RBC Signals LLC
Application for 180-Day Special Temporary Authorization

Technical Appendix

I. Technical Description

RBC Signals seeks to provide telemetry, tracking and command ("TT&C") services for the Aurorasat-1 spacecraft (or "AuroraSat"), a single 2U cubesat operated by Aurora Propulsion Technologies ("AuroraPT"). This Technical Description provides an overview of the UHF-band TT&C links of the Aurorasat-1 satellite in support of RBC Signals' request for a 180-day special temporary authorization ("STA") to provide earth station support for the Aurorasat-1 from its existing facility in Windham, New York. With the launch currently scheduled for December 2020, the Commission should be sufficient time to place this application on public notice in anticipation of the start of the mission (*see* Legal Narrative).

The Aurorasat-1 cubesat that is the subject of this Technical Description includes a single cubesat with two payloads: (1) a propulsive attitude control system with water propellant; and (2) the plasma brake, which is a propellant-less deorbiting system. The first phase of the mission (6-12 months) will be used to perform attitude control experiments, after which the plasma brake microtethers will be deployed. The second phase of the mission (12-24 months) includes the successful deployment of the plasma brake microtethers and demonstration of the satellite deorbiting system.[1] The Aurorasat-1 mission will demonstrate AuroraPT's 3-axis attitude control using an altitude and orbit control system ("AOCS") with a water-based resistojet propulsion module, and its rapid deorbit technology using electro-magnetic ("EM") microtethers.

To support this mission, RBC Signals seeks to provide TT&C services to AuroraPT, enabling them to validate and demonstrate key technologies of their plasma brake tether technology to establish further space heritage of their product line and demonstrate payload services. Towards this end, the Aurorasat-1 operations will allow AuroraPT to test and demonstrate components, software design, and operational concepts that are integral to the planned tether product line.

The tests and demonstrations planned by AuroraPT will be conducted intermittently over a two-year period commencing shortly after launch of the satellite. The TT&C 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 Aurorasat-1 satellite is December 1, 2020 to December 31, 2020 on a SpaceX Falcon 9 launch vehicle from Cape Canaveral, Florida. Therefore, RBC Signals respectfully requests that the Commission consider and authorize the proposed TT&C 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.

[1] If the plasma break microtethers do not deploy, the Aurorasat-1 cubesat will still passively deorbit within 2.125 years, under nominal condition, and a maximum of 4.57 years if the solar arrays never deploy from the nominal orbital altitude of 550 km circular sun-synchronous orbit.

Aurorasat-1

The Aurorasat-1 satellite conforms to the form factor of a 2U cubesat (200 mm x 100 mm x 100 mm in the stowed configuration and approximately 100 mm x 200 mm x 420 mm in the deployed configuration), with a total mass of approximately 1.8 kg. The maximum power generated by the solar panels is approximately 8 W (7 W at end-of-life "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 1.

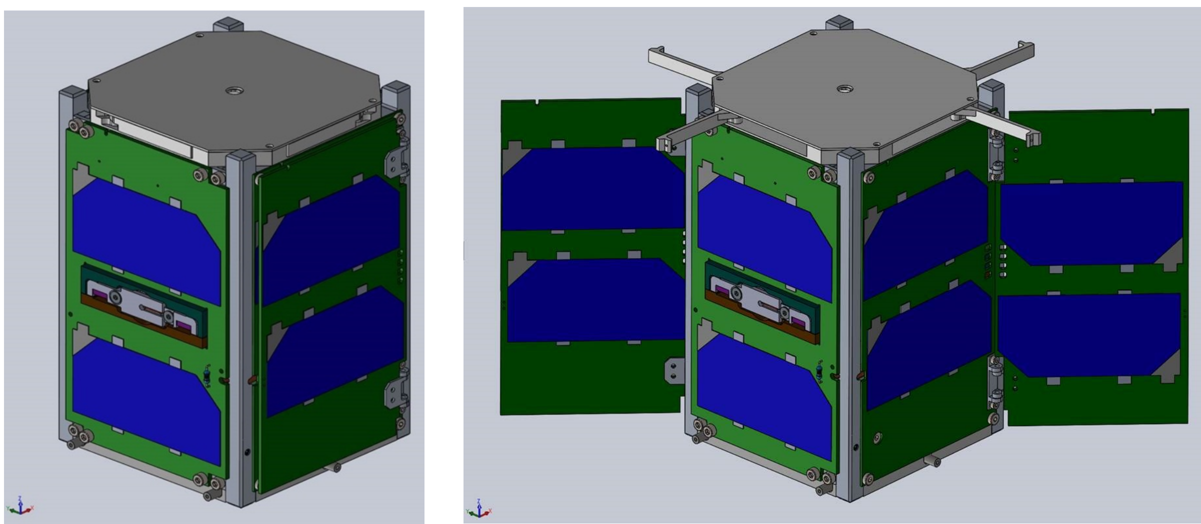

Figure 1. Aurorasat-1 Stowed and Deployed Configuration

Orbit. The Aurorasat-1 satellite will be launched aboard a SpaceX Falcon 9 launch vehicle from the Cape Canaveral launch center in Florida in December 2020. The satellite will be launched into a nominal circular, sun-synchronous orbit at 550 km apogee and 550 km perigee with an inclination from the equator of 97.5°. An orbital lifetime calculation for this orbit estimates that the satellite will remain in orbit for approximately 4.57 years (under worst case conditions), well within the limits set by internationally accepted guidelines.[2]

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' existing facility in Windham, New York, and will receive in the 401.0375-401.0625 MHz band (25 kHz bandwidth) and transmit in the 401.0875-401.1125 MHz band (25 kHz bandwidth). 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 as needed to ensure compatibility with any other co-frequency operations in the area.

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

The antenna patterns for the UHF transmit antenna at the earth station site is illustrated in Figure 2, below.

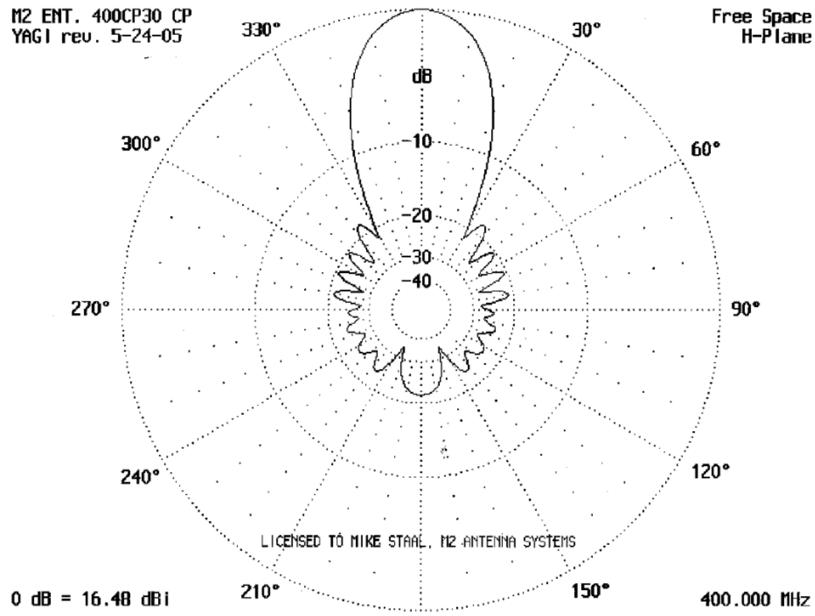

Figure 2. UHF Monopole Antenna Pattern

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:

- 0.12 W earth station transmitter output power, 7.0 dBW EIRP
- 0.8 W spacecraft transmitter output power, 2.0 dBW EIRP
- Tx (satellite downlink) from 401.0375-401.0625 MHz (25 kHz bandwidth)
- Rx (satellite uplink) from 401.0875-401.1125 MHz (25 kHz bandwidth)
- GFSK modulation (also AFSK modulation for 1.2 kbps downlink)
- 9.6 kbps uplink, 1.2/9.6 kbps downlink

Satellite telemetry and tracking communications will begin once the Aurorasat-1 spacecraft has been deployed into its intended orbit.

Satellite Antenna Pattern. The antenna patterns for the Aurorasat-1 UHF transmit antenna is illustrated in Figure 3.

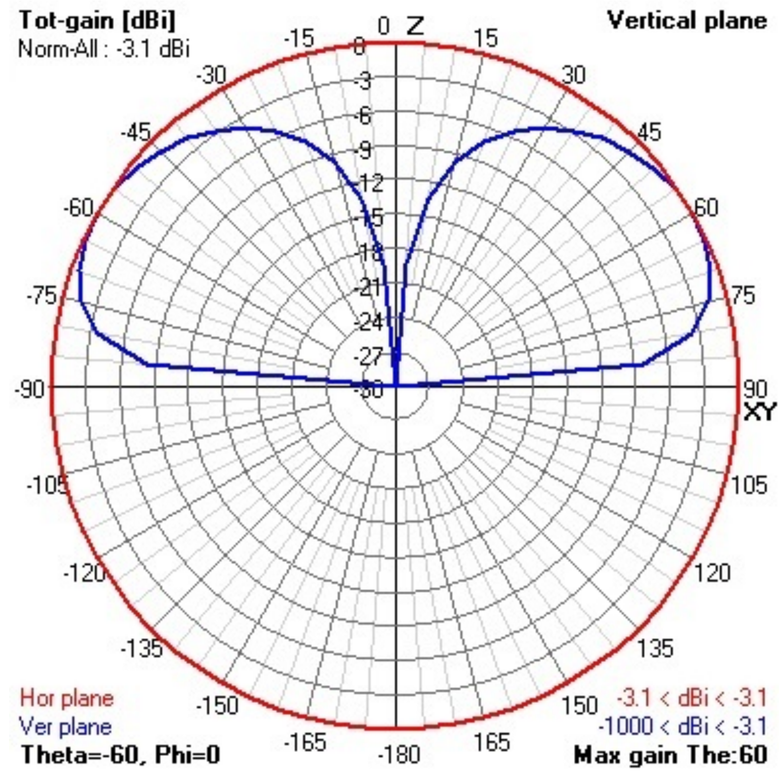

Figure 3. Satellite UHF TX/RX Antenna Pattern

II. AuroraSat-1 Orbital Debris Assessment Report (ODAR)

AURORASAT-ODAR-1.0

This report is presented as compliance with NASA-STD-8719.14, APPENDIX A. Report Version: 1.2, 8/21/2017

Aurora Propulsion Technologies
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02150 Espoo
Finland

Document Data is Not Restricted. This document contains no proprietary, ITAR, or export controlled information.

DAS Software Version Used In Analysis: v2.1.1

Revision Record				
Revision:	Date:	Affected Pages:	Changes:	Author(s):
1.0	6/21/2020	All –Initial	DAS Software Results Orbit Lifetime Analysis	D. Morse

Contents [NOTE PAGINATION SEEMS OFF; NEW SECTION BREAK?]

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

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

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:

Aurora Propulsion Technologies is a Finnish company. This ODAR follows the format in NASA-STD-8719.14, Appendix A.1 and includes the content indicated as a minimum, in each of Sections 2 through 8 below for the AuroraSat 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: Janne Sievinen

Senior Management: Perttu Yli-Opas (Chief Technology Officer)

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination: The AuroraSat mission will consist of a single satellite launched into sub-synchronous circular orbit with nominal orbit altitude of 550 km (based upon a range of SSO orbit altitudes from 500km to 600km).

Schedule of upcoming mission milestones:

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

Mission Overview: Each AuroraSat satellite will be launched into a sun-synchronous, Low Earth Orbit (LEO). Each satellite bus will use magnetic torque coils, solar arrays, GPS, an IMU and a water-based resistojet propulsion module to enable 3-axis pointing control.

Launch Vehicle and Launch Site: AuroraSat: 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.

AuroraSat will be deployed into an approximately sun synchronous circular low Earth orbit. AuroraSat will deploy one 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:[3]

Highest Apogee: 600 km

Highest Perigee: 600 km

[3] The AuroraSat satellite will be deployed between 500 km and 550 km at the discretion of the launch service provider. Aurora Propulsion Technologies has assumed a 550 km orbital altitude for AuroraSat for purposes of this orbital debris analysis report.

Target Inclination: 97.5° ± 0.3°

AuroraSat is demonstrating an on-board water-based propulsion system and an electro-magnetic ("EM") microtether based deorbiting mechanism. However, AuroraSat does not plan to actively change its orbit during the mission and will only deploy the microtether at the end of the mission. Therefore, there is no parking or transfer orbit.

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

ODAR Section 2: Spacecraft Description:

Physical description of the constellation: The AuroraSat satellite is based on the SatRevolution NanoBus bus. Basic physical dimensions are 200 mm x 100 mm x 100 mm with a mass of approximately 1.8 kg. The satellite is composed of the NanoBus 2U bus, deployable solar panel, and two payloads, an EM microtether to expedite deorbit and a water-based resisto-jet propulsion module for AOCS. The solar panel generates up to 8 W of electric power which is stored in a 35Wh COTS Li-Ion unpressurized battery assembly. The bus is 3-axis stabilized, employing GPS, 9-DOF IMU and the solar panels for attitude knowledge and magnetic torque rods and a water-based resisto-jet AOCS system for attitude control.

The AuroraSat 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 AuroraSat spacecraft is depicted in Figure 1 for the pre-deployment configuration and in Figure 3 for the post-deployment configuration.

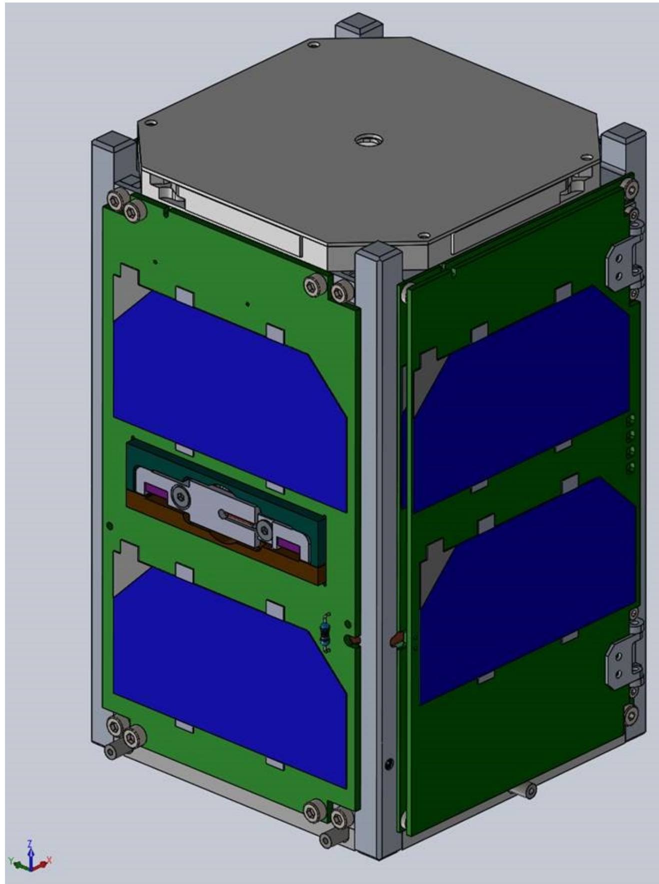


Figure 2 AuroraSat Spacecraft Configuration – Pre-deployment

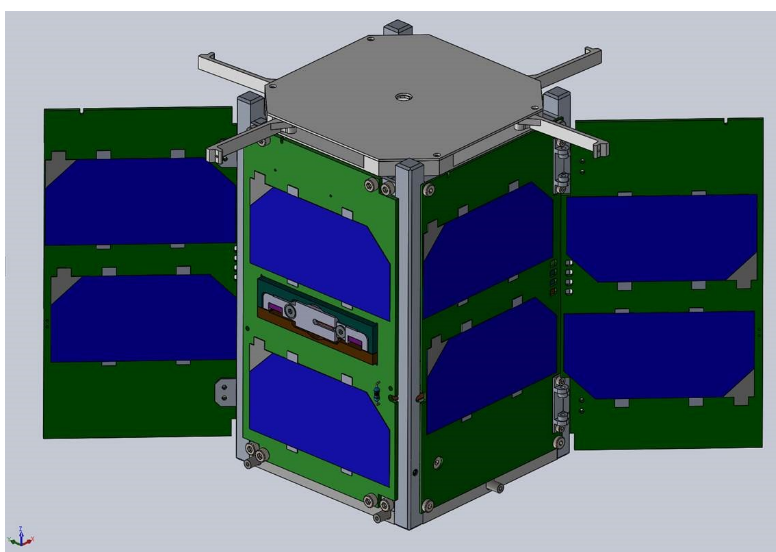


Figure 3 AuroraSat Spacecraft Configuration – Post-deployment

Total satellite mass at launch, including all propellants and fluids: 1.8 kg.

Dry mass of satellites at launch: 1.73 kg. (70g of water/methanol-based propellant onboard)

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear): 70g of water/methanol-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: 70g of water/methanol propellant and 0.7g of nPentane technical grade pressurant. Tank pressure will not exceed 50kPa, in accordance with cubesat launch standards.

Fluids in Pressurized Batteries: None

The AuroraSat satellite uses a three-cell unpressurized standard Lithium-Ion battery cells in each spacecraft. The total capacity energy capacity per spacecraft is 35 W-h.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector: The AuroraSat 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 AuroraSat 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 Lithium-Ion battery cells are charged before payload integration and provide 35 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 7 W at the end-of-life of the mission (2 years for calculation purposes).

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

Identification of any radioactive materials onboard: 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 v2.1.1)
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:

- AuroraSat satellite has a short orbital life due to the low orbital altitude (<6 years under worst-case failure conditions)
- AuroraSat satellite has very low mass
- AuroraSat satellite has 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 and pressurant will be vented and the cubesat will deploy the EM microtether to begin accelerated deorbit. 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 v2.1.1, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):

Requirement 4.5-1. Limiting debris generated by collisions with large objects when operating in Earth orbit:

"For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001 (Requirement 56506)."

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

Requirement 4.5-2. Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit:

"For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable postmission disposal requirements is less than 0.01 (Requirement 56507)."

Small Object Impact and Debris Generation Probability: Not applicable; 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 pair of microtethers, 100m each in length, that will be deployed to accelerate the natural deorbit process. In the case of tether deployment failure, the satellite will still de-orbit naturally by atmospheric re-entry. The water-based resisto-jet propulsion system is only for attitude control.

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: 1.8 kg

Cross-sectional Area: 0.0167 m^2

(Calculated by DAS 2.1.1). Area to mass ratio: 0167/1.8 = 0.00926 m^2/kg

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v2.1.1 and NASA-STD-8719.14 section): Requirement 4.6-1. Disposal for space structures passing through LEO:

"A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods: (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 AuroraSat satellites' method of disposal is COMPLIANT using method "a." In the worst-case orbit altitude of 600 x 600 km near-circular orbit, the passive deorbit time is 13.76 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 3.66 yrs.

The first spacecraft, AuroraSat will be deployed in a 550 x 550 km nominal near-circular orbit, reentering in approximately 4.57 years after launch with orbit history as shown in Figure 3 (analysis assumes a noon-midnight Sun synchronous orbit with solar array tracking). If the solar arrays deploy, the passive deorbit time will reduce to 2.125 years.

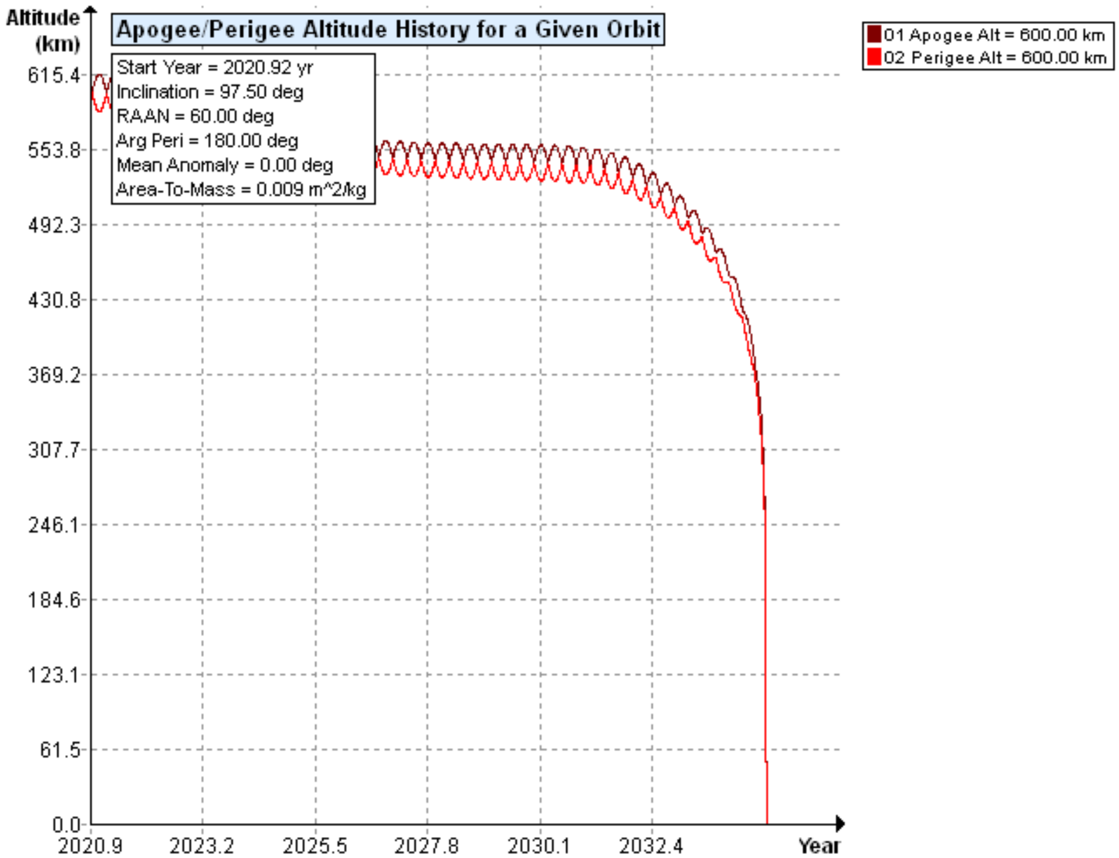


Figure 4 AuroraSat Orbit History – at Maximum Orbit Altitude of 600 km x 600 km SSO

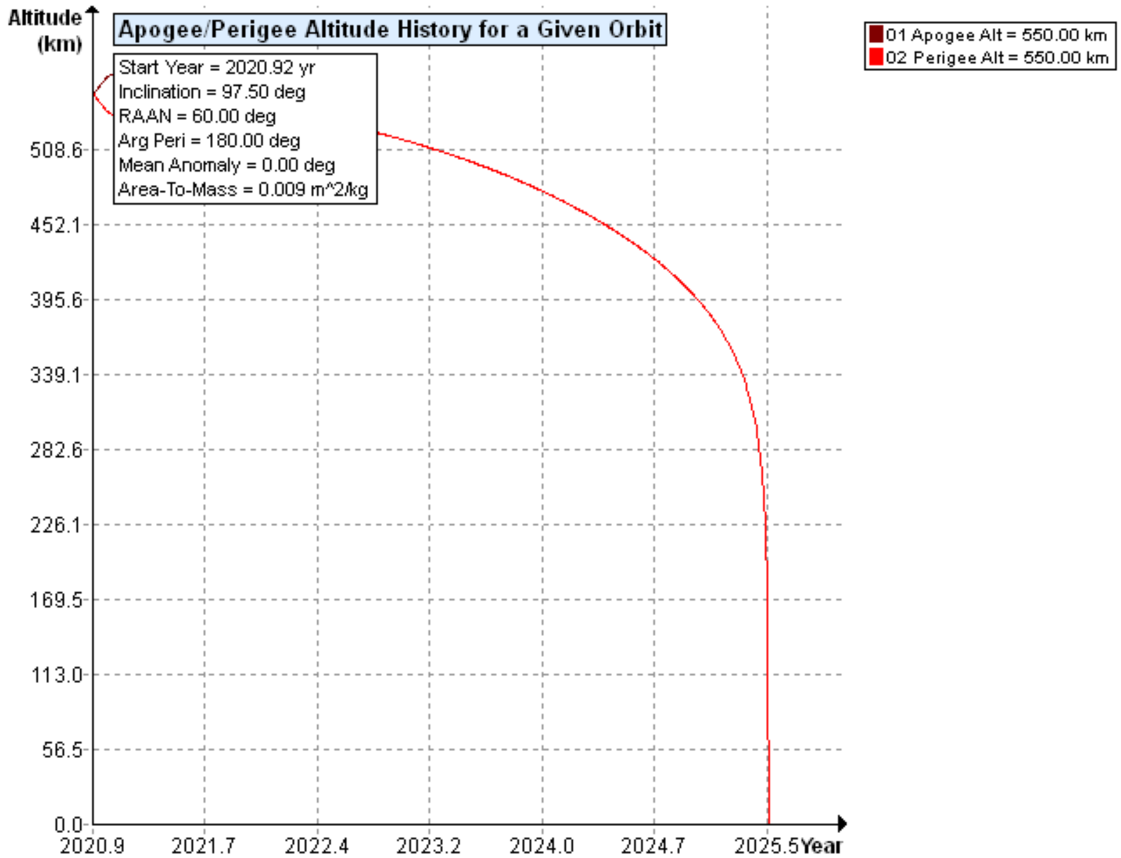


Figure 5 AuroraSat Orbit History – at Nominal Orbit Altitude of 550 km x 550 km SSO

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 v2.1.1 reports that the AuroraSat satellite is COMPLIANT with the requirement with a per satellite casualty risk of 1:100000000.

Experimentation has demonstrated that 1:100000000 is the smallest human casualty risk that the DAS software will report. Since the analysis shows all components of the AuroraSat satellites demising above an altitude of 60 km and both the Debris Casualty Area and the Impact Kinetic Energy are reported as 0.0 in all cases, this reflects 0 chance of human casualty.

This is expected to represent the absolute maximum casualty risk, as calculated with DAS's modeling capability.

The DAS Output Summary Follows:

06 16 2020; 15:13:36PM Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
06 16 2020; 15:13:40PM Requirement 4.4-3: Compliant

=============== End of Requirement 4.4-3 ===============
06 16 2020; 15:21:47PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = AURORA
Space Structure Type = Payload
Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass Ratio = 0.009260 (m^2/kg)
Start Year = 2020.000000 (yr)
Initial Mass = 1.800000 (kg)
Final Mass = 1.730000 (kg)
Duration = 10.000000 (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

Collision Probability = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range
Status = Pass

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

============== End of Requirement 4.5-1 ==============
06 16 2020; 15:25:36PM Requirement 4.5-2: Compliant
06 16 2020; 15:25:41PM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = AURORA
Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)
Apogee Altitude = 550.000000 (km)
Inclination = 97.500000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.009260 (m^2/kg)
Start Year = 2020.000000 (yr)
Initial Mass = 1.800000 (kg)
Final Mass = 1.730000 (kg)
Duration = 10.000000 (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 = 550.000000 (km)
Suggested Apogee Altitude = 550.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

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

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

=============== End of Requirement 4.6 ===============
06 16 2020; 15:25:48PM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = AURORA
quantity = 1
parent = 0
materialID = 8
type = Box
Aero Mass = 1.730000
Thermal Mass = 1.730000
Diameter/Width = 0.100000
Length = 0.200000
Height = 0.100000

name = Structure-1-HW
quantity = 84
parent = 1
materialID = 62
type = Cylinder
Aero Mass = 0.000200
Thermal Mass = 0.000200
Diameter/Width = 0.005000
Length = 0.005000

name = Structure-2
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.101000
Thermal Mass = 0.101000
Diameter/Width = 0.100000
Length = 0.200000
Height = 0.100000

name = Counterweight

quantity = 1
parent = 1
materialID = 14
type = Cylinder
Aero Mass = 0.429000
Thermal Mass = 0.429000
Diameter/Width = 0.050000
Length = 0.050000

name = Structure-3
quantity = 1
parent = 1
materialID = 64
type = Box
Aero Mass = 0.132000
Thermal Mass = 0.132000
Diameter/Width = 0.100000
Length = 0.200000
Height = 0.100000

name = Comms Module
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.041000
Thermal Mass = 0.041000
Diameter/Width = 0.030000
Length = 0.060000
Height = 0.030000

name = EPS Module
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.056000
Thermal Mass = 0.056000
Diameter/Width = 0.030000
Length = 0.060000
Height = 0.030000

name = Main Control Module
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.055000
Thermal Mass = 0.055000
Diameter/Width = 0.030000
Length = 0.060000

Height = 0.030000

name = Service Module
quantity = 1
parent = 1
materialID = 27
type = Box
Aero Mass = 0.045000
Thermal Mass = 0.045000
Diameter/Width = 0.030000
Length = 0.060000
Height = 0.030000

name = Payload-1
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.557000
Thermal Mass = 0.557000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.025000

name = Payload-1-SS
quantity = 1
parent = 1
materialID = 59
type = Box
Aero Mass = 0.032000
Thermal Mass = 0.032000
Diameter/Width = 0.020000
Length = 0.040000
Height = 0.020000

name = Payload-2-HW
quantity = 18
parent = 1
materialID = 65
type = Cylinder
Aero Mass = 0.000150
Thermal Mass = 0.000150
Diameter/Width = 0.005000
Length = 0.005000

name = Structure-1-Beams
quantity = 2
parent = 1
materialID = 62
type = Box
Aero Mass = 0.035000

Thermal Mass = 0.035000
Diameter/Width = 0.010000
Length = 0.100000
Height = 0.010000

name = Structure-1-Rails
quantity = 4
parent = 1
materialID = 62
type = Box
Aero Mass = 0.019000
Thermal Mass = 0.019000
Diameter/Width = 0.010000
Length = 0.050000
Height = 0.010000

name = Payload-2-Shafts
quantity = 2
parent = 1
materialID = 65
type = Cylinder
Aero Mass = 0.003560
Thermal Mass = 0.003560
Diameter/Width = 0.005000
Length = 0.500000

name = Payload-2-spring
quantity = 2
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.001800
Thermal Mass = 0.001800
Diameter/Width = 0.005000
Length = 0.050000

name = Pauyload-2
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.150000
Thermal Mass = 0.150000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.015000

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

name = AURORA

Demise Altitude = 77.992905
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-1-HW
Demise Altitude = 77.485275
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-2
Demise Altitude = 77.387825
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Counterweight
Demise Altitude = 69.358315
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-3
Demise Altitude = 77.798920
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Comms Module
Demise Altitude = 77.585220
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = EPS Module
Demise Altitude = 77.427856
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Main Control Module
Demise Altitude = 77.444450
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Service Module
Demise Altitude = 77.543938
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload-1
Demise Altitude = 69.056633
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload-1-SS
Demise Altitude = 73.749817
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload-2-HW
Demise Altitude = 77.339943
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-1-Beams
Demise Altitude = 73.499924
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Structure-1-Rails
Demise Altitude = 72.986908
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload-2-Shafts
Demise Altitude = 0.000000
Debris Casualty Area = 0.845000
Impact Kinetic Energy = 0.056451

****
name = Payload-2-spring
Demise Altitude = 77.166267
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Pauyload-2
Demise Altitude = 75.024567
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 AuroraSat 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)."*

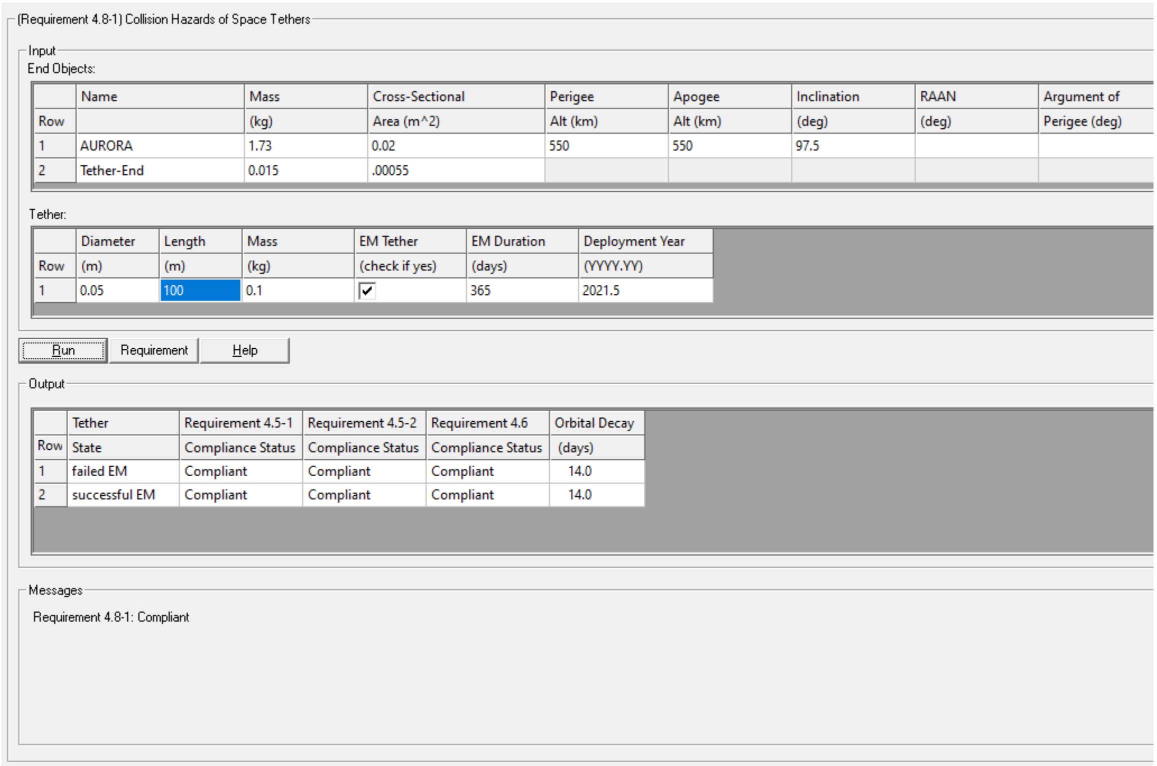
Not applicable to YAM. The spacecraft does not use controlled reentry and no debris is expected to survive.

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 AuroraSat. It does not use controlled reentry and no debris is expected to survive.

ODAR Section 8: Assessment for Tether Missions

The AuroraSat mission includes an EM tether that is less than 300m long. The tether will be deployed at the end of the mission to accelerate satellite deorbit. While not required, the following shows the DAS analysis results for the tether.

The EM microtether design consists of two wires that are ~50um in diameter, spaced 5cm apart and connect every 5cm to assure that a single micro-meteorite collision would not cause the tether to be severed. The tether mass is less than 200 mg / m. The low mass of the tether has been shown in the literature to cause minimal damage, typically in the form of small linear scratches when colliding at hypervelocity with another object. It is possible that the metallic nature of the microtether could result in the localized shorting of solar array strings. However, it is much more likely that the microtether would just completely vaporize upon collision with a solar array. The inputs and outputs of the DAS tether analysis are illustrated in Figure 6.



(Requirement 4.8-1) Collision Hazards of Space Tethers

Input

End Objects:

Row	Name	Mass (kg)	Cross-Sectional Area (m^2)	Perigee Alt (km)	Apogee Alt (km)	Inclination (deg)	RAAN (deg)	Argument of Perigee (deg)
1	AURORA	1.73	0.02	550	550	97.5		
2	Tether-End	0.015	.00055					

Tether:

Row	Diameter (m)	Length (m)	Mass (kg)	EM Tether (check if yes)	EM Duration (days)	Deployment Year (YYYY.YY)
1	0.05	100	0.1	☑	365	2021.5

Run Requirement Help

Output

Row	Tether State	Requirement 4.5-1 Compliance Status	Requirement 4.5-2 Compliance Status	Requirement 4.6 Compliance Status	Orbital Decay (days)
1	failed EM	Compliant	Compliant	Compliant	14.0
2	successful EM	Compliant	Compliant	Compliant	14.0

Messages

Requirement 4.8-1: Compliant

Figure 6 Results of the DAS Tether Analysis

Results from the DAS Tether analysis are provided below:

06 16 2020; 15:38:19PM Processing Requirement 4.8-1: Return Status : Passed

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

Project Data

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

INPUT

Tether Diameter = -1717986918
Tether Length = 100.000000
Tether Mass = 0.100000
EM Tether = Yes
duration EM = 365.000000
Launch Year = 2020.000000
Deployed Year = 2021.500000
Retraction Year = 3000.000000
Perigee of Highest Mass = 550.000000
Apogee of Highest Mass = 550.000000
RAAN = -1.000000
Inclination = 97.500000
Argument of Perigee = -1.000000

Mass of Highest Altitude End Mass = 1.730000
Mass of Lowest Altitude End Mass = 0.015000
Cross Sectional Area of Highest Altitude End Mass = 0.020000

OUTPUT
sever = 0.000000

END of ODAR for AuroraSat

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

III. Radiation Hazard Analysis

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, below:

Parameter	Value	Unit	Symbol	Formula
Antenna Surface Area	1.964	m^2	*A*	*Gλ2/(4π)/λ*
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.

IV. Microtether Safety Document

PROPULSION TECHNOLOGIES

<u>Document information</u>

Identification:	MSD
Revision:	0.2
Revision reason:	Formatting improvements
Date:	2020-06-11
Document owner:	Pyry Peitso

Contents

1 Meta

This section details the document itself rather that its contents

1.1 Revision History

Revision	Date	Author	Description	Reasoning
0.2	2020-06-10	Vili Vilenius	New formatting	Formatting improvements
0.1	2020-06-09	Pyry Peitso	Initial version	Document initialization

1.2 Purpose

The purpose of the Microtether Safety Document (MSD) is to

- Present the concept of a Microtether as opposed to a traditional space tether
- Show that microtethers are significantly safer in operational usage
- Present rudimentary FMECA table for microtether operations

Microtethers are considerably safer to operate than traditional space tether systems, due to their significantly smaller size and mass. Test flights are yet to be done, but extensive analysis and simulation on the safety aspects are available.

1.3 Scope

To present a brief summary of the Plasma Brake technology related to Microtether, and summarize scientific research related to safety of plasma brake operations to demonstrate the low impact hazard of the Microtether technology. Finally, a rudimentary FMECA analysis on different types of failure modes is presented.

2 Nomenclature

Terms and abbreviations used in this document are defined in the listing below.

Definitions

Microtether a tether that has on average mass of less than 200 milligrams (mg) per length of one meter (200 mg/m). 1, 2

Plasma Brake is novel, propellantless deorbiting technology that utilizes Coulomb drag to deorbit satellites in an efficient manner. The system consists of a very long deployable microtether of several hundreds of meters of length. 1

Acronyms

ESA European Space Agency. 3

In addition to the list above, the general terms are defined in Aurora Glossary of Terms & Definitions

3 Space Tether Overview

Space tethers are challenging system to deploy and operate in a space environment. Very large constructs with intricate deployment mechanisms, they are also quite fragile to the micrometeoroid and space debris hazards that are present especially Low Earth Orbit. The large tether system also proposes a hazard for other space borne systems in case of accidental collision [1].

4 Microtether definition

To differentiate a microtether from traditional space tether systems, the following definition is suggested: a tether is classified as a Microtether in case the total mass does not exceed the limit of 200 mg mass per length of 1 meter (200 mg/m).

5 Microtether operations

While tether deployment remains a challenging task, the safety concerns are largely mitigated by the significantly smaller size of the system.Impact hazard to space debris and micrometeoroids decreases since a microtether is of significantly smaller size. Impact hazard to other space systems is similarly much lower than with traditional tether systems.

The hazard to a micro tether snapping from space debris and micrometeoroid impact remains. In this case the detaching part of the tether poses little space debris risk due to it's low mass and very rapid destruction due to air drag in lower orbits.

6 Microtether Safety

Though microtethers have not been widely deployed to space missions yet, the safety criteria has been widely studied in the literature:

"The safety risk is relevant to active space assets, since the system is quite large, considering the length of the deployed tether. If the tether or part of it were to collide with other spacecraft at orbital hypervelocity, no significant harm or damage to the object, the tether collides with, would occur. Linear scratches resulting from such an accident would be equivalent to ones that spacecraft experience constantly under nominal operation. Optical elements are typically protected by baffles. If the collision happens with solar cells, it might cause a short circuit via the conductive tether; however, it was estimated that the tether will evaporate in a hypervelocity impact [37]." [2]

As well as in European Space Agency (ESA) projects:

"If the main tether collides with an active satellite at orbital hypervelocity, each subwire of the tether makes a small linear scratch where it collides. Satellites survive scratches of same and larger size all the time because of the existing micrometeoroid and debris environment. If the collision is with a solar panel, there could in principle be a risk that exposed conductors of the panel could be short-circuited by the tether (Stephen Taylor, private communication), but because the hypervelocity collision causes the tether to evaporate, such risk does not exist in reality. A concern was also raised during the project that may optical instruments might be harmed by such collisions, but since optical instruments are protectedby a baffle, the risk should be minimal (Tiaro Soares, private communication)" [3]

In conclusion, it is reasonable to assume that many of the shortcomings related to tether systems with regards to impact safety, both to other space systems as well as micrometeoroid and space debris impact, are significantly improved with the usage of microtether systems.

7 Failure Modes

Below are listed expected failure modes of the microtether system. It is worth noting that none of them critically endanger the full satellite.

System	Failure mode	Failure cause	Local effect	Severity	Recovery	Notes
Tether snapped	Tether snaps	Space debris or micrometeoroid impact	Partial loss of tether	Deorbit mission disrupted	No recovery possible	Deorbit mission can proceed with partial tether
Tether end mass detached	End mass detaches during deployment	Tether system structural failure	Tether deployment disrupted	Deorbit mission disrupted	Recovery is unlikely	Deorbit mission can proceed with partial tether. End mass is of low mass and volume and poses very little hazard to other space assets
Tether collision Fully deployed tether collision	Tether impact with another space asset	In-orbit collision with another space asset	Partial loss of tether	Deorbit mission disrupted	No recovery possible	Deorbit mission can proceed with partial tether. Snapped tether is of very low mass and volume, and thus poses no threat to the impacted space asset. It will disintegrate rapidly in the atmosphere.

References

[1] Donald D Tomlin, Gwyn C Faile, Kazuo B Hayashida, Cynthia L Frost, Carole Y Wagner, Michael L Mitchell, Jason A Vaughn, and Michael J Galuska. Space tethers: Design criteria. 1997.

[2] Iaroslav Iakubivskyi, Pekka Janhunen, Jaan Praks, Viljo Allik, Kadri Bussov, Bruce Clayhills, Janis Dalbins, Tõnis Eenmäe, Hendrik Ehrpais, Jouni Envall, et al. Coulomb drag propulsion experiments of estcube-2 and foresail-1. Acta Astronautica, 2019.

[3] Pekka Janhunen, Petri Toivanen, and Jouni Envall. Electrostatic tether plasma brake,. ESA CleanSat Building Block 15 final report, 2017.

Approved by OMB
3060-0678

V. Draft FCC Form 312 Schedule B

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 Windham-AuroraSat)

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. (selected) a1. Earth Station (N/A) a2. Space Station	b. (selected) 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:	19. If this filing is an amendment to a pending application enter:	
(a) Call sign of station:	(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
- [x] b. Mobile Satellite
- [ ] c. Radiodetermination Satellite
- [ ] d. Earth Exploration Satellite
- [ ] e. Direct to Home Fixed Satellite
- [ ] f. Digital Audio Radio Service
- [x] g. Other (please specify)

NGSO

21. STATUS: Choose the button next to the applicable status. Choose only one.
( ) Common Carrier (•) Non-Common Carrier

22. If earth station applicant, check all that apply.
- [ ] Using U.S. licensed satellites
- [x] 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)
- [x] c.Other (Please specify upper and lower frequencies in MHz.)

Frequency Lower: 401.03 Frequency Upper: 401.12

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? Finland	

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.	◉ A
By selecting B, the undersigned certifies that the applicant is subject to the geographic service or geographic	○ 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:	Windham	E5. Call Sign:	
E2: Contact Name	Zachary Reich	E6. Phone Number:	415-622-5548
E3. Street:	County Road 10	E7. City:	Windham
		E8. County:	Greene
E4. State	NY	E9. Zip Code	12496
E10. Area of Operation:		Windham, NY	
E11. Latitude:	42 ° 20 ' 11.3 " N		
E12. Longitude:	74 ° 15 ' 37.4 " W		
E13. Lat/Lon Coordinates are:		○ NAD-27	◉ NAD-83 ○ N/A
E14. Site Elevation (AMSL):		10.0 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 (N/A selected)
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 (selected) 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 (No selected)
E18. Is frequency coordination required? If YES, attach a frequency coordination report as	Yes No (No selected)
E19. Is coordination with another country required? If YES, attach the name of the country(ies) and plot of coordination contours as	Yes No (No selected)
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 (No selected)

POINTS OF COMMUNICATION

Satellite Name:OTHER | OTHER | If you selected OTHER, please enter the following:	
E21. Common Name: AURORASAT-1	E22. ITU Name:
E23. Orbit Location: NGSO	E24. Country: Finland

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

POINTS OF COMMUNICATION (Destination Points)

E25. Site Identifier: Windham	
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)
Windham	Yagi	1	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	E43/44. Frequency	E45. T/R	E46. Antenna Polarization(H,V,L,R)	E47. Emission	E48. Maximum EIRP per	E49. Maximum ERIP Density per

Id	Bands(MHz)	Mode		Designator	Carrier(dBW)	Carrier(dBW/4kHz)
Yagi	401.0375 401.0625	R	Right Hand Circular	20K0F1D	0.0	0.0
E50. Modulation and Services APSK; TT&C						
Yagi	401.0875 401.1125	T	Right Hand Circular	20K0F1D	9.2	0.00368
E50. Modulation and Services APSK; TT&C						

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	401.0875 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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