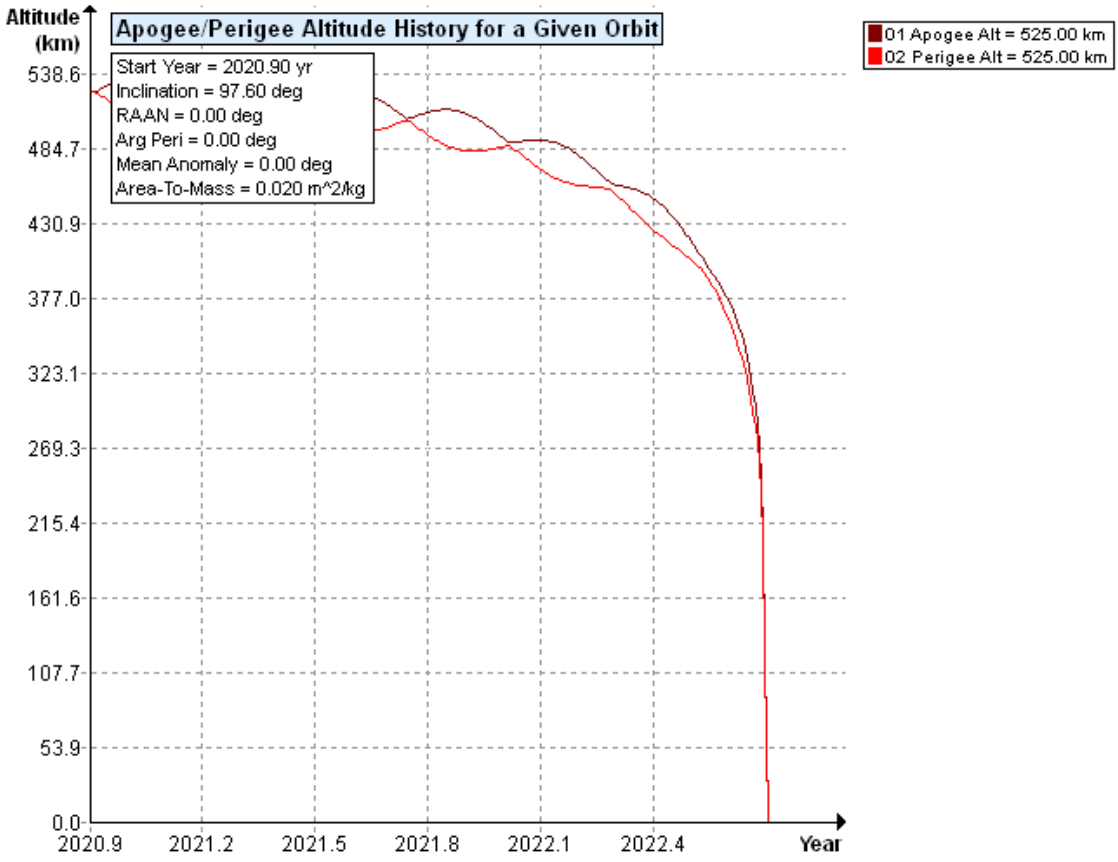

Figure 3 SW1FT Orbit History – at Nominal Orbit Altitude of 525 km x 525 km SSO in Deployed Configuration

Requirement 4.6-2. Disposal for space structures near GEO:
Analysis is not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO: Analysis is not applicable.

Requirement 4.6-4. Reliability of Post-mission Disposal Operations:
Analysis is not applicable. The satellite will reenter passively without post mission disposal operations within the allowable timeframe.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards:

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:
a) 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 v3.1.0 reports that the SW1FT satellite is COMPLIANT with the requirement with a per satellite casualty risk of 1:33000.

This represents an acceptable casualty risk, as calculated with DAS's modeling capability.

The DAS Output Summary Follows:

08 28 2020; 11:39:07AM Processing Requirement 4.3-2: Return Status : Passed

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

========== End of Requirement 4.3-2 ==========
08 28 2020; 11:42:37AM Processing Requirement 4.5-1: Return Status : Passed

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

****INPUT****

Space Structure Name = SW1FT
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.600 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0199 (m^2/kg)
Start Year = 2020.900 (yr)
Initial Mass = 3.000 (kg)
Final Mass = 3.000 (kg)
Duration = 3.000 (yr)
Station-Kept = False
Abandoned = True

****OUTPUT****

Collision Probability = 2.2934E-07

Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==========

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

08 28 2020; 11:42:43AM Processing Requirement 4.6 Return Status : Passed

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

****INPUT****

Space Structure Name = SW1FT
Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.019869 (m^2/kg)
Start Year = 2020.900000 (yr)
Initial Mass = 3.000000 (kg)
Final Mass = 3.000000 (kg)
Duration = 3.000000 (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)

****OUTPUT****

Suggested Perigee Altitude = 525.000000 (km)
Suggested Apogee Altitude = 525.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2022 (yr)

Requirement = 61
Compliance Status = Pass

==========

========== End of Requirement 4.6 ==========
08 28 2020; 11:42:46AM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = SW1FT
quantity = 1
parent = 0
materialID = 8
type = Box
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.100000
Length = 0.200000
Height = 0.100000

name = Structure-PTFE
quantity = 1
parent = 1
materialID = 64
type = Box
Aero Mass = 0.127000
Thermal Mass = 0.127000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.100000

name = Structure-AL
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.455000
Thermal Mass = 0.455000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.100000

name = Structure-Steel

quantity = 1
parent = 1
materialID = 58
type = Box
Aero Mass = 0.003760
Thermal Mass = 0.003760
Diameter/Width = 0.020000
Length = 0.020000
Height = 0.020000

name = Comm Module - HF
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.130000
Thermal Mass = 0.130000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.050000

name = Comm Module - LF
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = C&DH Module
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.020000

name = Battery Management
quantity = 1
parent = 1

materialID = 27
type = Box
Aero Mass = 0.275000
Thermal Mass = 0.275000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.050000

name = Energy Harvesting System
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.060000
Thermal Mass = 0.060000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.020000

name = Aux Power Supply
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = ADCS
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.250000
Thermal Mass = 0.250000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.050000

name = Reaction Wheels
quantity = 3
parent = 1
materialID = 54
type = Cylinder

Aero Mass = 0.183000
Thermal Mass = 0.183000
Diameter/Width = 0.100000
Length = 0.050000

name = Payload
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.654000
Thermal Mass = 0.654000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.050000

name = Payload processor
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.252000
Thermal Mass = 0.252000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.050000

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

name = SW1FT
Demise Altitude = 77.997551
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-PTFE
Demise Altitude = 77.726250
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-AL
Demise Altitude = 74.142998
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-Steel
Demise Altitude = 0.000000
Debris Casualty Area = 0.384400
Impact Kinetic Energy = 0.265090

****
name = Comm Module - HF
Demise Altitude = 0.000000
Debris Casualty Area = 0.422500
Impact Kinetic Energy = 50.931648

****
name = Comm Module - LF
Demise Altitude = 0.000000
Debris Casualty Area = 0.415666
Impact Kinetic Energy = 26.284269

****
name = C&DH Module
Demise Altitude = 0.000000
Debris Casualty Area = 0.411950
Impact Kinetic Energy = 12.537213

****
name = Battery Management
Demise Altitude = 0.000000
Debris Casualty Area = 0.471423
Impact Kinetic Energy = 85.388275

****
name = Energy Harvesting System
Demise Altitude = 0.000000
Debris Casualty Area = 0.411950
Impact Kinetic Energy = 18.063890

****
name = Aux Power Supply
Demise Altitude = 0.000000
Debris Casualty Area = 0.415666
Impact Kinetic Energy = 26.284269

****
name = ADCS
Demise Altitude = 0.000000

Debris Casualty Area = 0.471423
Impact Kinetic Energy = 70.546532

****
name = Reaction Wheels
Demise Altitude = 68.459587
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload
Demise Altitude = 70.578758
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload processor
Demise Altitude = 74.943100
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

========== End of Requirement 4.7-1 ==========Requirements 4.7-1b, and 4.7-1c:
These requirements are non-applicable requirements because the SW1FT mission does not use controlled reentry.

4.7-1, b): *"For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627)."*

Not applicable to YAM. The spacecraft does not use controlled reentry and no debris is expected to survive.

4.7-1 c): *"For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628)."*
Not applicable to SW1FT. It does not use controlled reentry and no debris is expected to survive.

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers used in the SW1FT mission.

END of ODAR for SW1FT

Appendix A: Acronyms

Arg peri	Argument of Perigee
CDR	Critical Design Review
cm	centimeter
COTS	Commercial Off-The-Shelf (items)
DAS	Debris Assessment Software
EOM	End Of Mission
FRR	Flight Readiness Review
GEO	Geosynchronous Earth Orbit
ITAR	International Traffic In Arms Regulations
kg	kilogram
km	kilometer
LEO	Low Earth Orbit
Li-Ion	Lithium Ion
m^2	Meters squared
ml	milliliter
mm	millimeter
N/A	Not Applicable.
NET	Not Earlier Than
ODAR	Orbital Debris Assessment Report
OSMA	Office of Safety and Mission Assurance
PDR	Preliminary Design Review
PL	Payload
ISIPOD	ISIS CubeSat Deployer
PSIa	Pounds Per Square Inch, absolute
RAAN	Right Ascension of the Ascending Node
SMA	Safety and Mission Assurance
Ti	Titanium
Yr	year

STEAMSAT Orbital Debris Assessment Report (ODAR)

STEAMSAT-ODAR-1.0

This report is presented as compliance with NASA-STD-8719.14B, APPENDIX A, 4/25//2019

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DAS Software Version Used In Analysis: v3.1.0

Revision Record				
Revision:	Date:	Affected Pages:	Changes:	Author(s):
1.0	7/19/2020	All –Initial	DAS Software Results Orbit Lifetime Analysis	D. Morse

Contents

Self-assessment of the ODAR using the format in Appendix A.2 of NASA-STD-8719.14B:

A self-assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14B.

Section	Status	Comments
4.3-1, Mission-Related Debris Passing Through LEO	COMPLIANT	
4.3-2, Mission-Related Debris Passing Near GEO	COMPLIANT	
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	COMPLIANT	
4.4-2, Design for passivation after completion of mission operations while in orbit about Earth or the Moon	N/A	
4.4-3, Limiting the long-term risk to other space systems from planned breakups	COMPLIANT	
4.4-4, Limiting the short-term risk to other space systems from planned breakups	COMPLIANT	
4.5-1, Probability of Collision with Large Objects	COMPLIANT	
4.5-2, Probability of Damage from Small Objects	COMPLIANT	System will passively deorbit; therefore, no components are critical to deorbit.
4.6-1, Disposal for space structures passing through LEO	COMPLIANT	
4.6-2, Disposal for space structures passing through GEO	N/A	
4.6-3, Disposal for space structures between LEO and GEO	N/A	
4.6-4, Reliability of post-mission disposal operations	COMPLIANT	
4.8-1, Collision Hazards of Space Tethers	COMPLIANT	

Assessment Report Format:

ODAR Technical Sections Format Requirements:

SatRevolution is a Polish company with a US presence. This ODAR follows the format in NASA-STD-8719.14B, Appendix A.1 and includes the content indicated as a minimum, in each of sections 2 through 8 below for the STEAMSAT mission. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Program/project manager: Mateusz Kellar

Senior Management: Grzegorz Zwolinski (Chief Executive Officer, SatRevolution)

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination: The STEAMSAT mission will consist of a single satellite launched into sub-synchronous circular orbit with nominal orbit altitude of 525 km (based upon a range of SSO orbit altitudes from 500km to 550km).

Schedule of upcoming mission milestones:

- Scheduled Launch Date: December 16, 2020. SatRevolution has contracted SpaceX Rideshare to broker the STEAMSAT launch. SpaceX's most recent manifest indicates a launch window of December 1, 2020 – December 31, 2020.

Mission Overview: The STEAMSAT satellite will be launched into a sun-synchronous, Low Earth Orbit (LEO). The satellite bus will use magnetic torque coils, reaction wheel, star tracker cameras, sun sensor, GPS, and an IMU to enable 3-axis pointing control. The STEAMSAT mission will demonstrate a resistojet water-based propulsion system.

Launch Vehicle and Launch Site: Falcon 9 Launch Vehicle, Dedicated SSO Rideshare Mission #1. The launch site is Cape Canaveral, Florida. The Falcon-9 launch vehicle will transport multiple mission payloads to orbit.

STEAMSAT will be deployed into an approximately sun synchronous circular low Earth orbit. STEAMSAT will deploy solar panels and UHF antenna once deployed from the Momentus Vigoride deployer fitted with an ISIS Quadpack CubeSat deployer. The spacecraft is expected to be deployed with the following orbital parameters:[1]

Highest Apogee: 550 km

[1] The STEAMSAT satellite will be deployed between 500 km and 550 km at the discretion of the launch service provider. SatRevolution has assumed a 550 km orbital altitude for STEAMSAT for purposes of this orbital debris analysis report.

Highest Perigee: 550 km

Target Inclination: 97.6° ± 0.3°

STEAMSAT is demonstrating an on-board water-based propulsion system. STEAMSAT plans to actively lower its orbit during the mission but this ODAR will assume a worst-case scenario that no orbit lower is achieved.

Mission Duration: The anticipated lifetime of the spacecraft is 3 years in LEO.

ODAR Section 2: Spacecraft Description:

Physical description of the constellation: The STEAMSAT satellite is based on the SatRevolution NanoBus bus. Basic physical dimensions are 190.5 mm x 111 mm x 100 mm with a wet mass of approximately 1.37 kg. The satellite is composed of the NanoBus 1.5U bus, deployable solar panels, deployable UHF antenna and a water-based resisto-jet propulsion module. The solar panel generates up to 8 W of electric power which is stored in a 37.2Wh COTS Li-Ion unpressurized 3-cell battery assembly. The bus is 3-axis stabilized, employing GPS, 9-DOF IMU, sun sensors, and star trackers for attitude knowledge and magnetic torque rods and reaction wheels for attitude control.

The STEAMSAT satellite will be separated from the Falcon 9 launch vehicle using the Momentus Vigoride deployer fitted with an ISIS CubeSat deployer which provide debris free actuation.

The STEAMSAT spacecraft is depicted in Figure 1 for the pre-deployment configuration and in Figure 2 for the post-deployment configuration.

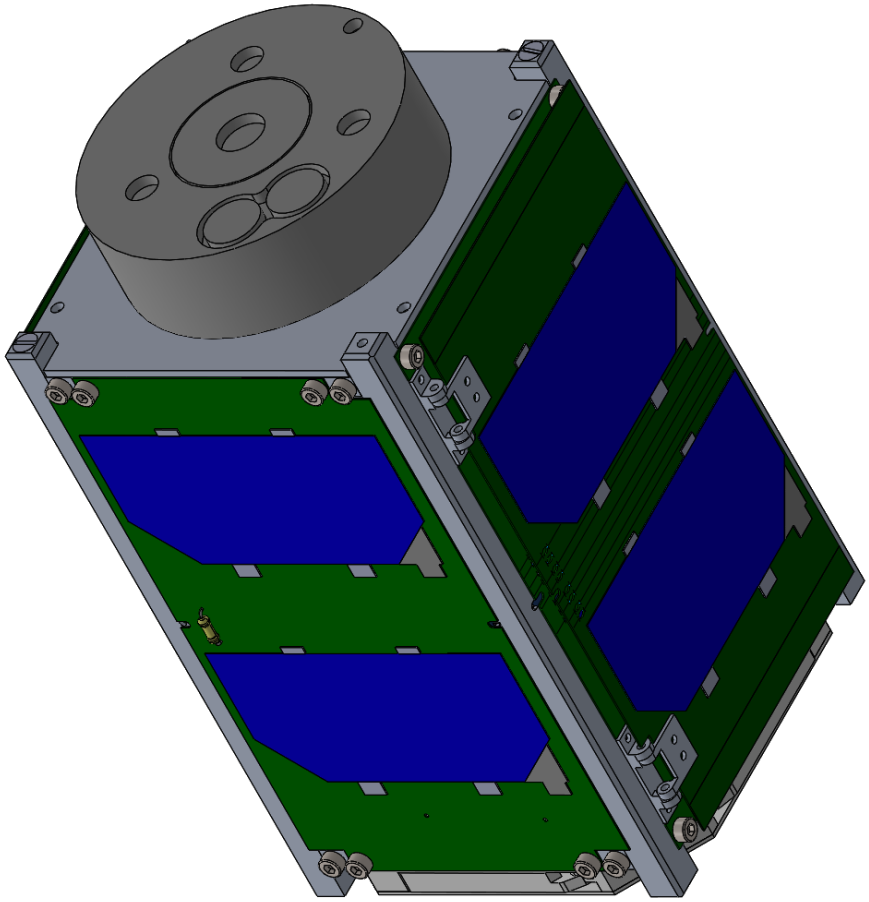

Figure 1 STEAMSAT Spacecraft Configuration – Pre-deployment

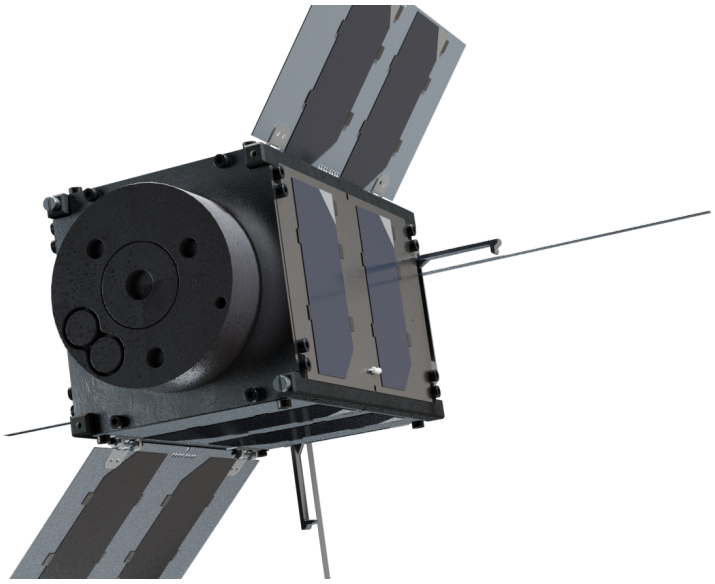

Figure 2 STEAMSAT Spacecraft Configuration – Post-deployment

Total satellite mass at launch, including all propellants and fluids: 1.5 kg.

Dry mass of satellites at launch: 1.37 kg. (130g of water-based propellant onboard)

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear): 130g of water-based propellant onboard

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: 130g of water propellant. Tank pressure will not exceed 101kPa (1 atm), thus fulfilling all CubeSat launch standards.

Fluids in Pressurized Batteries: None

The STEAMSAT satellite uses a 3-cell unpressurized standard COTS Lithium-Ion battery cells in each spacecraft. The total capacity energy capacity per spacecraft is 37.2 W-h.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector: The STEAMSAT spacecraft attitude will be controlled initially by torque rods, which will allow the satellite to be aligned relative to the Earth's magnetic field. These will allow the satellite to detumble and align with the magnetic field.

- A *safe mode* that is optimized for solar power generation from the satellite. The spacecraft's deployable panel will be oriented towards the sun.
- A *targeted tracking mode*, which will allow the satellite Nadir panel to be directed at any location on the Earth's surface.

- An *LVLH mode* that keeps the Nadir panel pointed towards the Earth's surface.

Description of any range safety or other pyrotechnic devices: None.

The STEAMSAT satellite will be released from the Falcon 9 launch vehicle using the Momentus Vigoride deployer fitted with an ISIS CubeSat deployer which provides debris-free actuation.

Description of the electrical generation and storage system: Standard COTS Lithium-Ion battery cells are charged before payload integration and provide 37.2 W-h of electrical energy during the eclipse portion of the satellite's orbit. The Solar Cells generate a maximum on-orbit power of approximately 8 W degrading down to 6 W at the end-of-life of the mission (3 years for calculation purposes).

Identification of any other sources of stored energy not noted above: None

Identification of any radioactive materials on board: None

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

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 v3.1.0)
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.

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 in-orbit failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell explosion.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions: There are no planned breakups.

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

- Three (3) Lithium Ion Battery Cells – configure spacecraft to prevent battery charging, let batteries deplete
- Propulsion – all propellant will be vented before passivation

Rationale for all items which are required to be passivated, but cannot be due to their design: None

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; COMPLIANT.

Supporting Rationale and FMEA details:

Battery explosion:

On-orbit failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell deflagration. Multiple independent failures must first occur for this effect. In the event of an unlikely explosion, the effect to the far-term LEO environment is considered negligible due to the following:

- STEAMSAT satellites have a short orbital life due to the low orbital altitude (<6 years under worst-case failure conditions)
- STEAMSAT satellites have very low mass
- STEAMSAT satellites have spacecraft structural covers will likely contain debris results from a battery rupturing, except for those that may be vented through small orifices

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 post-mission 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: At EOM, all propellant will be vented and the cubesat. In the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the spacecraft due to the lack of penetration energy to the multiple enclosures surrounding the batteries.

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

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v3.1.0, and calculation methods provided in NASA-STD-8719.14B, 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: 0.0000017; 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; the spacecraft is planned orbital disposal by atmospheric entry, and does not require a specific spacecraft orientation and drag state to meet the disposal requirements. Therefore, no element or component of the spacecraft system is required to complete post-mission operations.

Identification of all systems or components required to accomplish any post-mission disposal operation, including passivation and maneuvering: None

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

6.1 Description of spacecraft disposal option selected: The satellite includes a water-based propulsion demonstration that will be used to lower the orbit altitude by up to 70 km. In the case of propulsion demonstrator failure (or other general CubeSat failure), the satellite will still de-orbit naturally by atmospheric re-entry.

6.2 Plan for any spacecraft maneuvers required to accomplish post-mission disposal: None

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

Spacecraft Mass (Dry): 1.37 kg

Cross-sectional Area: 0.05014 m^2

(Calculated by DAS 2.1.1). Area to mass ratio: 05014/1.37 = 0.036599 m^2/kg

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v3.1.0 and NASA-STD-8719.14B 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: (Requirement 56557)*

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 STEAMSAT satellites' method of disposal is COMPLIANT using method "a." In the worst-case orbit altitude of 550 x 550 km near-circular orbit, the passive deorbit time is 3.34 years after launch with orbit history as shown in Figure 3 if the solar arrays do not deploy. It should be noted that this is assuming a launch date of December 2020. If the solar arrays do deploy, the passive deorbit time will be reduced to 1.61 yrs.

Under planned launch conditions, STEAMSAT will be deployed in a 525 x 525 km nominal near-circular orbit, reentering in approximately 2.513 years after launch. If the solar arrays deploy, the passive deorbit time will reduce to 1.287 years with orbit history as shown in Figure 4 (analysis assumes a noon-midnight Sun synchronous orbit with solar array tracking).

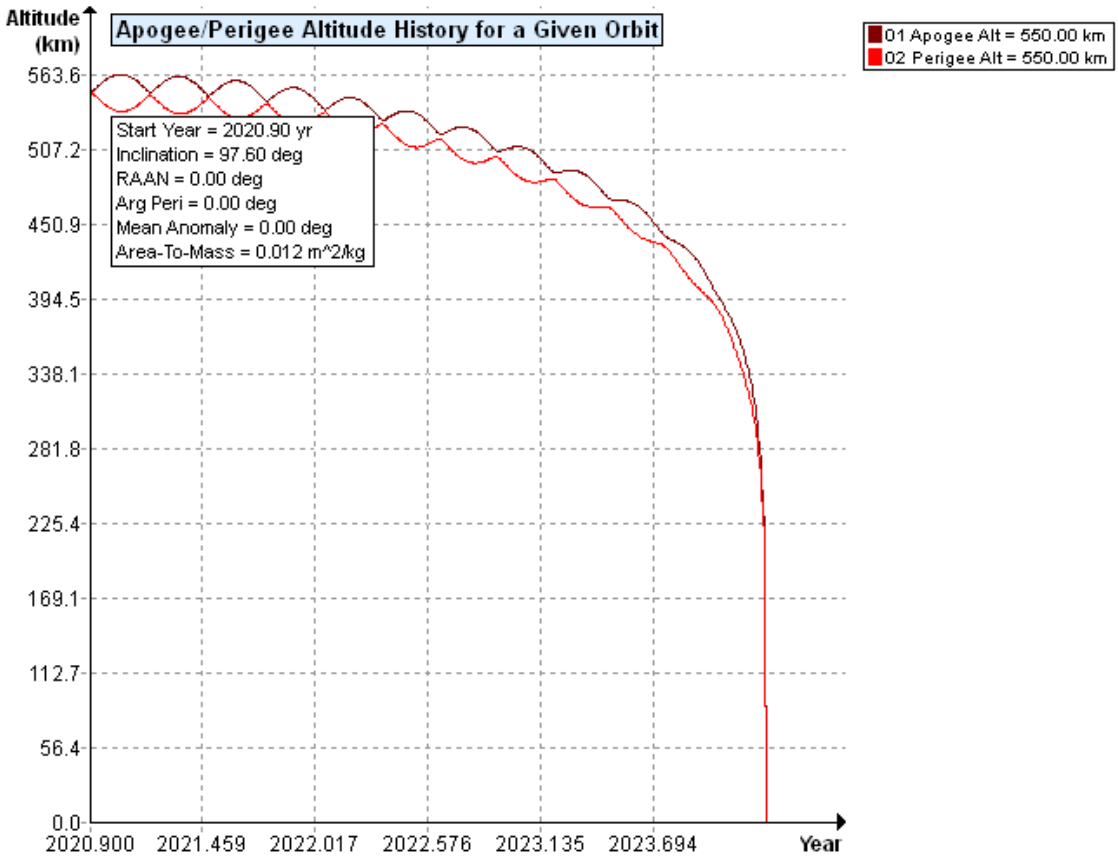

Figure 3 STEAMSAT Orbit History – at Maximum Orbit Altitude of 550 km x 550 km SSO in Stowed Configuration

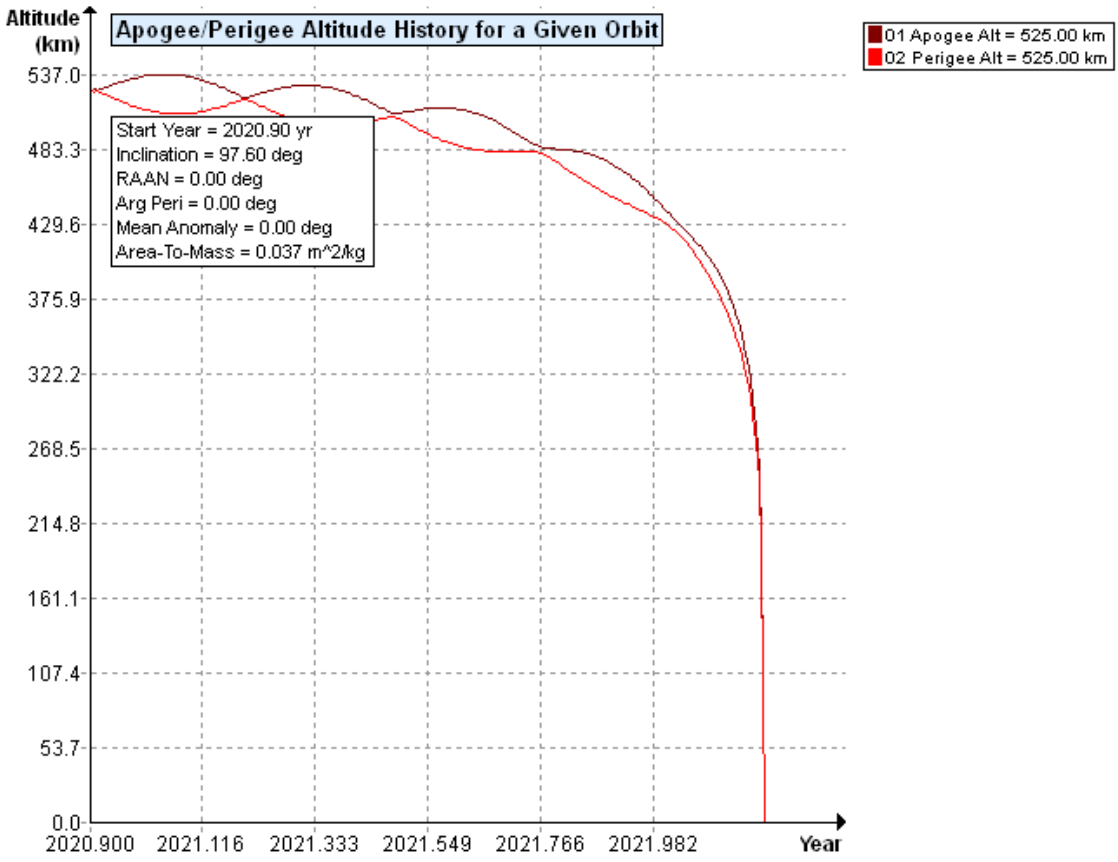

Figure 4 STEAMSAT Orbit History – at Nominal Orbit Altitude of 525 km x 525 km SSO in Deployed Configuration

Requirement 4.6-2. Disposal for space structures near GEO:
Analysis is not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO: Analysis is not applicable.

Requirement 4.6-4. Reliability of Post-mission Disposal Operations:
Analysis is not applicable. The satellite will reenter passively without post mission disposal operations within the allowable timeframe.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards:

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:
a) 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 v3.1.0 reports that the STEAMSAT satellite is COMPLIANT with the requirement with a per satellite casualty risk of 1:50800.

This represents an acceptable casualty risk, as calculated with DAS's modeling capability.

The DAS Output Summary Follows:

08 27 2020; 16:15:32PM Processing Requirement 4.3-2: Return Status : Passed

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

========== End of Requirement 4.3-2 ==========
08 27 2020; 17:19:14PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = STEAMSAT
Space Structure Type = Payload
Perigee Altitude = 525.000 (km)
Apogee Altitude = 525.000 (km)
Inclination = 97.600 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0366 (m^2/kg)
Start Year = 2020.900 (yr)
Initial Mass = 1.500 (kg)
Final Mass = 1.370 (kg)
Duration = 3.000 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 1.6602E-07
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==========

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

08 27 2020; 17:19:29PM Project Data Saved To File
08 28 2020; 06:47:31AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = STEAMSAT
Space Structure Type = Payload

Perigee Altitude = 525.000000 (km)
Apogee Altitude = 525.000000 (km)
Inclination = 97.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.036599 (m^2/kg)
Start Year = 2020.900000 (yr)
Initial Mass = 1.500000 (kg)
Final Mass = 1.370000 (kg)
Duration = 3.000000 (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)

OUTPUT

Suggested Perigee Altitude = 525.000000 (km)
Suggested Apogee Altitude = 525.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2022 (yr)
Requirement = 61
Compliance Status = Pass

==========

========== End of Requirement 4.6 ==========
08 28 2020; 06:47:38AM *********Processing Requirement 4.7-1
Return Status : Passed

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Item Number = 1

name = STEAMSAT
quantity = 1
parent = 0
materialID = 8
type = Box
Aero Mass = 1.370000
Thermal Mass = 1.370000
Diameter/Width = 0.111000
Length = 0.190500
Height = 0.100000

name = EPS
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.056000
Thermal Mass = 0.056000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.020000

name = Comms Module LF
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.041000
Thermal Mass = 0.041000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.020000

name = Main Control Module
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.055000
Thermal Mass = 0.055000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.020000

name = Payload Service Module
quantity = 1
parent = 1
materialID = 27

type = Box
Aero Mass = 0.180000
Thermal Mass = 0.180000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.020000

name = Propulsion - Structure
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.080000
Length = 0.050000

name = Propulsion - electronics
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.075000
Thermal Mass = 0.075000
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.020000

name = Propulsion - membrane
quantity = 1
parent = 1
materialID = 64
type = Flat Plate
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.080000
Length = 0.080000

name = Propulsion - thruster
quantity = 1
parent = 1
materialID = 40
type = Cylinder
Aero Mass = 0.053000
Thermal Mass = 0.053000
Diameter/Width = 0.050000
Length = 0.020000

name = Frame
quantity = 1
parent = 1

materialID = 8
type = Box
Aero Mass = 0.190000
Thermal Mass = 0.190000
Diameter/Width = 0.111000
Length = 0.190500
Height = 0.100000

name = Frame - HW
quantity = 68
parent = 1
materialID = 61
type = Cylinder
Aero Mass = 0.000110
Thermal Mass = 0.000110
Diameter/Width = 0.005000
Length = 0.003000

name = Structure - Rails
quantity = 4
parent = 1
materialID = 61
type = Flat Plate
Aero Mass = 0.020000
Thermal Mass = 0.020000
Diameter/Width = 0.020000
Length = 0.100000

name = Battery - cover
quantity = 2
parent = 1
materialID = 64
type = Flat Plate
Aero Mass = 0.040000
Thermal Mass = 0.040000
Diameter/Width = 0.100000
Length = 0.100000

name = Antenna
quantity = 1
parent = 1
materialID = 64
type = Cylinder
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.040000
Length = 0.050000

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

name = STEAMSAT
Demise Altitude = 77.992226
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = EPS
Demise Altitude = 0.000000
Debris Casualty Area = 0.411950
Impact Kinetic Energy = 15.731412

****

name = Comms Module LF
Demise Altitude = 0.000000
Debris Casualty Area = 0.411950
Impact Kinetic Energy = 8.425300

****

name = Main Control Module
Demise Altitude = 0.000000
Debris Casualty Area = 0.411950
Impact Kinetic Energy = 15.175708

****

name = Payload Service Module
Demise Altitude = 0.000000
Debris Casualty Area = 0.458952
Impact Kinetic Energy = 52.254951

****

name = Propulsion - Structure
Demise Altitude = 67.418098
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Propulsion - electronics
Demise Altitude = 0.000000
Debris Casualty Area = 0.411950
Impact Kinetic Energy = 28.246407

****

name = Propulsion - membrane
Demise Altitude = 77.472610
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Propulsion - thruster
Demise Altitude = 73.569260
Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Frame
Demise Altitude = 76.650391
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Frame - HW
Demise Altitude = 77.591415
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure - Rails
Demise Altitude = 0.000000
Debris Casualty Area = 1.662663
Impact Kinetic Energy = 3.265547

****
name = Battery - cover
Demise Altitude = 77.698715
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Antenna
Demise Altitude = 77.076950
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

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

Requirements 4.7-1b, and 4.7-1c:
These requirements are non-applicable requirements because the STEAMSAT mission does not use controlled reentry.

4.7-1, b): *"For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627)."*

Not applicable to YAM. The spacecraft does not use controlled reentry and no debris is expected to survive.

4.7-1 c): *"For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628)."* Not applicable to STEAMSAT. It does not use controlled reentry and no debris is expected to survive.

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers used in the STEAMSAT mission.

END of ODAR for STEAMSAT

Appendix A: Acronyms

Arg peri	Argument of Perigee
CDR	Critical Design Review
cm	centimeter
COTS	Commercial Off-The-Shelf (items)
DAS	Debris Assessment Software
EOM	End Of Mission
FRR	Flight Readiness Review
GEO	Geosynchronous Earth Orbit
ITAR	International Traffic In Arms Regulations
kg	kilogram
km	kilometer
LEO	Low Earth Orbit
Li-Ion	Lithium Ion
m^2	Meters squared
ml	milliliter
mm	millimeter
N/A	Not Applicable.
NET	Not Earlier Than
ODAR	Orbital Debris Assessment Report
OSMA	Office of Safety and Mission Assurance
PDR	Preliminary Design Review
PL	Payload
ISIPOD	ISIS CubeSat Deployer
PSIa	Pounds Per Square Inch, absolute
RAAN	Right Ascension of the Ascending Node
SMA	Safety and Mission Assurance
Ti	Titanium
Yr	year

IV. Radiation Hazard Study

400 MHz Earth Station

This study analyzes the non-ionizing radiation levels for a 400 MHz Yagi tracking earth station. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

Bulletin No. 65 specifies that there are two separate tiers of exposure limits that are depending on the area of exposure and/or the status of the individuals who are subject to the exposure -- the General Population/Uncontrolled Environment and the Controlled Environment, where the general population cannot access.

The maximum level of non-ionizing radiation to which individuals may be exposed is limited to a power density level of 1.33 milliwatts per square centimeter (1.33 mW/cm^2) averaged over any 6 minute period in a controlled environment, and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 0.27 milliwatt per square centimeter (0.27 mW/cm^2) averaged over any 30 minute period in a uncontrolled environment.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna surface are expected to exceed safe levels. The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

Parameters:	Value	Unit	Symbol
Antenna Diameter	3.57	m	*D*
Antenna Transmit Gain	16.2	dBi	*G*
Transmit Frequency	400	MHz	*f*
Power Input to the Antenna	0.2	W	*P*

Calculated Parameters:

The following values were calculated using the above input parameters and the

corresponding formulas:

Parameter	Value	Unit	Symbol	Formula
Antenna Surface Area	1.964	m^2	*A*	$G\lambda 2/(4\pi)/\lambda$
Antenna Efficiency	0.95		η	$G\lambda^2/(\pi^2 D^2)$
Gain Factor	41.7		*g*	$10^{G/10}$
Wavelength	0.75	m	λ	$300/f$

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also is the region between the antenna and ground.

For yagi antennas with circular cross sections, such as the antenna under study, the near-field, far-field and transition region distances are calculated as follows:

Parameter	Value	Unit	Formula
Near-Field Distance	4.25	m	$R_{nf} = D^2/(4\lambda)$
Distance to Far-Field	10.2	m	$R_{ff} = 0.60D^2/(\lambda)$
Distance of Transition Region	4.25	m	$R_t = R_{nf}$

The distance in the transition region is between the near and far fields. Thus, $R_{nf} \leq R_t \leq R_{ff}$. However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, D, equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions.

Parameter	Value	Unit	Symbol	Formula
Power Density in the Near-Field	0.039	mW/cm^2	S_{nf}	$16.0\ \eta\ P/(\pi D^2)$
Power Density in the Far-Field	0.0064	mW/cm^2	S_{ff}	$GP/(4\pi\ Rff^2)$
Power Density in the Transition Region	0.039	mW/cm^2	S_t	$S_{nf}\ R_{nf}/(R_t)$

The power density between the antenna and ground, is calculated as follows:

Parameter	Value	Unit	Symbol	Formula
Power Density b/w Reflector and Ground	0.01	mW/cm^2	S_g	*P / A*

The below table summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are shown below.

These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

Power Density	Value	Unit	Controlled Environment
Far Field Calculation	0.0064	mW/cm^2	Satisfies FCC MPE
Near Field Calculation	0.039	mW/cm^2	Satisfies FCC MPE
Transition Region	0.039	mW/cm^2	Satisfies FCC MPE
Region b/w Antenna & Ground	0.01	mW/cm^2	Satisfies FCC MPE

In conclusion, the results show that the antenna, in a controlled environment, may exist in the regions noted above and applicant will take the proper mitigation procedures to ensure it meets the guidelines specified in 47 C.F.R. § 1.1310.

The antenna will be installed at 42°20’11.3” N 74°15’37.4” W in Windham, NY. Access to the antenna will be limited to authorized personnel and should safely restrict any public access. It should be noted that the operations of this antenna satisfy the FCC MPE limits for the general population. Nonetheless, the earth station will be marked with the standard radiation hazard warnings, as well as the area in the vicinity of the earth station to inform the general population, who might be working or otherwise present in or near the path of the main beam.

The applicant will ensure that the main beam of the antenna will be pointed at least one diameter away from any building, or other obstacles in those areas that exceed the MPE limits. Since one diameter removed from the center of the main beam the levels are down at least 20 dB, or by a factor of 100, public safety will be ensured.

V. Updated SW1FT ITU Filing Information

Résumé / Summary / Resumen				
Article 9, sous-section IA	/	Article 9, sub-section IA	/	Artículo 9, sub-sección IA
第9条第1A分节	/	Статья 9, подраздел IA	/	المادة 9، القسم الفرعي IA

B1a Beam designation	B2 Emi-Rcp	BR8 Action code	BR7a Group id.	BR9 Action code	BR47 Frequency band (MHz)			C4a Class of station
UPLINK	R	M	3 /2896	M	401.0375	-	401.0625	ED, EW
DOWLINKS	E	M	4 /2896	M	2261.5	-	2269.5	EW
DOWNLINK	E	M	1 /2896	M	401.0125	-	401.0375	EW

A1f2 Submitted on behalf	POL

A1g Short Mission Duration Res 32	N		

A4b1 No. of orbital planes	1	*A4b2* Ref. body	T	*BR43* Orbital configuration	0

A4b1a Constellation	N	*A4b1b* Configuration type		*A4b1c* Number of sub-sets mutually exclusive		*A4b1d* Attachment no.	

A4b3a No. of space stations simult. trans. on Northern Hemisphere		*A4b3b* No. of space stations simult. trans. on Southern Hemisphere	

Orbital	*A4b4a*	*A4b4b*	*A4b4c*	*A4b4d*	*A4b4e*	*A4b4f*	*A4b4i*	*A4b4j*	*A4b4m,n,o Sun synchronous*		
plane id. no.	*Inclination angle*	*No. of satellites in this plane*	*Period*	*Apogee*	*Perigee*	*Min. altitude*	*Arg. of perigee*	*Long. asc. node*	*Y/N*	*Node reference time*	*Node local time*
1	97.6	1	0-01:31	550e0	550e0	550e0			Y		

Orbital plane no.	*Satellite no.*	*A4b4h Initial phase angle*	*A4b4k Date*	*A4b4l Time*	*B4a Orbit link / List of beams*
1	1				ALL

M	*B1a/BR17* Beam designation	UPLINK		*B1b* Steerable		*B2* Emi-Rcp	R	*B3a1* Max. co-polar gain	3		

B2a1 Transmit only when visible from notified service area		*B2a2* Min. Elev. Angle	

B3c1 Co-polar antenna pattern						
Co-polar ref. pattern	Coef. A	Coef. B				Co-polar rad. diag.
						2

List of orbital planes
1

B4a3a1 Angle alpha		*B4a3a2* Angle beta			

BR92 Attach. for missing angle alpha/beta	

M	*BR7a/BR7b* Group id.	3	2896	*BR1* Date of receipt	28.08.2018	*C2c* RR No. 4.4					

BR14 Special Section			

C4a Class of station	ED	EW			*C3a* Assigned freq. band		*C5a* Noise temperature	100		

C4b Nature of service	CO	CO			*C6a* Polarization type	L	*C6b* Polarization angle	0

C11a2 Service area	USA									*C11a3* Service area diagram	

A2b Period of valid.	10	*A3a* Op. agency	404	*A3b* Adm. resp.	A	*BR16* Value of type C8b	

BR96 Start date for 9.1/9.1A	

BR60 Regulatory deadline(s)	11.44/11.44.1			

C1 Frequency Range

C1a Lower limit		*C1b* Upper limit	
401.0375	MHz	401.0625	MHz

	C7a	*C8a1/C8b1*	*C8a2/C8b2*	*C8c1*	*C8c2*	*C8c3*	*C8c4*	*C8e1*	*C8e2*	*C8f2*
	Design. of emission	Max. peak pwr	Max. pwr dens.	Min. peak pwr	Attch.	Min. pwr dens.	Attch.	C/N ratio	Attch.	E.i.r.p. on the beam axis
1	25K0F1D--	-7	-43	-20		-56		10		

C7b Carrier frequency of the emissions (25K0F1D--)

401.05	MHz

	C10b1 Assoc. earth station id.	*C10b2* Type	*C10c1* Geographical coord.		*C10c2* Ctry	*C10d1/C10d2* Cls. / Nat.		*C10d3* Max. iso. gain	*C10d4* Bmwdth
M	DEADHORSE, AK	S	148W24 29	70N12 45	USA	1	TD CO	16.2	20
						2	TW CO		

C10d5a Co-polar antenna pattern

C10b1 Assoc. earth station id.	Co-polar ref. pattern	Coef. A	Coef. B	Coef. C	Coef. D	Phi1	Co-polar rad. diag.
DEADHORSE, AK							3

13C Remarks	

M	*B1a/BR17* Beam designation	DOWLINKS		*B1b* Steerable		*B2* Emi-Rcp	E	*B3a1* Max. co-polar gain	7		

B2a1 Transmit only when visible from notified service area	Y	*B2a2* Min. Elev. Angle	

B3c1 Co-polar antenna pattern

Co-polar ref. pattern	Coef. A	Coef. B				Co-polar rad. diag.
						1

List of orbital planes
1

B4a3a1 Angle alpha		*B4a3a2* Angle beta			

BR92 Attach. for missing angle alpha/beta	

M	*BR7a/BR7b* Group id.	4	2896	*BR1* Date of receipt	28.08.2018	*C2c* RR No. 4.4					

BR14 Special Section			

C4a Class of station	EW				*C3a* Assigned freq. band					

C4b Nature of service	CO				*C6a* Polarization type	CR	*C6b* Polarization angle	

C8d1 Max. tot. peak pwr.		*C8d2* Contiguous bandwidth	

C11a2 Service area	USA								*C11a3* Service area diagram	

A2b Period of valid.	10	*A3a* Op. agency	404	*A3b* Adm. resp.	A	*BR16* Value of type C8b	

BR96 Start date for 9.1/9.1A	

BR60 Regulatory deadline(s)	11.44/11.44.1			

C1 Frequency Range			
C1a Lower limit		*C1b* Upper limit	
2261.5	MHz	2269.5	MHz

	C7a	*C8a1/C8b1*	*C8a2/C8b2*	*C8c1*	*C8c2*	*C8c3*	*C8c4*	*C8e1*	*C8e2*	*C8f1*
	Design. of emission	Max. peak pwr	Max. pwr dens.	Min. peak pwr	Attch.	Min. pwr dens.	Attch.	C/N ratio	Attch.	E.i.r.p. on the beam axis
1	8M00D1D--	3	-75	-15		-80		10		

C7b Carrier frequency of the emissions (8M00D1D--)																			
2265.5	MHz																		

C10b1 Assoc. earth station id.	*C10b2* Type	*C10c1* Geographical coord.		*C10c2* Ctry	*C10d1/C10d2* Cls. / Nat.		*C10d3* Max. iso. gain	*C10d4* Bmwdth	*C10d6* Noise temp.				
M DEADHORSE, AK	S	148W24 29	70N12 45	USA	1	TW	CO	36.7	3	100			

	C10d5a Co-polar antenna pattern						
C10b1 Assoc. earth station id.	Co-polar ref. pattern	Coef. A	Coef. B	Coef. C	Coef. D	Phi1	Co-polar rad. diag.
DEADHORSE, AK							3

13C Remarks	

M	*B1a/BR17* Beam designation	DOWNLINK		*B1b* Steerable		*B2* Emi-Rcp	E	*B3a1* Max. co-polar gain	3		

B2a1 Transmit only when visible from notified service area	Y	*B2a2* Min. Elev. Angle	

B3c1 Co-polar antenna pattern						
Co-polar ref. pattern	Coef. A	Coef. B				Co-polar rad. diag.
						2

List of orbital planes
1

B4a3a1 Angle alpha		*B4a3a2* Angle beta			

BR92 Attach. for missing angle alpha/beta	

M	*BR7a/BR7b* Group id.	1	2896	*BR1* Date of receipt	28.08.2018	*C2c* RR No. 4.4					

BR14 Special Section			

C4a Class of station	EW				*C3a* Assigned freq. band					

C4b Nature of service	CO				*C6a* Polarization type	L	*C6b* Polarization angle	0

C8d1 Max. tot. peak pwr.		*C8d2* Contiguous bandwidth	

C11a2 Service area	USA	*C11a3* Service area diagram	

A2b Period of valid.	10	*A3a* Op. agency	404	*A3b* Adm. resp.	A	*BR16* Value of type C8b	

BR96 Start date for 9.1/9.1A	

BR60 Regulatory deadline(s)	11.44/11.44.1			

C1 Frequency Range			
C1a Lower limit		*C1b* Upper limit	
401.0125	MHz	401.0375	MHz

	C7a	*C8a1/C8b1*	*C8a2/C8b2*	*C8c1*	*C8c2*	*C8c3*	*C8c4*	*C8e1*	*C8e2*	*C8f1*
	Design. of emission	Max. peak pwr	Max. pwr dens.	Min. peak pwr	Attch.	Min. pwr dens.	Attch.	C/N ratio	Attch.	E.i.r.p. on the beam axis
1	25K0F1D--	0	-36	-10		-46			10	

C7b Carrier frequency of the emissions (25K0F1D--)																	
401.025	MHz																

C10b1		*C10b2*	*C10c1*		*C10c2*	*C10d1/C10d2*		*C10d3*	*C10d4*	*C10d6*		
Assoc. earth station id.		Type	Geographical coord.		Ctry	Cls. / Nat.		Max. iso. gain	Bmwdth	Noise temp.		
M	DEADHORSE, AK	S	148W24 29	70N12 45	USA	1	TW	CO	16.2	20	100	

	C10d5a Co-polar antenna pattern						
C10b1 Assoc. earth station id.	Co-polar ref. pattern	Coef. A	Coef. B	Coef. C	Coef. D	Phi1	Co-polar rad. diag.
DEADHORSE, AK							3

13C Remarks	

BR22 Administration remarks	

BR23 Radiocommunication Bureau comments	

	SWIATOWID_2	SW1FT-VISION
Constellation	Same as ISS orbit	550km circular SSO
SV Uplink UHF Beam		
Gain	20 dBi	3 dBi
Emission RF Power	1 to -1 dBW	-7 to -20 dBW
Emission RF Density	-10 to -101.2 dBW/Hz	-43 to -56 dBW/Hz
Service Type	EESS	EESS, Telecommand
Service Area	Poland, Region 1	USA
SV Downlink UHF Beam		
Emission RF Power	1 to -1 dBW	0 to -10 dBW
Emission RF Density	-10 to -101.2 dBW/Hz	-36 to -46 dBW/Hz
Service Type	Space Operations	EESS
Service Area	Poland, Region 1	USA
SV Downlink S-band Beam		
Gain	2 dBi	7 dBi
Frequency	2270 MHz	2265.5 MHz
Polarization	Linear	RHCP
Emission BW	1 MHz	8 MHz
Emission RF Power	-4 dBW	3 to -15 dBW
Emission RF Density	-10 dBW/Hz	-75 to -80 dBW/Hz
Service Type	EESS	EESS
Service Area	Poland, Region 1	USA
ES Uplink UHF Beam		
Location	SatRevolution offices, Poland	Deadhorse, AK, USA
Gain	18	16.2
ES Downlink UHF Beam		
Location	SatRevolution offices, Poland	Deadhorse, AK, USA
Gain	18	16.2
ES Downlink S-band Beam		
Location	SatRevolution offices, Poland	Deadhorse, AK, USA
Gain	18	36.7

Approved by OMB
3060-0678

Date & Time Filed:
File Number: ---
Callsign/Satellite ID:

APPLICATION FOR EARTH STATION AUTHORIZATIONS FCC 312 MAIN FORM FOR OFFICIAL USE ONLY	FCC Use Only

APPLICANT INFORMATION

Enter a description of this application to identify it on the main menu:
Draft Form (180-Day STA for Deadhorse-SatRevolution)

1-8. Legal Name of Applicant

Name:	RBC Signals, LLC	Phone Number:	404-803-7734
DBA Name:		Fax Number:	
Street:	2205 152nd Ave NE	E-Mail:	crichins@rbcsignals.com
City:	Redmond	State:	WA
Country:	USA	Zipcode:	98052 -
Attention:	Mr. Christopher Richins		

9-16. Name of Contact Representative

Name:	Carlos Nalda	Phone Number:	6099021670
Company:	LMI Advisors	Fax Number:	
Street:	2550 M Street NW Suite 345	E-Mail:	cnalda@lmiadvisors.com
City:	Washington	State:	DC
Country:	USA	Zipcode:	20037-
Attention:	Carlos Nalda	Relationship:	Other

CLASSIFICATION OF FILING

17. Choose the button next to the classification that applies to this filing for both questions a. and b. Choose only one for 17a and only one for 17b.

a.
- (●) a1. Earth Station
- (N/A) a2. Space Station

b.
- (●) b1. Application for License of New Station
- ( ) b2. Application for Registration of New Domestic Receive-Only Station
- (N/A) b3. Amendment to a Pending Application
- (N/A) b4. Modification of License or Registration
- (N/A) b5. Assignment of License or Registration
- (N/A) b6. Transfer of Control of License or Registration
- (N/A) b7. Notification of Minor Modification
- (N/A) b8. Application for License of New Receive-Only Station Using Non-U.S. Licensed Satellite
- (N/A) b9. Letter of Intent to Use Non-U.S. Licensed Satellite to Provide Service in the United States
- ( ) b10. Other (Please specify)
- ( ) b11. Application for Earth Station to Access a Non-U.S.satellite Not Currently Authorized to Provide the Proposed Service in the Proposed Frequencies in the United States.

17c. Is a fee submitted with this application?
- ( ) If Yes, complete and attach FCC Form 159.

If No, indicate reason for fee exemption (see 47 C.F.R.Section 1.1114).
- ( ) Governmental Entity
- ( ) Noncommercial educational licensee

◉ Other(please explain): DRAFT FORM

17d.
Fee Classification

18. If this filing is in reference to an existing station, enter: (a) Call sign of station:	19. If this filing is an amendment to a pending application enter: (a) Date pending application was filed:	(b) File number of pending application:
Not Applicable	Not Applicable	Not Applicable

TYPE OF SERVICE

20. NATURE OF SERVICE: This filing is for an authorization to provide or use the following type(s) of service(s): Select all that apply:

- ☐ a. Fixed Satellite
- ☐ b. Mobile Satellite
- ☐ c. Radiodetermination Satellite
- ☐ d. Earth Exploration Satellite
- ☐ e. Direct to Home Fixed Satellite
- ☐ f. Digital Audio Radio Service
- ☑ g. Other (please specify)

NGSO

21. STATUS: Choose the button next to the applicable status. Choose only one.	22. If earth station applicant, check all that apply.
○ Common Carrier ◉ Non-Common Carrier	☐ Using U.S. licensed satellites ☑ Using Non-U.S. licensed satellites

23. If applicant is providng INTERNATIONAL COMMON CARRIER service, see instructions regarding Sec. 214 filings. Choose one. Are these facilities:

○ Connected to a Public Switched Network ○ Not connected to a Public Switched Network ◉ N/A

24. FREQUENCY BAND(S): Place an "X" in the box(es) next to all applicable frequency band(s).

☐ a. C-Band (4/6 GHz) ☐ b. Ku-Band (12/14 GHz)

☑ c.Other (Please specify upper and lower frequencies in MHz.)

Frequency Lower: 401 Frequency Upper: 402

TYPE OF STATION

25. CLASS OF STATION: Choose the button next to the class of station that applies. Choose only one.

- ◉ a. Fixed Earth Station
- ○ b. Temporary-Fixed Earth Station
- ○ c. 12/14 GHz VSAT Network
- ○ d. Mobile Earth Station

(N/A) e. Geostationary Space Station

(N/A) f. Non-Geostationary Space Station

- ○ g. Other (please specify)

26. TYPE OF EARTH STATION FACILITY: Choose only one.

◉ Transmit/Receive ○ Transmit-Only ○ Receive-Only ○ N/A

PURPOSE OF MODIFICATION

27. The purpose of this proposed modification is to: (Place an 'X' in the box(es) next to all that apply.)

Not Applicable

ENVIRONMENTAL POLICY

28. Would a Commission grant of any proposal in this application or amendment have a significant environmental impact as defined by 47 CFR 1.1307? If YES, submit the statement as required by Sections 1.1308 and 1.1311 of the Commission's rules, 47 C.F.R. §§ 1.1308 and 1.1311, as an exhibit to this application.A Radiation Hazard Study must accompany all applications for new transmitting facilities, major modifications, or major amendments.

○ **Yes** ◉ **No**

ALIEN OWNERSHIP Earth station applicants not proposing to provide broadcast, common carrier, aeronautical en route or aeronautical fixed radio station services are not required to respond to Items 30-34.

29. Is the applicant a foreign government or the representative of any foreign government?	○ Yes ◉ No
30. Is the applicant an alien or the representative of an alien?	○ Yes ○ No ◉ N/A
31. Is the applicant a corporation organized under the laws of any foreign government?	○ Yes ○ No ◉ N/A
32. Is the applicant a corporation of which more than one-fifth of the capital stock is owned of record or voted by aliens or their representatives or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country?	○ Yes ○ No ◉ N/A
33. Is the applicant a corporation directly or indirectly controlled by any other corporation of which more than one-fourth of the capital stock is owned of record or voted by aliens, their representatives, or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country?	○ Yes ○ No ◉ N/A
34. If any answer to questions 29, 30, 31, 32 and/or 33 is Yes, attach as an exhibit an identification of the aliens or foreign entities, their nationality, their relationship to the applicant, and the percentage of stock they own or vote.	

BASIC QUALIFICATIONS

35. Does the Applicant request any waivers or exemptions from any of the Commission's Rules? If Yes, attach as an exhibit, copies of the requests for waivers or exceptions with supporting documents.	◉ Yes ○ No
36. Has the applicant or any party to this application or amendment had any FCC station authorization or license revoked or had any application for an initial, modification or renewal of FCC station authorization, license, or construction permit denied by the Commission? If Yes, attach as an exhibit, an explination of circumstances.	○ Yes ◉ No
37. Has the applicant, or any party to this application or amendment, or any party directly or indirectly controlling the applicant ever been convicted of a felony by any state or federal court? If Yes, attach as an exhibit, an explination of circumstances.	○ Yes ◉ No
38. Has any court finally adjudged the applicant, or any person directly or indirectly controlling the applicant, guilty of unlawfully monopolizing or attemptiing unlawfully to monopolize radio communication, directly or indirectly, through control of manufacture or sale of radio apparatus, exclusive traffic arrangement or any other means or unfair methods of competition?If Yes, attach as an exhibit, an explanation of circumstances	○ Yes ◉ No
39. Is the applicant, or any person directly or indirectly controlling the applicant, currently a party in any pending matter referred to in the preceding two items? If yes, attach as an exhinit, an explanation of the circumstances.	○ Yes ◉ No
40. If the applicant is a corporation and is applying for a space station license, attach as an exhibit the names, address, and citizenship of those stockholders owning a record and/or voting 10 percent or more of the Filer's voting stock and the percentages so held. In the case of fiduciary control, indicate the beneficiary(ies) or class of beneficiaries. Also list the names and addresses of the officers and directors of the Filer.	
41. By checking Yes, the undersigned certifies, that neither applicant nor any other party to the application is subject to a denial of Federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Act of 1988, 21 U.S.C. Section 862, because of a conviction for possession or distribution of a controlled substance. *See 47 CFR 1.2002(b) for the meaning of "party to the application" for these purposes*.	◉ Yes ○ No
42a. Does the applicant intend to use a non-U.S. licensed satellite to provide service in the United States? If Yes, answer 42b and attach an exhibit providing the information specified in *47 C.F.R. 25.137, as appropriate*. If No, proceed to question 43.	◉ Yes ○ No
42b. What administration has licensed or is in the process of licensing the space station? If no license will be issued, what administration has coordinated or is in the process of coordinating the space station?Poland	
43. Description. (Summarize the nature of the application and the services to be provided). See Narrative.	
43a. Geographic Service Rule Certification By selecting A, the undersigned certifies that the applicant is not subject to the geographic service or geographic coverage requirements specified in 47 C.F.R. Part 25. By selecting B, the undersigned certifies that the applicant is subject to the geographic service or geographic	◉ A ○ B

coverage requirements specified in 47 C.F.R. Part 25 and will comply with such requirements.

By selecting C, the undersigned certifies that the applicant is subject to the geographic service or geographic coverage requirements specified in 47 C.F.R. Part 25 and will not comply with such requirements because it is not feasible as a technical matter to do so, or that, while technically feasible, such services would require so many compromises in satellite design and operation as to make it economically unreasonable. A narrative description and technical analysis demonstrating this claim are attached. ○ **C**

CERTIFICATION

The Applicant waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and requests an authorization in accordance with this application. The applicant certifies that grant of this application would not cause the applicant to be in violation of the spectrum aggregation limit in 47 CFR Part 20. All statements made in exhibits are a material part hereof and are incorporated herein as if set out in full in this application. The undersigned, individually and for the applicant, hereby certifies that all statements made in this application and in all attached exhibits are true, complete and correct to the best of his or her knowledge and belief, and are made in good faith.

44. Applicant is a (an): (Choose the button next to applicable response.)

- ○ Individual
- ○ Unincorporated Association
- ○ Partnership
- ○ Corporation
- ○ Governmental Entity
- ◉ Other (please specify)

LLC

45. Name of Person Signing	46. Title of Person Signing
Christopher Richins	CEO

47. Please supply any need attachments.

Attachment 1:	Attachment 2:	Attachment 3:

WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND / OR IMPRISONMENT (U.S. Code, Title 18, Section 1001), AND/OR REVOCATION OF ANY STATION AUTHORIZATION (U.S. Code, Title 47, Section 312(a)(1)), AND/OR FORFEITURE (U.S. Code, Title 47, Section 503).

SATELLITE EARTH STATION AUTHORIZATIONS
FCC Form 312 - Schedule B:(Technical and Operational Description)

FOR OFFICIAL USE ONLY

Location of Earth Station Site

E1: Site Identifier:	Brewster	E5. Call Sign:	
E2: Contact Name	Zachary Reich	E6. Phone Number:	415-622-5548
E3. Street:	DS12 Access Road	E7. City:	Deadhorse
		E8. County:	
E4. State	AK	E9. Zip Code	99734
E10. Area of Operation:		Deadhorse, AK	
E11. Latitude:	70 ° 12 ' 45.0 " N		
E12. Longitude:	148 ° 24 ' 29.0 " W		
E13. Lat/Lon Coordinates are:		○ NAD-27 15.0	◉ NAD-83 ○ N/A
E14. Site Elevation (AMSL):		meters	

E15. If the proposed antenna(s) operate in the Fixed Satellite Service (FSS) with geostationary satellites,

do(es) the proposed antenna(s) comply with the antenna gain patterns specified in Section 25.209(a) and (b) as demonstrated by the manufacturer's qualification measurement? If NO, provide asa technical analysis showing compliance with two-degree spacing policy.	○ Yes ○ No ◉ N/A
E16. If the proposed antenna(s) do not operate in the Fixed Satellite Service (FSS), or if they operate in the Fixed Satellite Service (FSS) with non-geostationary satellites, do(es) the proposed antenna(s) comply with the antenna gain patterns specified in Section 25.209(a2) and (b) as demonstrated by the manufacturer's qualification measurements?	◉ Yes ○ No ○ N/A
E17. Is the facility operated by remote control? If YES, provide the location and telephone number of the control point.	○ Yes ◉ No
E18. Is frequency coordination required? If YES, attach a frequency coordination report as	○ Yes ◉ No
E19. Is coordination with another country required? If YES, attach the name of the country(ies) and plot of coordination contours as	○ Yes ◉ No
E20. FAA Notification - (See 47 CFR Part 17 and 47 CFR part 25.113(c)) Where FAA notification is required, have you attached a copy of a completed FCC Form 854 and or the FAA's study regarding the potential hazard of the structure to aviation? **FAILURE TO COMPLY WITH 47 CFR PARTS 17 AND 25 WILL RESULT IN THE RETURN OF THIS APPLICATION.**	○ Yes ◉ No

POINTS OF COMMUNICATION

Satellite Name:OTHER | OTHER | If you selected OTHER, please enter the following:	
E21. Common Name: SW1FT	E22. ITU Name:
E23. Orbit Location: NGSO	E24. Country: Poland

Satellite Name:OTHER | OTHER | If you selected OTHER, please enter the following:	
E21. Common Name:	E22. ITU Name:
E23. Orbit Location: NGSO	E24. Country:

Satellite Name:OTHER | OTHER | If you selected OTHER, please enter the following:	
E21. Common Name: STEAMSAT	E22. ITU Name:
E23. Orbit Location: NGSO	E24. Country: Poland

POINTS OF COMMUNICATION (Destination Points)

E25. Site Identifier: Deadhorse	
E26. Common Name:	E27. Country:USA

ANTENNA

Site ID	E28. Antenna Id	E29. Quantity	E30. Manufacturer	E31. Model	E32. Antenna Size	E41/42. Antenna GainTransmint and/or Recieve(____dBi at _____GHz)
Deadhorse	Yagi	2	M2 Antenna Systems	400CP30A	3.57	16.2 dBi at 0.400

E28. Antenna Id	E33/34. Diameter Minor/Major(meters)	E35. Above Ground Level (meters)	E36. Above Sea Level (meters)	E37. Building Height Above Ground Level (meters)	E38. Total Input Power at antenna flange (Watts)	E39. Maximum Antenna Height Above Rooftop (meters)	E40. Total EIRP for al carriers (dBW)
Yagi	0.25/3.57	4.0	0.0	0.0	0.2	0.0	9.2

FREQUENCY

E28. Antenna Id	E43/44. Frequency Bands(MHz)	E45. T/R Mode	E46. Antenna Polarization(H,V,L,R)	E47. Emission Designator	E48. Maximum EIRP per Carrier(dBW)	E49. Maximum ERIP Density per Carrier(dBW/4kHz)
Yagi	401.050 401.150	R	Right Hand Circular	20K5F1D	0.0	0.0
E50. Modulation and Services 2GFSK						
Yagi	401.0 401.1	T	Right Hand Circular	20K5F1D	9.2	0.00368
E50. Modulation and Services 2GFSK						
Yagi	401.0125 401.0375	R	Right Hand Circular	20K5F1D	0.0	0.0
E50. Modulation and Services 2GFSK						
Yagi	401.0375 401.0625	T	Right Hand Circular	20K5F1D	9.2	0.00368
E50. Modulation and Services 2GFSK						
E50. Modulation and Services						

FREQUENCY COORDINATION

E28. Antenna Id	E51. Satellite Orbit Type	E52/53. Frequency Limits(MHz)	E54/55. Range of Satellite Arc E/W Limit	E56. Earth Station Azimuth Angle Eastern Limit	E57. Antenna Elevation Angle Eastern Limit	E58. Earth Station Azimuth Angle Western Limit	E59. Antenna Elevation Angle Western Limit	E60. Maximum EIRP Density toward the Horizon(dBW/4kHz)
Yagi	Non-Geostationary	401.0375 401.0625	0.0/ 0.0	0.0	5.0	360.0	5.0	0.0
	Non-Geostationary	401.0 401.1	0.0/ 0.0	0.0	5.0	360.0	5.0	0.00368
	Non-Geostationary	401.0875 401.1125	0.0/ 0.0	0.0	5.0	360.0	5.0	0.00368

REMOTE CONTROL POINT LOCATION

REMOTE CONTROL POINT LOCATION

E61. Call Sign NOTE: Please enter the callsign of the controlling station, not the callsign for which this application is being filed.			E65. Phone Number
E62. Street Address			
E63. City	E67. County	E64/68. State/Country /	E66. Zip Code

FCC NOTICE REQUIRED BY THE PAPERWORK REDUCTION ACT

The public reporting for this collection of information is estimated to average 0.25 - 24 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the required data, and completing and reviewing the collection of information. If you have any comments on this burden estimate, or how we can improve the collection and reduce the burden it causes you, please write to the Federal Communications Commission, AMD-PERM, Paperwork Reduction Project (3060-0678), Washington, DC 20554. We will also accept your comments regarding the Paperwork Reduction Act aspects of this collection

via the Internet if you send them to PRA@fcc.gov. PLEASE DO NOT SEND COMPLETED FORMS TO THIS ADDRESS.

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