Orbital Debris Assessment Report

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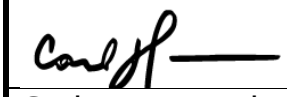
ASPERA-UA-DOC-00028, Rev B
Date: July 17, 2026

THE UNIVERSITY OF ARIZONA

SIGNATURES

Approvers
 Carl Hergenrother (Author) Conops Lead
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SELF ASSESSMENT OF THE ODAR

NASA-STD-8719.14C

OSMA/ODPO's SMAR ODAR Evaluation: Aspera Mission

(Based upon ODAR version, dated DD MM 20XX; evaluated by , DD MM 20XX)

Reqm't #	Launch Vehicle			Spacecraft		Comments
	Compliant or N/A	Not Compliant	Std. Non-Compliant	Compliant or N/A	Not Compliant	
4.3-1.a *MRD 25-year limit*	☒	☐	☐	☒	☐	No debris created by Aspera spacecraft.
4.3-1.b *MRD<100 object x year limit*	☒	☐	☐	☒	☐	No debris created by Aspera spacecraft.
4.3-2 *GEO MRD*	☒	☐	☐	☒	☐	Aspera will not operate in the GEO region.
4.4-1 *<0.001 Explosion Risk*	☒	☐	☐	☒	☐	Battery passivation risk assessment report included in this document.
4.4-2 *Passivate Energy Sources*	☒	☐	☐	☒	☐	Batteries will not be passivated. Battery passivation risk assessment report included in this document.
4.4-3 *Limit Intentional BU*	☒	☐	☐	☒	☐	No intention to breakup.
4.4-4 *Limit Intentional BU*	☒	☐	☐	☒	☐	No intention to breakup.
4.5-1 *<0.001 10cm Impact Risk*	☒	☐	☐	☒	☐	Probability of collision is 2.1568E-04.
4.5-2 *<0.01 Small MMOD Impacts*	☐	☐	☐	☒	☐	Can successfully de-orbit with random tumbling – no critical components required to execute postmission disposal.
4.6-1a-c *LEO Disposal*	☒	☐	☐	☒	☐	DAS modeled de-orbit via natural re-entry within 17.45 years.
4.6-2 *Storage or Earth-escape*	☒	☐	☐	☒	☐	Aspera will reside in LEO, and not GEO/MEO, and will not require storage or escape to a heliocentric trajectory.
4.6-3 *Long-term Reentry*	☒	☐	☐	☒	☐	Aspera will reside in LEO, and not GEO/MEO, and will not require long-term reentry.
4.6-4 *Disposal Reliability*	☒	☐	☐	☒	☐	No mechanisms required for disposal – spacecraft de-orbits via atmospheric drag in tumble attitude configuration.
4.7-1 *Reentry Risk*	☒	☐	☐	☒	☐	Risk of human casualty is 0.
4.8-1 *Special Classes*	☐	☐	☐	☒	☐	Aspera spacecraft does not include any special cases.

DOCUMENT HISTORY

Version	Date mm/dd/yyyy	Affected Section(s)	ECR#	Reason/Initiation/Remarks
A	02/12/2024	All	None	Initial Release
B	07/15/2026	All	None	Final Release

DAS VERSION

DAS version used in analysis: 3.2.7.

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FORWARD

This document is an Aspera Project controlled document. Changes to this document require prior approval of the Aspera project Configuration Management Team. Proposed changes shall be submitted to the Aspera Change Control Board along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

ABBREVIATIONS AND ACRONYMS

Table 1: Abbreviations and Acronyms

Phrase/Acronym	Description
DAS	Debris Assessment Software
EOM	End of Mission
ESA	European Space Agency
FWHM	Full Width Half Maximum
FoV	Field of View
GEO	Geosynchronous Orbit
JAXA	Japan Aerospace Exploration Agency
LEO	Low Earth Orbit
LTAN	Local Time of the Ascending Node
MCP	Microchannel Plate Detector
MMOD	Micrometeoroids and Orbital Debris
NASA	National Aeronautics and Space Administration
OAP	Off-Axis Parabola
OVI / Ovi	Oxygen Six (6)
QE	Quantum Efficiency
SSO	Sun Synchronous Orbit
TBD	To Be Determined
TRL	Technology Readiness Level
UArizona / UA	University of Arizona
UV	Ultraviolet

1 Program Management and Mission Overview

1.1 Governance

1.1.1 NASA Project Oversight

The Aspera project is a NASA Astrophysics Pioneers flight project that is classified as a “Do No Harm” mission within the Astrophysics Division of the NASA Science Mission Directorate. It is governed by NPR 7120.8.

For Astrophysics Pioneers missions the DA is the Astrophysics Associate Division Director (ADD). The Program Scientist (PS) and Program Executive (PE) provide formal recommendations to the ADD.

Project Management authority flows from the NASA Astrophysics Division to the S3PO Pioneers Portfolio Manager at NASA’s Wallops Flight Facility (WFF), and then to the Aspera Principal Investigator at UA.

UA is the owner and operator of the spacecraft and has sole responsibility for implementation of the Aspera mission.

1.1.2 Governance Structure

This Aspera Project draws upon the experience of the UA core team and establishes a disciplined approach to provide project management, engineering, safety and mission assurance, and all other aspects of the project.

Dr. Carlos Vargas of the University of Arizona is the Principal Investigator (PI). Dr. Vargas has authority and responsibility for the overall success of the Aspera Project. The PI oversees the science team and actively supports the coordination and development of the science data algorithm development and verification for the astronomical data products. Dr. Vargas is also the applications POC for Aspera. The PI exercises decision authority for all scope changes, decisions affecting total cost including the release of project cost and schedule reserves, and the scheduling of major milestones. He assures that the science team activities are commensurate with and support a successful investigation. He delegates day-to-day program management to the management team at UA.

1.2 Schedule Milestones

Phase/Milestone	Date(s)
Mission Selection	January 2021
Concept Design Study	January – August 2021
Concept Study Report submission	**August 31, 2021**
Preliminary Design	December 2021 – September 2022
Preliminary Design Review	**September 13, 2022**
Critical Design	September 2022 – June 2023
Critical Design Review	**June 28, 2023**
Flight Build, Alignment, and Calibration	June 2023 – April 2026
Payload Environmental Testing	May 2026
Payload Delivery to SFL	June 3, 2026
Spacecraft Integration and Test	June – September 2026
Flight Readiness Review	**November 2026**
Aspera Launch Ready	**January 29, 2027**
Commissioning	January 29, 2027 – February 28, 2027
Science Operations	March 1, 2027 – October 31, 2027

1.3 Mission Overview

Aspera is a UV SmallSat designed to map OVI emission from nearby galaxy halos for the first time. It will combine a simple optical design using recent advances in highly reflective UV-coated optics with an advanced UV MCP detector to optimize throughput and sensitivity. Aspera will build up multiple days of exposure time on each individual target to ensure spectroscopic detection of OVI emission and produce 2D morphological maps and direct measurements of physical conditions such as kinematics. The target selection prioritizes detection criteria derived from the most recent theories and custom simulations while also covering a diverse sample to inform models of galaxy evolution and constrain gas cycling mechanisms.

1.4 Launch Description

Aspera is scheduled to be launched on January 29, 2027 from the Rocket Lab launch facility in Mahia, New Zealand.

Aspera is designated as the primary payload. Aspera's mission objectives require a 9-month primary mission with the possibility of extended science missions.

1.5 Orbit Description

As a rideshare launch, *Aspera* is expected to be launched directly into the final orbit via the rideshare deployment mechanism. The destination orbit is to have an apogee and perigee of 600 kilometers. Its Sun Synchronous Orbit (SSO) will

have an inclination near 97.5 degrees and a Local Time of Ascending Node (LTAN) between 10 AM and 2 PM.

The identified orbit has been chosen to meet multiple mission requirements.

The SSO orbit family is chosen to maintain a consistent power and thermal environment for the spacecraft, reducing operational complexity. The specific 10:00-14:00 LTAN SSO orbit family is chosen specifically for the consistent solar occlusions, further reducing the range of thermal environments *Aspera* would be exposed to, reducing *Aspera's* design complexity. Aspera is a Far-UV observatory that is very sensitive to coronal emissions from the Earth's atmosphere ("airglow").

The orbital altitude of 600 kilometers is chosen to avoid fundamentally compromising the primary mission objective due to the airglow impact at lower altitudes. See Appendix B for details.

Aspera will not interact or interfere with other operational spacecraft during the mission lifetime.

1.6 Spacecraft Description

The *Aspera* spacecraft is provided by Space Flight Laboratory (SFL) at the University of Toronto Institute for Aerospace Studies. Specifically, *Aspera* will be based upon SFL's scalable DEFIANT microsatellite platform. This platform provides *Aspera* with a tried-and-true heritage. Aspera does not have a propulsion system, and thus has no significant maneuver capability.

1.7 Science Payload Description

Aspera measures the OVI 1032 Å line emission using two parallel channels of Rowland-Circle configuration spectrographs, each with a 45 mm x 75 mm off-axis parabola (OAP) primary mirror and a toroidal diffraction grating. Each identical spectrograph channel is designed to have a moderate spectral resolving power (R > 1500) at 1035 Å with a spatial resolution of > 120 arcsec. This two channel design lets *Aspera* efficiently detect and map the 2D spatial distribution of OVI coronal gas over the short (9 months) science mission lifetime using a step-and-stare concept observation strategy. All *Aspera* instrument systems, subsystems, and components are at or greater than technology readiness level (TRL) 6, including high heritage hardware wherever possible. The system development benchmarks various similar Far-UV space telescopes run by NASA/ESA/JAXA in terms of wavelength range (1020-1050 ˚A)

and optical design (Rowland-Circle). These include FUSE, HST-COS, Alice line of UV spectrographs for Rosetta, New Horizons, LAMP, JUNO planetary missions, and HISAKI.

2 Spacecraft Description

2.1 Physical Properties

The *Aspera* spacecraft is a Smallsat measuring 395 x 395 x 530 mm in the stowed launch configuration. Upon separation from the rideshare launch vehicle, the two solar panels will be deployed. The spacecraft bus is constructed from 7075-T73 aluminum alloy. *Aspera* will have a mass not to exceed 54.5 kg, including the *Aspera* instrument payload. See Figure 1 for details.

The *Aspera* spacecraft contains no propellant or other consumable masses. The launch mass is the expected final dry mass.

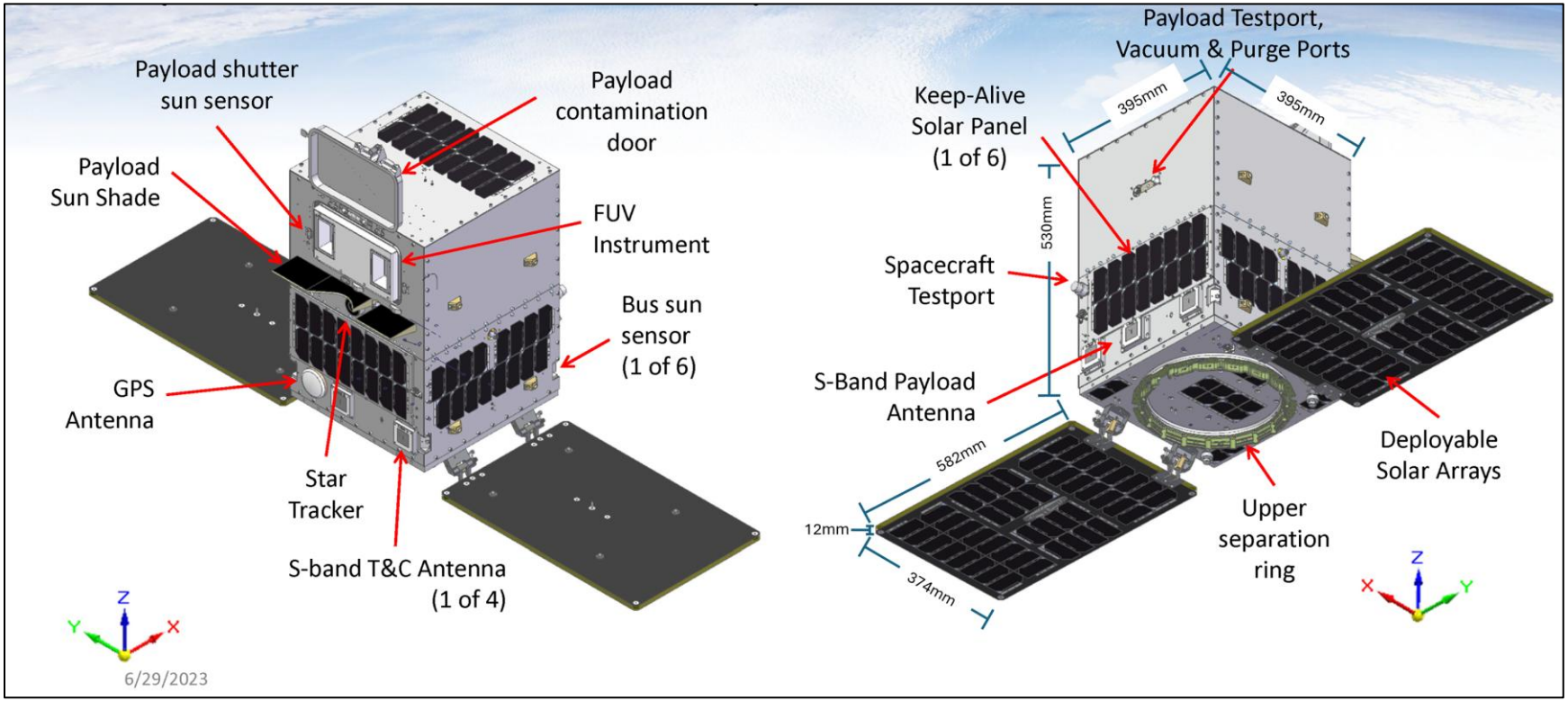

Figure 1. Aspera Spacecraft External Layout and Dimensions

2.2 Fluids and Propulsion

The *Aspera* spacecraft contains no fluids of any kind in the launch configuration. *Aspera* contains no propulsion system.

2.3 Attitude Control System(s)

The *Aspera* spacecraft contains two attitude control mechanisms. Reaction wheels will be the primary attitude control mechanism while magnetotorquers will be the secondary reaction control mechanism, responsible for the de-saturation of the primary attitude control mechanism so that *Aspera* maintains control authority over the mission lifetime.

The *Aspera* mission requires pointing at various targets distributed across the celestial sphere so that there will not be a consistent relationship between the spacecraft attitude and the orbital velocity vector. However, three common modes will be exercised by *Aspera* over the mission lifetime:

Science Mode – This mode will be exercised when the *Aspera* spacecraft is acquiring data of a science target. This may be a science target itself, a point near a science target making up a larger science scan pattern, or a calibration target. During this time, *Aspera* will be oriented so that payload boresight (spacecraft body –X axis) is vector aligned with the target. The solar panels (spacecraft body –Z axis) will be planar aligned with the Sun, possibly with some angular offset. The orientation of the spacecraft's orbital velocity vector in the body coordinate system is based on the location of the science target on the celestial sphere as well as the season during which the observation is acquired. For this reason, the spacecraft is modeled as "tumbling" to account for the variety of different experienced attitudes over *Aspera's* mission lifetime.

Communication Mode – This mode will be exercised during communication passes between the *Aspera* spacecraft and ground stations via KSATlite using the High Gain Antenna (HGA). During these activities, the HGA will be oriented to track the selected ground site during the communications pass, and *Aspera* solar panels will be planar aligned with the Sun.

Quiescent Mode – This mode will be exercised when no other mode is active and when the spacecraft cannot be either left in the prior science target's mode or articulated into the next science target's mode. In this mode, the spacecraft

will be oriented such that the solar array normal is vector aligned to the Sun while the payload boresight vector is planar aligned away from the Earth.

2.4 Range Safety / Pyrotechnic Devices

Not Applicable, no range safety or pyrotechnic devices.

2.5 Electrical Generation and Storage System

The *Aspera* spacecraft generates electricity via solar cells. The solar cells are largely concentrated on two panels which are deployed after separation from the ride-share system, with some more solar cells distributed across each of *Aspera's* body panels to provide some power while *Aspera* is not in quiescent mode.

The *Aspera* spacecraft will store electrical energy in 14 battery cells. *Aspera* will use MP 176065 xlr rechargeable Li-ion cell batteries, which have a nominal voltage of 3.65 V and each has a nominal energy of 24.8 Wh.

2.6 Other Energy Sources

The *Aspera* spacecraft contains three one-time deployable mechanisms. The solar panels described in Section 2.5, an aperture door which protects the instrument during launch ("Payload Contamination Door" in Figure 1, and the vacuum window of the micro-channel plate detector. Each of these will be deployed following orbit insertion and checkout.

There are two solenoids with attached flags, one at each slit location, which are deployed to block the path of light to the detector if the Sun sensors detect that the instrument boresight is pointed too close to the Sun.

2.7 Radioactive Materials

The *Aspera* spacecraft contains no radioactive materials.

2.8 Planned Proximity Operations

The *Aspera* spacecraft will not engage, nor have the ability to participate, in any proximity operations with other spacecraft.

3 ODAR Compliance Analysis

The NASA DAS (Debris Assessment Software) (version 3.2.7) was used for the analysis. Model inputs can be found in Table 2, and Appendix A. Model outputs can be found in Section 4, Section 5, Section 6, Section 7, Section 8, Section 9, and Appendix A.

4 Assessment of Spacecraft Debris Released During Normal Operation

4.1 Identification and Rationale

The *Aspera* mission does not intend to release any objects or materials from the spacecraft during the mission lifetime.

4.2 Compliance with Requirements

4.2.1 Requirement 4.3-1 Compliance

4.3-1: Limit number and orbital lifetime of debris passing through LEO
Not Applicable, no objects released

4.2.2 Requirement 4.3-2 Compliance

4.3-2: Limit lifetime of objects passing near GEO
Not Applicable, no objects released

5 Assessment of Spacecraft Potential for Explosions and Intentional Breakups

5.1 Identification and Rationale

The *Aspera* mission plan does not include intentional spacecraft breakup at any time during mission operations.

5.2 Summary of Failure Modes and Effects

An analysis of accidental breakup and battery passivation is given in Section 10: Battery Passivation.

5.3 Detailed Plan for Designed Spacecraft Breakup

The *Aspera* spacecraft will not conduct any intended breakups during mission operations.

5.4 Components to be Passivated at EOM

The *Aspera* spacecraft will not passivate the batteries prior to EOM, as discussed in Section 9. The stored energy in each of 4 reaction wheels is 0.4J nominally. At end of life, the reaction wheels will be powered down, resulting in no stored energy within approximately 2 minutes - the time it takes for the reaction wheels to spin down.

There are no other sources of stored energy.

Components which should be Passivated but Cannot

The design approach is to avoid incorporating any commands or programmed behaviors that if accidentally initiated, would cause the end of the mission. This means that there is no command to passivate batteries at end of mission. Battery passivation is discussed in detail in Section 10.

Similarly, there will be no command that could shut down the radio receiver.

5.5 Compliance with Requirements

5.5.1 Requirement 4.4-1 Compliance

4.4-1: Limit probability of accidental explosion during mission operations
This risk is considered a low probability due to the long history of these batteries being used by other spacecraft manufactured and flown by SFL. An analysis on accidental breakup and battery passivation is given in Section 10: Battery Passivation.

5.5.2 Requirement 4.4-2 Compliance

4.4-2: Passivate to limit probability of accidental explosion after EOM
The *Aspera* spacecraft does not require power to execute a successful de-orbit plan and thus a non-explosive battery failure does not impact *Aspera* de-orbit. An analysis on accidental breakup and battery passivation is given in Section 10: Battery Passivation.

5.5.3 Requirement 4.4-3 Compliance

4.4-3: Limit number, size, and orbital lifetime of debris larger than 1mm and 10cm (respectively)
The *Aspera* spacecraft will not execute an intended breakup during the mission and is therefore compliant with requirement 4.4-3.

5.5.4 Requirement 4.4-4 Compliance

4.4-4: Assess risk to other programs for times immediately after a test when the debris cloud contains regions of high debris density
The *Aspera* spacecraft will not execute an intended breakup during the mission and is therefore compliant with requirement 4.4-4.

6 Assessment of Spacecraft Potential for On-Orbit Collisions

6.1 Assessment of probability of Spacecraft Collision with objects larger than 10 cm

The *Aspera* spacecraft probability of collision with large objects is calculated to be 2.1568E-04 by DAS analysis.

6.2 Assessment of postmission disposal risk due to collision with small objects

The *Aspera* spacecraft contains no components or elements which are required to execute the disposal plan.

6.3 Assessment of plans for Debris Avoidance and Tracking

The *Aspera* spacecraft is equipped with a GPS antenna to provide enhanced tracking during mission operations, which will reported to the US Space Force. This may be leveraged to reduce the covariance of collision estimates.

The *Aspera* spacecraft has no propulsive capability and is therefore incapable of changing or otherwise adjusting orbit once delivered by the rideshare program. Therefore, the *Aspera* spacecraft has no capability to avoid detected debris.

6.4 Compliance with Requirements

6.4.1 Requirement 4.5-1 Compliance

4.5-1: Assess probability of collision with intact space systems or large debris (>10cm)
The risk of the *Aspera* spacecraft colliding with an object larger than 10 cm in diameter is calculated to be a probability of 2.1568E-04 and thus is in compliance with requirement 4.5-1.

6.4.2 Requirement 4.5-2 Compliance

4.5-2: Assess and limit the probability of damage to critical components as a result of impact with small debris
The *Aspera* spacecraft can successfully execute the de-orbit plan – passive demise - without the use of any systems. No critical components are required to execute postmission disposal and thus is in compliance with requirement 4.5-2.

7 Assessment of Spacecraft Postmission Disposal Plans and Procedures

7.1 Description of Spacecraft Disposal Plan

The *Aspera* spacecraft will de-orbit naturally due to atmospheric drag and re-entry. There is no propulsion system. At the end of the mission, all equipment except the spacecraft receiver is powered off. The power system continues to operate, but no other spacecraft systems are engaged. Power will be disconnected from the reaction wheels, with the reaction wheels spinning down within approximately 2 minutes. The receiver remains powered until demise. Commands or programmed behaviors that may result in the accidental end of the mission, specifically, commands for "Receiver Off" and "Passivate Batteries" were not included, to avoid accidental mission termination.

For a desired circular polar orbit of a maximum altitude of 600 km and an inclination of 97.5 degrees, the *Aspera* spacecraft will be expected to de-orbit within approximately 17.45 years after launch (Figure 2). Since the on-orbit lifetime exceeds the 5-year deorbit rule defined in FCC 22-74, the *Aspera* project is requesting a waiver for FCC 22-74. See *Section 12 Appendix B: FCC 22-74 Five-Year Deorbit Rule Waiver Request.*

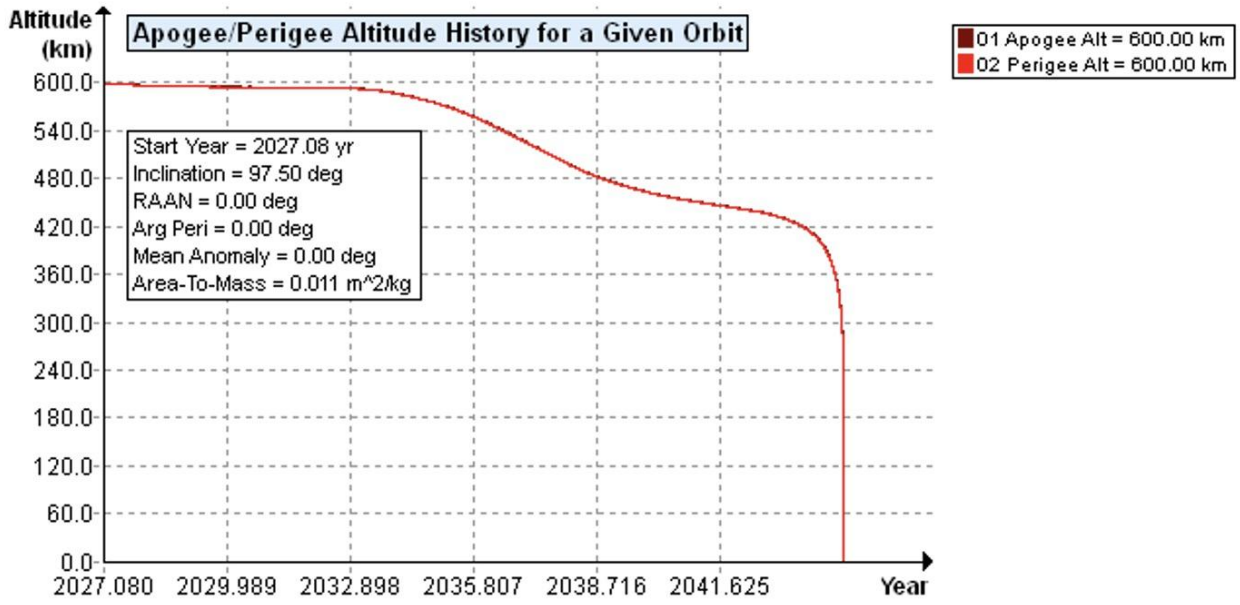

Figure 2: Aspera orbital lifetime as a function of altitude

7.2 Identification of systems or components required to accomplish postmission Disposal Plan

The *Aspera* spacecraft requires neither active attitude control nor a propulsion system to execute the post-mission disposal plan.

7.3 Calculation of Area-to-Mass ratio

The *Aspera* spacecraft has a total mass with contingency of 54.5 kg. The cross-sectional area for the *Aspera* spacecraft in a random attitude configuration is 0.601 m^2, calculated by the DAS cross-sectional area engineering utility (Table 2). Therefore, the *Aspera* spacecraft's effective area-to-mass ratio is 0.011 m^2/kg.

Table 2: Aspera spacecraft surface areas

Item	Units	Value	Comment
Face A1 Area	m^2	0.6375	
Face A2 Area	m^2	0.3036	
Face A3 Area	m^2	0.2617	
Effective Area	m^2	0.601	(A1 + A2 + A3)/2
Effective Area/mass Ratio	m^2/kg	0.011	0.601/54.5

7.4 Compliance with Requirements

7.4.1 Requirement 4.6-1 Compliance

4.6-1: Remove space structures from LEO to reduce collision threat to future space operations

The *Aspera* mission is compliant with Requirement 4.6-1 as demonstrated by analysis using DAS.

Item	Units	Value	Comment
Orbit Life	Years	17.45	
Large Object Collision Probability	Fraction	2.1568E-04	
Demise Risk	Fraction	0	All components demise

7.4.2 Requirement 4.6-2 Compliance

4.6-2: Remove space structures from GEO to reduce collision threat to future space operations

The entirety of the Aspera mission will take place in LEO, and not GEO or MEO, and will not require storage or escape to a heliocentric trajectory. Analysis is not applicable.

7.4.3 Requirement 4.6-3 Compliance

4.6-3: Govern intermediate disposal orbits
The entirety of the Aspera mission will take place in LEO, and not GEO or MEO, and will not require long-term reentry. Analysis is not applicable.

7.4.4 Requirement 4.6-4 Compliance

4.6-4: Assess reliability of postmission disposal
The *Aspera* spacecraft design includes no components which are required to execute the disposal plan. The *Aspera* mission is compliant with Requirement 4.6-4.

8 Assessment of Spacecraft Reentry Hazards

8.1 Spacecraft Components

The table below lists all spacecraft components as defined in DAS.

Row	Name	Parent	Qty	Material	Shape	Mass	W	L	H
1	**ASPERA**	0	1	Aluminum 7075-T6	Box	55.41	0.395	0.48	0.395
2	SC Bus	1	1	Aluminum 7075-T6	Box	13.23	0.395	0.48	0.395
3	Mounting Plate	2	1	Aluminum 6061-T6	Box	0.45	0.14	0.155	0.01
4	Enclosure	2	2	Polycarbonate (aka Lexan)	Box	0.16	0.13	0.165	0.02
5	Battery Cell Casing	4	14	Stainless Steel 17-4 ph	Box	0.058	0.06	0.065	0.02
6	Battery Cell Interior	5	14	Zinc	Box	0.092	0.06	0.065	0.02
7	Reaction Wheel Frame	2	4	Aluminum 6061-T6	Box	0.14	0.075	0.075	0.038
8	Reaction Wheel Rotor	7	4	Stainless Steel 17-4 ph	Box	0.1	0.06	0.06	0.024
9	Radio Enclosures	1	2	Aluminum 6061-T6	Box	0.39	0.1	0.115	0.075
10	Radio Boards	9	4	Fiberglass	Box	0.055	0.062	0.106	0.005
11	On-Board Computer Bracket	2	1	Aluminum 6061-T6	Box	0.13	0.09	0.18	0.03
12	SC On-board Computers	2	2	Fiberglass	Box	0.05	0.07	0.08	0.005
13	Hold-Down Release Mechanism	2	2	Aluminum 6061-T6	Cylinder	0.1	0.04	0.05	
14	Power System Cards	2	11	Fiberglass	Box	0.06	0.05	0.06	0.011
15	Power System Interface	2	1	Fiberglass	Box	0.08	0.075	0.2	0.008
16	Optical Bench	2	1	Aluminum 6061-T6	Box	3.018	0.3135	0.4345	0.01

Row	Name	Parent	Qty	Material	Shape	Mass	W	L	H
17	Contamination Barrier Assembly	2	1	Aluminum 6061-T6	Box	0.331	0.17994	0.23807	0.00635
18	Contamination Metal Cover	2	1	Aluminum 6061-T6	Box	1.065	0.23667	0.39167	0.15251
19	Gratings	18	2	Corning ULE 7972	Box	0.07	0.06	0.08	0.007
20	Gratings Mount - Al	18	2	Aluminum 6061-T6	Box	0.163	0.05529	0.0773	0.05207
21	Gratings Mount - Invar	18	2	Invar	Box	0.058	0.04042	0.07042	0.00514
22	OAPs	18	2	Corning ULE 7972	Box	0.09	0.065	0.09	0.007
23	OAP Mounts - Al	18	2	Aluminum 6061-T6	Box	0.223	0.08414	0.1046	0.03946
24	OAP Mounts - Invar	18	2	Invar	Box	0.08	0.04642	0.07642	0.00541
25	MCP Mount (2024-T3)	18	1	Aluminum 2024-T3	Box	0.19	0.076	0.10256	0.035
26	MCP Mount (6061-T6)	18	1	Aluminum 6061-T6	Box	0.07	0.07	0.08759	0.0073
27	MCP - SS	18	1	Steel AISI 304	Box	0.1325	0.0665	0.0775	0.0052
28	MCP - Al	18	1	Aluminum 7075-T6	Box	0.3995	0.07	0.0825	0.03726
29	MCP Vacuum Lines - SS	18	1	Steel AISI 304	Cylinder	0.208	0.01	0.434424	
30	MCP Bulkhead Plate	18	1	Steel AISI 304	Box	0.08	0.03175	0.09049	0.00476
31	Baffling	18	2	Aluminum 6061-T6	Box	1.02	0.08835	0.3485	0.05553
32	Grating Baffle	18	1	Aluminum 6061-T6	Box	0.541	0.10966	0.13624	0.10508
33	Slit Assemblies	18	2	Aluminum 6061-T6	Box	0.11	0.04075	0.10578	0.023
34	Corner Cubes	18	5	Zerodur	Box	0.003	0.01	0.012	0.01
35	Flexures	18	4	Titanium (6 Al-4 V)	Cylinder	0.0072	0.015	0.02286	

Row	Name	Parent	Qty	Material	Shape	Mass	W	L	H
36	MCP HOP Actuator	18	1	Steel AISI 304	Cylinder	0.035	0.01422	0.04496	
37	High Voltage Cable Feedthrough Support	18	3	Aluminum 6061-T6	Box	0.019	0.0381	0.1016	0.00476
38	One-way Vent Valve	18	1	Aluminum 6061-T6	Box	0.045	0.033	0.033	0.029
39	Fasteners - Payload	18	208	Steel AISI 304	Cylinder	0.0075	0.01	0.026	
40	Electronics Crate	2	1	Aluminum 6061-T6	Box	4.01	0.278	0.286	0.108
41	Payload Computer Enclosure	40	1	Aluminum 6061-T6	Box	0.387	0.097	0.097	0.071
42	Payload Computers	41	3	Fiberglass	Box	0.05	0.07	0.08	0.005
43	PCC Box	40	1	Aluminum 6061-T6	Box	1.5	0.105	0.125	0.091
44	MCP Electronics Box Bracket	40	1	Aluminum 6061-T6	Box	0.22	0.095	0.155	0.078
45	MCP Electronics Box	40	1	Aluminum 7075-T6	Box	0.75	0.0889	0.122	0.0684
46	MCP Window Actuator Assembly	40	1	Aluminum 6061-T6	Box	0.03	0.04661	0.0701	0.01318
47	Heaters	40	8	Aluminum 6061-T6	Box	0.012	0.02697	0.02743	0.01387
48	Fasteners - Electronics	40	208	Steel AISI 304	Cylinder	0.0075	0.01	0.026	
49	Cable Harnessing	40	1	Copper Alloy	Box	1.5	0.02	1	0.01
50	Avionics Tray	2	2	Aluminum 7075-T6	Box	1.06	0.24	0.38	0.0125
51	Payload Tray	2	1	Aluminum 7075-T6	Box	2.11	0.38	0.38	0.038
52	Star Tracker Mount	2	1	Aluminum 7075-T6	Box	0.058	0.065	0.077	0.028
53	Star Tracker	2	1	Aluminum 7075-T6	Box	0.18	0.062	0.0665	0.056

Row	Name	Parent	Qty	Material	Shape	Mass	W	L	H
54	Separation Ring	1	1	Aluminum 7075-T6	Box	0.52	0.344	0.344	0.026
55	SA Array Hinge	1	4	Titanium (6 Al-4 V)	Box	0.15	0.055	0.08	0.025
56	Deployable SA	1	2	Aluminum 5052	Box	1.4	0.374	0.582	0.012
57	SA Substrate	1	4	GaAs	Box	0.236	0.374	0.582	0.005
58	Contaminati on Door	1	1	Aluminum 6061-T6	Box	0.271	0.16	0.265	0.02
59	Sun Shade	1	1	Aluminum 6061-T6	Box	0.28	0.0935	0.394	0.019
60	MCP Window	18	1	Magnesium Fluoride	Box	0.025	0.0508	0.0508	0.003175

8.2 Component Survivability Analysis

No components are expected to survive an uncontrolled re-entry according to DAS analysis.

8.3 Probability of Human Casualty

The risk of human casualty calculated by DAS is 0.

8.4 Requirements Compliance

8.4.1 Requirement 4.7-1 Compliance

4.7-1: Limit number and size of debris fragments that survive atmospheric reentry
The *Aspera* mission is compliant with Requirement 4.7-1, which requires that the risk of human casualty from re-entry debris be less than 1:10,000.

8.5 Assessment of Spacecraft Hazardous Materials

The *Aspera* spacecraft contains no known hazardous materials.

9 Assessment for Special Classes

9.1 Description of Special Classes

The *Aspera* spacecraft design contains no special classes.

9.2 Requirements Compliance

9.2.1 Requirement 4.8-1 Compliance

4.8-1: Clarification and additional requirements for certain special classes of space missions, such as tether systems.
Not Applicable. The *Aspera* mission is compliant with Requirement 4.8-1.

10 Battery Passivation

Spacecraft Potential for Explosion

1 Accidental Explosion

1.1 Requirement

NASA-STD-8719.14C, 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 LV orbital stage employed for a mission (i.e., every individual free-flying structural object), the program or project shall demonstrate, via failure mode and effects analyses, probabilistic risk assessments, or other appropriate analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and LV is less than 0.001 (excluding small particle impacts).

1.2 Assessment

Potential Causes of Spacecraft Accidental Breakup
This note presents an examination of the potential causes for the Aspera spacecraft to create orbital debris via explosion or breakup of onboard components due to self-initiated accidents during the mission.

The only sources of stored energy aboard the Aspera spacecraft are the battery and the reaction wheels. The reaction wheels will be spun down within two minutes after initiation of decommissioning as described in Section 7.1.
Potential causes of explosion or break up of the Aspera spacecraft are:

1. Battery explosion due to overcharge and/or overheating

The following subsections will address those failure scenarios.

Potential for Battery Explosion
Battery failures that could generate debris are those that result in over-pressurization of individual cells to the point of violent cell rupture/explosion. The two primary causes of cell over-pressurization are overcharging and excessive environmental heating.

Risks of overcharging are managed by three separate elements in the system; the Modular Power System (MPS) SABRIN, the MPS Battery Interface Module (BIM)and the battery itself.

The SABRIN in the MPS for the Aspera spacecraft manages battery regulation and power conversion on the spacecraft. The SABRIN uses both battery voltage

and battery current feedback to ensure that battery overcharge does not take place.

The battery is also protected from over-discharge with a three stage loadshed that first (software based) sheds the instrument loads, second (hardware based) sheds all non-essential spacecraft loads, and third (hardware based) sheds all remaining loads and reinitializes in the kick-off state as occurs at the time of separation from the launch vehicle. The first level loadshed is managed by the spacecraft Housekeeping computer (HKC) while the two lower level loadshed actions are managed by the BIM. All are based on voltage feedback from the battery.

The Aspera battery consists of a 7s2p arrangement of SAFT176065xlr cells. Each cell of the battery contains an external protection circuit that protects from overvoltage, overcharge, and over-discharge. These protections reset when nominal battery conditions are present. The overvoltage protection is cell voltage based. Overcharge protection is cell current based. Two independent over-discharge protections are present with one voltage based and the other current based.

Each cell additionally is protected by an in-built current breaker that physically open circuits at 4-9 bars pressure and a burst vent that opens at 11-12 bars pressure in a controlled and non-hazardous manner. These final layers of protection that prevent explosion of the battery are permanent and non-resettable.

The temperature of the battery is managed actively at cold temperatures and passively at high temperatures. The BIM manages battery heaters which are active only below 15˚C. Overheating of the battery is ensured through the spacecraft thermal design which ensures that all conditions of the spacecraft maintain the battery below its operational temperature limit of 60˚C. The BIM ensures that supplemental battery heating is not applied above 15˚C to ensure that the battery temperature is passively controlled while it is at elevated operating temperatures.

The final protection against explosion of the battery due to overtemperature is the overpressure protection of in-built current breaker and burst vent that prevent buildup of pressure in the battery due to overheating as well as overcharge.

All of these features provide multiple layers of protection to prevent any cell of the battery from having an explosive failure. This leads to a very low overall

probably for explosive failure, and therefore mitigates the need for battery passivation.

11 Appendix A: Aspera ODAR Model Inputs and Outputs

Launch From: Mahia, New Zealand, RL Electron
Launch date: NET Jan 29, 2027
Altitude: 600 km circular
Inclination: 97.5 degrees
SSO? Yes
LTAN: 1000
Attitude Average over Mission: Random
Mass: 54.5 kg. No Propulsion.

DAS Activity Log

```
06 18 2026; 19:43:14PM        Activity Log Started
06 18 2026; 19:51:40PM        Project Data Saved To File
06 18 2026; 19:51:45PM        Mission Editor Changes Applied
06 18 2026; 19:51:45PM        Project Data Saved To File
06 18 2026; 19:51:45PM        Project Data Saved To File
06 18 2026; 19:53:03PM        Science and Engineering - Orbit
Lifetime/Dwell Time

**INPUT**

               Start Year = 2027.080000 (yr)
               Perigee Altitude = 600.000000 (km)
               Apogee Altitude = 600.000000 (km)
               Inclination = 97.500000 (deg)
               RAAN = 0.000000 (deg)
               Argument of Perigee = 0.000000 (deg)
               Area-To-Mass Ratio = 0.011000 (m^2/kg)

**OUTPUT**

               Orbital Lifetime from Startyr = 17.452011 (yr)
               Time Spent in LEO during Lifetime  = 17.452011 (yr)
               Last year of Propagation = 2044 (yr)
               Returned Error Message: Object reentered
06 18 2026; 19:53:56PM        Science and Engineering - Apogee/Perigee
History for a Given Orbit

**INPUT**

               Perigee Altitude = 600.000000 (km)
               Apogee Altitude = 600.000000 (km)
               Inclination = 97.500000 (deg)
               RAAN = 0.000000 (deg)
               Argument of Perigee = 0.000000 (deg)
               Mean Anomaly = 0.000000 (deg)
```

```
               Area-To-Mass Ratio = 0.011000 (m^2/kg)
               Start Year = 2027.080000 (yr)
               Integration Time = 20.000000 (yr)

**OUTPUT**

               Plot
06 18 2026; 19:58:41PM       Processing Requirement 4.5-1: Return Status
:  Passed

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

**INPUT**

               Space Structure Name = ASPERA
               Space Structure Type = Payload
               Perigee Altitude = 600.000 (km)
               Apogee Altitude = 600.000 (km)
               Inclination = 97.500 (deg)
               RAAN = 0.000 (deg)
               Argument of Perigee = 0.000 (deg)
               Mean Anomaly = 0.000 (deg)
               Final Area-To-Mass Ratio = 0.0110 (m^2/kg)
               Start Year = 2027.080 (yr)
               Initial Mass = 54.500 (kg)
               Final Mass = 54.500 (kg)
               Duration = 25.000 (yr)
               Station-Kept = False
               Abandoned = True
               Long-Term Reentry = False

**OUTPUT**

               Collision Probability = 2.1568E-04
               Returned Message: Normal Processing
               Date Range Message: Normal Date Range
               Status = Pass

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

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




==============
```

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

**INPUT**

               Space Structure Name = ASPERA
               Space Structure Type = Payload

               Perigee Altitude = 600.000000 (km)
               Apogee Altitude = 600.000000 (km)
               Inclination = 97.500000 (deg)
               RAAN = 0.000000 (deg)
               Argument of Perigee = 0.000000 (deg)
               Mean Anomaly = 0.000000 (deg)
               Area-To-Mass Ratio = 0.011000 (m^2/kg)
               Start Year = 2027.080000 (yr)
               Initial Mass = 54.500000 (kg)
               Final Mass = 54.500000 (kg)
               Duration = 25.000000 (yr)
               Station Kept = False
               Abandoned = True
               PMD Perigee Altitude = -1.000000 (km)
               PMD Apogee Altitude = -1.000000 (km)
               PMD Inclination = 0.000000 (deg)
               PMD RAAN = 0.000000 (deg)
               PMD Argument of Perigee = 0.000000 (deg)
               PMD Mean Anomaly = 0.000000 (deg)
               Long-Term Reentry = False

**OUTPUT**

               Suggested Perigee Altitude = 600.000000 (km)
               Suggested Apogee Altitude = 600.000000 (km)
               Returned Error Message = Reentry during mission (no PMD
req.).

               Released Year = 2044 (yr)
               Requirement = 61
               Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
06 18 2026; 20:28:10PM       *********Processing Requirement 4.7-1
               Return Status :  Passed

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

name = ASPERA
```

```
quantity = 1
parent = 0
materialID = 9
type = Box
Aero Mass = 54.500000
Thermal Mass = 54.500000
Diameter/Width = 0.395000
Length = 0.480000
Height = 0.395000

name = SC Bus
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 44.329799
Thermal Mass = 13.230000
Diameter/Width = 0.395000
Length = 0.480000
Height = 0.395000

name = Mounting Plate
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.140000
Length = 0.155000
Height = 0.010000

name = Enclosure
quantity = 2
parent = 2
materialID = 77
type = Box
Aero Mass = 1.210000
Thermal Mass = 0.160000
Diameter/Width = 0.130000
Length = 0.165000
Height = 0.020000

name = Battery Cell Casing
quantity = 14
parent = 4
materialID = 56
type = Box
Aero Mass = 0.150000
Thermal Mass = 0.058000
```

```
Diameter/Width = 0.060000
Length = 0.065000
Height = 0.020000

name = Battery Cell Interior
quantity = 14
parent = 5
materialID = 70
type = Box
Aero Mass = 0.092000
Thermal Mass = 0.092000
Diameter/Width = 0.060000
Length = 0.065000
Height = 0.020000

name = Reaction Wheel Frame
quantity = 4
parent = 2
materialID = 8
type = Box
Aero Mass = 0.240000
Thermal Mass = 0.140000
Diameter/Width = 0.075000
Length = 0.075000
Height = 0.038000

name = Reaction Wheel Rotor
quantity = 4
parent = 7
materialID = 56
type = Box
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.060000
Length = 0.060000
Height = 0.024000

name = On-Board Computer Bracket
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 0.130000
Thermal Mass = 0.130000
Diameter/Width = 0.090000
Length = 0.180000
Height = 0.030000

name = SC On-board Computers
quantity = 2
```

```
parent = 2
materialID = 23
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.070000
Length = 0.080000
Height = 0.005000

name = Hold-Down Release Mechanism
quantity = 2
parent = 2
materialID = 8
type = Cylinder
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.040000
Length = 0.050000

name = Power System Cards
quantity = 11
parent = 2
materialID = 23
type = Box
Aero Mass = 0.060000
Thermal Mass = 0.060000
Diameter/Width = 0.050000
Length = 0.060000
Height = 0.011000

name = Power System Interface
quantity = 1
parent = 2
materialID = 23
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.075000
Length = 0.200000
Height = 0.008000

name = Optical Bench
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 3.018000
Thermal Mass = 3.018000
Diameter/Width = 0.313500
Length = 0.434500
```

```
Height = 0.010000

name = Contamination Barrier Assembly
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 0.331000
Thermal Mass = 0.331000
Diameter/Width = 0.179940
Length = 0.238070
Height = 0.006350

name = Contamination Metal Cover
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 8.079800
Thermal Mass = 1.065000
Diameter/Width = 0.236670
Length = 0.391670
Height = 0.152510

name = Gratings
quantity = 2
parent = 16
materialID = -1
type = Box
Aero Mass = 0.070000
Thermal Mass = 0.070000
Diameter/Width = 0.060000
Length = 0.080000
Height = 0.007000

name = Gratings Mount - AI
quantity = 2
parent = 16
materialID = 8
type = Box
Aero Mass = 0.163000
Thermal Mass = 0.163000
Diameter/Width = 0.055290
Length = 0.077300
Height = 0.052070

name = Gratings Mount - Invar
quantity = 2
parent = 16
materialID = 72
```

```
type = Box
Aero Mass = 0.058000
Thermal Mass = 0.058000
Diameter/Width = 0.040420
Length = 0.070420
Height = 0.005140

name = OAPs
quantity = 2
parent = 16
materialID = -1
type = Box
Aero Mass = 0.090000
Thermal Mass = 0.090000
Diameter/Width = 0.065000
Length = 0.090000
Height = 0.007000

name = OAP Mounts - AI
quantity = 2
parent = 16
materialID = 8
type = Box
Aero Mass = 0.223000
Thermal Mass = 0.223000
Diameter/Width = 0.084140
Length = 0.104600
Height = 0.039460

name = OAP Mounts - Invar
quantity = 2
parent = 16
materialID = 72
type = Box
Aero Mass = 0.080000
Thermal Mass = 0.080000
Diameter/Width = 0.046420
Length = 0.076420
Height = 0.005410

name = MCP Mount (2024-T3)
quantity = 1
parent = 16
materialID = 3
type = Box
Aero Mass = 0.190000
Thermal Mass = 0.190000
Diameter/Width = 0.076000
Length = 0.102560
Height = 0.035000
```

```
name = MCP Mount (6061-T6)
quantity = 1
parent = 16
materialID = 8
type = Box
Aero Mass = 0.070000
Thermal Mass = 0.070000
Diameter/Width = 0.070000
Length = 0.087590
Height = 0.007300

name = MCP - SS
quantity = 1
parent = 16
materialID = 58
type = Box
Aero Mass = 0.132500
Thermal Mass = 0.132500
Diameter/Width = 0.066500
Length = 0.077500
Height = 0.005200

name = MCP - AI
quantity = 1
parent = 16
materialID = 9
type = Box
Aero Mass = 0.399500
Thermal Mass = 0.399500
Diameter/Width = 0.070000
Length = 0.082500
Height = 0.037260

name = MCP Vacuum Lines - SS
quantity = 1
parent = 16
materialID = 58
type = Cylinder
Aero Mass = 0.208000
Thermal Mass = 0.208000
Diameter/Width = 0.010000
Length = 0.434424

name = MCP Bulkhead Plate
quantity = 1
parent = 16
materialID = 58
type = Box
Aero Mass = 0.080000
```

```
Thermal Mass = 0.080000
Diameter/Width = 0.031750
Length = 0.090490
Height = 0.004760

name = Baffling
quantity = 2
parent = 16
materialID = 8
type = Box
Aero Mass = 1.020000
Thermal Mass = 1.020000
Diameter/Width = 0.088350
Length = 0.348500
Height = 0.055530

name = Grating Baffle
quantity = 1
parent = 16
materialID = 8
type = Box
Aero Mass = 0.541000
Thermal Mass = 0.541000
Diameter/Width = 0.109660
Length = 0.136240
Height = 0.105080

name = Slit Assemblies
quantity = 2
parent = 16
materialID = 8
type = Box
Aero Mass = 0.110000
Thermal Mass = 0.110000
Diameter/Width = 0.040750
Length = 0.105780
Height = 0.023000

name = Corner Cubes
quantity = 5
parent = 16
materialID = 71
type = Box
Aero Mass = 0.003000
Thermal Mass = 0.003000
Diameter/Width = 0.010000
Length = 0.012000
Height = 0.010000

name = Flexures
```

```
quantity = 4
parent = 16
materialID = 65
type = Cylinder
Aero Mass = 0.007200
Thermal Mass = 0.007200
Diameter/Width = 0.015000
Length = 0.022860

name = MCP HOP Actuator
quantity = 1
parent = 16
materialID = 58
type = Cylinder
Aero Mass = 0.035000
Thermal Mass = 0.035000
Diameter/Width = 0.014220
Length = 0.044960

name = High Voltage Cable Feedthrough Support
quantity = 3
parent = 16
materialID = 8
type = Box
Aero Mass = 0.019000
Thermal Mass = 0.019000
Diameter/Width = 0.038100
Length = 0.101600
Height = 0.004760

name = One-way Vent Valve
quantity = 1
parent = 16
materialID = 8
type = Box
Aero Mass = 0.045000
Thermal Mass = 0.045000
Diameter/Width = 0.033000
Length = 0.033000
Height = 0.029000

name = Fasteners - Payload
quantity = 208
parent = 16
materialID = 58
type = Cylinder
Aero Mass = 0.007500
Thermal Mass = 0.007500
Diameter/Width = 0.010000
Length = 0.026000
```

```
name = MCP Window
quantity = 1
parent = 16
materialID = -2
type = Box
Aero Mass = 0.025000
Thermal Mass = 0.025000
Diameter/Width = 0.050800
Length = 0.050800
Height = 0.003175

name = Electronics Crate
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 10.203000
Thermal Mass = 4.010000
Diameter/Width = 0.278000
Length = 0.286000
Height = 0.108000

name = Payload Computer Enclosure
quantity = 1
parent = 39
materialID = 8
type = Box
Aero Mass = 0.537000
Thermal Mass = 0.387000
Diameter/Width = 0.097000
Length = 0.097000
Height = 0.071000

name = Payload Computers
quantity = 3
parent = 40
materialID = 23
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.070000
Length = 0.080000
Height = 0.005000

name = PCC Box
quantity = 1
parent = 39
materialID = 8
type = Box
```

```
Aero Mass = 1.500000
Thermal Mass = 1.500000
Diameter/Width = 0.105000
Length = 0.125000
Height = 0.091000

name = MCP Electronics Box Bracket
quantity = 1
parent = 39
materialID = 8
type = Box
Aero Mass = 0.220000
Thermal Mass = 0.220000
Diameter/Width = 0.095000
Length = 0.155000
Height = 0.078000

name = MCP Electronics Box
quantity = 1
parent = 39
materialID = 9
type = Box
Aero Mass = 0.750000
Thermal Mass = 0.750000
Diameter/Width = 0.088900
Length = 0.122000
Height = 0.068400

name = MCP Window Actuator Assembly
quantity = 1
parent = 39
materialID = 8
type = Box
Aero Mass = 0.030000
Thermal Mass = 0.030000
Diameter/Width = 0.046610
Length = 0.070100
Height = 0.013180

name = Heaters
quantity = 8
parent = 39
materialID = 8
type = Box
Aero Mass = 0.012000
Thermal Mass = 0.012000
Diameter/Width = 0.026970
Length = 0.027430
Height = 0.013870
```

```
name = Fasteners - Electronics
quantity = 208
parent = 39
materialID = 58
type = Cylinder
Aero Mass = 0.007500
Thermal Mass = 0.007500
Diameter/Width = 0.010000
Length = 0.026000

name = Cable Harnessing
quantity = 1
parent = 39
materialID = 19
type = Box
Aero Mass = 1.500000
Thermal Mass = 1.500000
Diameter/Width = 0.020000
Length = 1.000000
Height = 0.010000

name = Avionics Tray
quantity = 2
parent = 2
materialID = 9
type = Box
Aero Mass = 1.060000
Thermal Mass = 1.060000
Diameter/Width = 0.240000
Length = 0.380000
Height = 0.012500

name = Payload Tray
quantity = 1
parent = 2
materialID = 9
type = Box
Aero Mass = 2.110000
Thermal Mass = 2.110000
Diameter/Width = 0.380000
Length = 0.380000
Height = 0.038000

name = Star Tracker Mount
quantity = 1
parent = 2
materialID = 9
type = Box
Aero Mass = 0.058000
Thermal Mass = 0.058000
```

```
Diameter/Width = 0.065000
Length = 0.077000
Height = 0.028000

name = Star Tracker
quantity = 1
parent = 2
materialID = 9
type = Box
Aero Mass = 0.180000
Thermal Mass = 0.180000
Diameter/Width = 0.062000
Length = 0.066500
Height = 0.056000

name = Radio Enclosures
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.390000
Diameter/Width = 0.100000
Length = 0.115000
Height = 0.075000

name = Radio Boards
quantity = 4
parent = 53
materialID = 23
type = Box
Aero Mass = 0.055000
Thermal Mass = 0.055000
Diameter/Width = 0.062000
Length = 0.106000
Height = 0.005000

name = Separation Ring
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.520000
Thermal Mass = 0.520000
Diameter/Width = 0.344000
Length = 0.344000
Height = 0.026000

name = SA Array Hinge
quantity = 4
```

```
parent = 1
materialID = 65
type = Box
Aero Mass = 0.150000
Thermal Mass = 0.150000
Diameter/Width = 0.055000
Length = 0.080000
Height = 0.025000

name = Deployable SA
quantity = 2
parent = 1
materialID = 7
type = Box
Aero Mass = 1.400000
Thermal Mass = 1.400000
Diameter/Width = 0.374000
Length = 0.582000
Height = 0.012000

name = SA Substrate
quantity = 4
parent = 1
materialID = 24
type = Box
Aero Mass = 0.236000
Thermal Mass = 0.236000
Diameter/Width = 0.374000
Length = 0.582000
Height = 0.005000

name = Contamination Door
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.271000
Thermal Mass = 0.271000
Diameter/Width = 0.160000
Length = 0.265000
Height = 0.020000

name = Sun Shade
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.280000
Thermal Mass = 0.280000
Diameter/Width = 0.093500
```

```
Length = 0.394000
Height = 0.019000

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

name = ASPERA
Demise Altitude = 78.004998
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = SC Bus
Demise Altitude = 73.248192
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Mounting Plate
Demise Altitude = 71.132991
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Enclosure
Demise Altitude = 73.043324
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
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12 Appendix B: FCC 22-74 Five-Year Deorbit Rule Waiver Request

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FEDERAL COMMUNICATIONS COMMISSION
FCC 22-74
FIVE-YEAR DEORBIT RULE WAIVER APPLICABILITY QUESTIONNAIRE

PROJECT INFORMATION

1. PROJECT NAME:	2. PROJECT POINT OF CONTACT *(Name and title)*:
Aspera	Hannah Tanquary, Project Systems Engineer

3. QUESTIONS

QUESTION NUMBER	QUESTION	PROJECT RESPONSE (a) YES	PROJECT RESPONSE (a) NO
1	Will the spacecraft be operating at or below 2000 km?	☒	☐
2	Based on your current operational plan, will you be able to deorbit the spacecraft no more than 5 years after the end of the mission? If no, how many years is the spacecraft expected to stay in orbit following the end of the mission? ☐5-10 ☐ 10-15 ☒15-20 ☐20-25	☐	☒
3	Does your spacecraft have a deorbiting system? If yes, check one: ☐passive ☐ active	☐	☒
4	Describe the deorbit system, in detail, if there is one.		
5	For spacecraft without a propulsion system, are you intentionally performing actions that will change the spacecraft orbit (e.g., differential drag, drag sail, tether, boom, etc.) If so, describe how these actions will be accomplished and maintained throughout the orbital lifetime of the spacecraft.	☐	☒
6	Are you participating in a government research program, grant, prize, challenge, cooperative agreement, or AO?	☒	☐
7	If you answered "yes" to question 6, please specify which program is providing the funding and how the funds were used to develop and operate the proposed mission. Aspera is a NASA-funded astrophysics mission developed and operated by the University of Arizona. It is funded by the Pioneers Program within the NASA Science Mission Directorate, Astrophysics Division. NASA funds have been used to support all the development and operations of the mission.		
8	Are the project costs, not including launch costs, supported at least 50% by the US government and/or NASA?	☒	☐
9	Are launch costs supported by the US government and/or NASA?	☒	☐
10	Specify the deployment orbital parameters: apogee altitude 600km perigee altitude 600km inclination 97.5° Specify the mission orbital parameters: apogee altitude 600km perigee altitude 600km inclination 97.5° Specify the end-of-mission orbital parameters: apogee altitude 597km perigee altitude 597km inclination 97.5°		

4. QUESTIONAIRE COMPLETION RECOMMENDATION

(*To be completed by NASA Representative*)

Based on the information provided, NASA makes the following recommendation:

CLASSIFICATION (SELECT ONE) (a)	RECOMMENDATION (b)
☐	This project meets the criteria of FCC 22-74. No further analysis is recommended unless future changes to the project would change the response to one of the questions.
☒	The project does not meet all of the FCC 22-74 criteria. A waiver is required.

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FEDERAL COMMUNICATIONS COMMISSION
FCC 22-74
FIVE-YEAR DEORBIT RULE WAIVER

PROJECT INFORMATION

1. PROJECT NAME:	2. PROJECT POINT OF CONTACT *(Name and title)*:
Aspera	Hannah Tanquary, Project Systems Engineer

▶ 3. Provide a description of the unique mission and research objectives that cannot be achieved at a lower altitude that would allow for reentry within the 5-year post-mission timeframe.

1. Introduction
The Aspera mission team respectfully requests **a waiver of the FCC's five-year post-mission disposal requirement** under IB Docket Nos. 22-271 and 18-313 (§25.283(e)) to operate at **600 km altitude.** The expected orbital lifetime after mission completion is **approximately 20 years** (per NASA DAS v3.1.2 analysis), which exceeds the five-year benchmark but remains within the previous 25-year maximum orbital debris mitigation guideline in place at the time of mission selection and design.

2. Mission Overview
Aspera is a **NASA-funded astrophysics research mission** competitively selected in 2021 under the Astrophysics Pioneers program, which supports innovative small satellite missions addressing fundamental science. The Aspera mission is designed to detect and map the warm-hot circumgalactic medium (CGM) surrounding nearby galaxies by observing the faint far-ultraviolet (FUV) emission lines of doubly ionized oxygen (O VI) at 103.2 nm. This diffuse hot halo gas is likely to contain a significant fraction of a galaxy's baryons and plays a critical role in regulating star formation and galaxy evolution. Aspera will deploy a custom FUV spectrograph to carry out the first-ever emission line mapping survey of O VI in galaxy halos, building on limited detections by the FUSE mission (~766 km orbit). The primary science mission is baselined for 9 months, with the goal of observing **at least ten edge-on nearby galaxies** to characterize the distribution, morphology, and physical conditions of the warm-hot CGM. The resulting dataset will be the first of its kind, providing critical observational constraints on galaxy evolution models and helping to close the gap in the cosmic baryon census.

3. Spacecraft and Mission Characteristics
- Spacecraft bus: DEFIANT-Class microsatellite provided by SFL Missions Inc. (LEO-compatible, no unique spacecraft design)
- Mass: ~60 kg
- Propulsion: None; no collision avoidance capability
- Requested Orbit: 600 km Sun-Sync. LEO. MLTAN/MLTDN 10:00 or 14:00.
- Launch vehicle/provider: Primary payload on Rocket Lab Electron; orbit altitude of 600 km is confirmed to be feasible with Rocket Lab.
- Primary Mission duration: 9 months
- Two deployable solar panels
- S/C designed minimum life expectancy >5 years
- Funding and oversight: NASA Astrophysics, fundamental research program
- Data release: All data will be publicly archived at Mikulski Archive for Space Telescopes (MAST, https://archive.stsci.edu). Peer-reviewed publications are planned by the end of the mission.

4. Rationale for Waiver
Technical and scientific justification:

- To comply with the five-year deorbit rule, Aspera would need to be launched to approx. 515 km.
- **However, the mission objectives may not be achieved at 515 km.**
  - **Airglow impact:** At lower altitudes, atmospheric number density increases, strengthening geocoronal airglow emission lines near 103.2 nm.
  - **Solar cycle effect:** Airglow line strength is also proportional to solar activity. The current 2026 solar activity is ~40-50% stronger than predicted by the 2019 NOAA/NASA/ISES Panel.
  - **Combined effect:** Airglow line brightness at 515 km, combined with the stronger solar activity, will result in **up to 4 times higher background noise** than the baseline estimate at 600 km.
- Impact on science return:
  - The increased background would require **~65% longer exposure time** to reach target sensitivity.
  - Consequently, the mission would be able to observe **fewer nearby galaxies than planned**, fundamentally compromising its primary objective of observing the warm-hot CGM.

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▶ 4. Provide a description of the anticipated findings for the mission and any plans for publishing or otherwise reporting the findings.

Science and Technology Goals:

The Aspera mission aims to achieve three primary science objectives:

1. Determine the ubiquity of the warm-hot circumgalactic medium (CGM) around nearby galaxies.
2. Characterize the morphology of the warm-hot CGM, including its spatial extent and structural features.
3. Measure the kinematics of the warm-hot CGM, including line-of-sight velocities and velocity dispersions derived from OVI 103.2 nm emission lines.

These objectives will address longstanding questions in galaxy evolution by providing the first direct emission maps of the warm-hot CGM. The mission plans to conduct long-exposure observations of a minimum of 10 edge-on nearby galaxies, with the goal of producing spatially resolved O VI emission maps for at least 3 galaxies.

1. Products of the Research:

The research will produce calibrated science products including:

- L0: Raw time-tagged photon event lists and spacecraft/payload housekeeping and telemetry data.
- L1: FITS files converted from the L0 files, with the relevant housekeeping and telemetry data in its header.
- L2: FITS files, comprised of screened, wavelength calibrated, and doppler corrected photon events list.
- L3a: FITS files, spatially binned and photometrically calibrated 1D spectra.
- L3b: Combined, final three-dimensional spectral cubes (FITS files) for each target galaxy, containing spatial (RA, DEC) and spectral (wavelength) dimensions, surface brightness values, associated uncertainties, and effective exposure time maps.

L0 to L3b data, along with the calibration data (astrometry, wavelength calibration, and flux calibration) will be archived at MAST for the reproduction of the published results.

2. Science data processing pipeline:

A dedicated data reduction pipeline (DRP) is under development for Aspera, implemented in Python 3 using Astropy and affiliated packages. The pipeline will 1) ingest Level 0 photon event lists, 2) Apply calibrations and corrections (thermal distortion, wavelength calibration, Doppler correction, background subtraction), 3) Perform spectral extraction and flux calibration, and 3) Combine spatially dithered observations into final Level 3b data cubes, reconstructing the CGM's spatial and spectral emission distribution. Details of the pipeline design and methodology are described in Keppler et al. 2024.

3. Data Format and Distribution Plans:

All data products will be delivered in FITS format with complete header metadata containing instrument configuration, observation parameters, and calibration information. The final Level 3b data cubes are estimated to be ~4 GB per target galaxy, while intermediate products (Levels 1–3a) will be smaller and organized by observation segment.

4. Data Release and Archiving:

All data from the primary science mission will be made publicly available via the Mikulski Archive for Space Telescopes (MAST) by the end of the 7-month mission. Any subsequent data acquired during an extended mission, if applicable, will be released within 6–12 months of the respective observations.

5. Policies for Re-Use, Re-Distribution, and Production of Derivatives:

All Aspera data will be released to the public without restriction. Users are encouraged to re-use and re-distribute the data and produce derivative works, with appropriate citation of the Aspera mission and relevant publications.

6. Publication of the results:

Publications describing the Aspera mission concept (Chung et al. 2021), payload design (Chung et al. 2024), and data processing pipeline (Keppler et al. 2024) have already been issued. Additional technical papers on optical alignment procedures (Khan et al. 2024) and contamination control strategies (Melso et al. 2024) have also been published. Scientific results and further technical performance reports will be published in relevant journals such as *The Astrophysical Journal, Astronomy & Astrophysics, SPIE Proceedings, and Nature.*

7. Community Engagement for Maximizing Science Impact:

The mission's impact will be maximized through open data access and peer-reviewed publications. If an extended mission phase occurs, the science team plans to seek community input to inform target selection and observation priorities for that phase. Community engagement will primarily occur through post-release data use, conference presentations, and scientific collaborations leveraging the publicly archived data.

▶ 5. Provide a proposed operations survey incorporating any other research or related missions that indicate that the proposed operations would satisfy a unique area of research, including any findings and actions of other government agencies and educational institutions that support the importance and public interest benefits of the mission.

The Aspera mission addresses a unique area of astrophysical research by conducting the first-ever far-ultraviolet emission mapping survey of the warm-hot circumgalactic medium (CGM) around nearby galaxies. The CGM is a massive, multi-phase reservoir of baryonic matter surrounding galaxies and plays a critical role in galaxy formation and evolution. However, its warm-hot (10^5–10^6 K) phase remains poorly characterized, especially in emission.

Prior related missions include:

- Far Ultraviolet Spectroscopic Explorer (FUSE): Conducted limited observations of O VI 103.2 nm emission in the CGM. While FUSE successfully made a few faint detections in emission at ~766 km orbit, it was not designed to produce spatially resolved emission maps of the CGM.
- Hubble Space Telescope Cosmic Origins Spectrograph (HST-COS): Provided extensive absorption-line surveys of the CGM along pencil-beam sightlines to background quasars but cannot detect CGM emission or map its morphology.

No other government or academic missions to date have been able to perform volume-filled, spatially resolved emission line mapping of the warm-hot CGM. Aspera is the first mission specifically designed for this purpose, filling a key observational gap highlighted by the astrophysics community.

Supporting agencies and institutions:

- NASA Science Mission Directorate, Astrophysics Division selected Aspera under the Pioneers program to advance high-priority fundamental research.
- The mission supports NASA's Science Mission Directorate goals to "discover how the universe works, explore how it began and evolved, and search for life on planets around other stars."

The anticipated findings of the Aspera mission will significantly advance public scientific knowledge by revealing the structure, distribution, and kinematics of the warm-hot CGM. Its data products will inform galaxy evolution models and the cosmic baryon census, benefiting the broader astrophysics and education communities through open data and publications.

▶ 6. Provide a description of ways the spacecraft is providing situational awareness (Examples: GPS, reflective surface coating, increased surface area, etc.) and state if these would continue after passivation of the spacecraft.

The Aspera spacecraft is equipped with a GPS receiver that provides orbit determination and timing for mission operations. This enables accurate ephemeris generation, tracking, and coordination with ground systems throughout the primary mission. The spacecraft exterior is covered with highly reflective and emissive aluminized optical tapes. These tapes will allow for improved observability of the spacecraft for situational awareness. The spacecraft utilizes two deployable solar panels in addition to its body-mounted panels, increasing its radar cross-section for ground-based tracking.

The GPS receiver remains available so long as the spacecraft is operable, but will be turned off for end of mission. The spacecraft's physical structure, including deployed solar panels and reflective tapes, will remain intact to support ongoing radar tracking until atmospheric reentry.

▶ For government supported missions, provide a description demonstrating that the proposed mission supports and serves a government purpose.

The Aspera mission is a NASA-funded astrophysics research mission, competitively selected under the NASA Astrophysics Pioneers program in 2021. The mission directly supports the U.S. government's scientific objectives by advancing fundamental knowledge of galaxy formation and evolution through observations of the warm-hot circumgalactic medium, a key component in
the cosmic baryon cycle.

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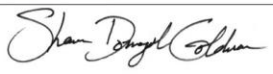
Aspera's goals are fully aligned with the NASA Science Mission Directorate strategic objectives, which include:
• Understanding the origin and evolution of galaxies, stars, and cosmic structures.
• Providing observations that inform and validate theoretical models used by the broader astrophysics community.
• Enabling public scientific data access to advance education, innovation, and U.S. leadership in space science.
In addition, while Aspera was selected after the Astro2020 Decadal Survey release, its mission approach is consistent with
Decadal recommendations encouraging the development of cost-effective SmallSat missions to achieve high-impact science.

▶ 7. Additional discussion of the need and rationale for a waiver.

8. Attachments

☒	NASA letter of support for the mission.
☐	Letter from the project showing alignment with NASA strategic objectives.
☐	Orbital Analysis
☐	Other (Title)

d. NASA Sponsor (Name and title):	e. SIGNATURE	f. DATE
Shawn Domagal-Goldman		6/14/26

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

Reply to Attn of: SMD/Astrophysics Division

Dear FCC,

This letter is to verify that the NASA Science Mission Directorate, Astrophysics Division, supports the launch and operations of the Aspera mission. We appreciate your assistance in providing the Aspera team with the necessary broadcast license.

Dr. Carlos Vargas is the Principal Investigator of the Aspera mission. NASA is supporting Aspera through the Astrophysics Division Pioneers Program. Aspera is a UV SmallSat observatory designed to map O VI emission from the halos of nearby galaxies, enabling the first direct measurements of the inflow and outflow of gas that regulates star formation and drives the evolution of galaxies. By probing the extreme ultraviolet environment around galaxies, Aspera will quantify how gas cycles between the circumgalactic medium and galactic disks, addressing key questions about feedback, accretion, and the baryon cycle.

Aspera will thus provide unique, transformative measurements of the physical processes that shape galaxy evolution, contributing directly to NASA's broader astrophysics science goals and the strategic priorities of the Astrophysics Division.

Sincerely,

Digitally signed by Pablo Saz Parkinson (affiliate)
Date: 2026.06.08 05:54:19 -04'00'

Pablo Saz Parkinson
Astrophysics Division Science Mission Directorate
Program Scientist for the Pioneers Program