Orbital Debris Assessment Report for Space AI SAI-1 Mission per NASA-STD-8719.14B

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REVISION AND HISTORY PAGE

PAG.	SEC.	ED	DESCRIPTION
iv		1.0	Revision and history page added
4	2.6	1.0	The value of orbital life time is adjusted
15	6.1	1.0	The cross sectional area value is adjusted
17	7.3	1.0	Information about the orbital decay calculations are complemented. Figure 5 is added
19	8.1	1.0	A table (Table 2) with the materials with the highest melting points
21	11	1.0	References added

1 INTRODUCTION

1.1 Objective

The purpose of this report is to satisfy the orbital debris requirements listed in NPR 8715.6B, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments for SAI-1 Mission. This report address the requirements stated on NASA-STD-8719.14B, Process for Limiting Orbital Debris covering sections 2 to 8 as indicated, sections 9 to 14 falls under the requirements for the primary mission responsible and for that are not presented here.

1.2 About Space AI

Space AI is a company based in Silicon Valley, California USA that has developed Node 1 as its core product. Node 1 will be the base infrastructure for the 4th industrial revolution. Node 1 is the next generation of SDR and the 5 senses of smart devices. Capable to deliver information data at the fastest speed, including the most advanced sensors for nano accuracy geolocation in the market; allowing innovators to connect and share resources with Distributed Computing Systems, Networks or Collaborative Systems and enhance their own devices, unmanned vehicles, robot systems or spacecraft's through standard connectors.

The company has sites in USA, Argentina, Mexico and Israel with a highly qualified team capable to deal with any kind of project. Space AI is currently working in different countries and sectors. Among them: agribusiness, transportation, space industry, solar energy and autonomous vehicles.

1.3 Self-assessment of the ODAR

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

NASA-STD-8719.14B – 2019-04-25 Final Orbital Debris Assessment Report Evaluation: SAI-1 Mission		
Requirement	**Status**	**Comments**
4.3-1a	Compliant	No planned debris release in LEO.
4.3-1b	Compliant	No planned debris release in LEO.
4.3-2	Compliant	NO planned debris release in near GEO for normal operations
4.4-1	Compliant	On board energy source (batteries) incapable of debris producing failure
4.4-2	Compliant	On board energy source (batteries) incapable of debris producing failure
4.4-3	Not applicable	No planned breakups
4.4-4	Not applicable	No planned breakups
4.5-1	Compliant	Probability well below 0.001
4.5-2	Not applicable	No post-mission disposal operation
4.6-1(a)	Compliant	
4.6-1(b)	Not applicable	
4.6-1(c)	Not applicable	
4.6-2	Not applicable	Non GEO Mission
4.6-3	Not applicable	Non MEO Mission
4.6-4	Compliant	Passive disposal
4.7-1	Compliant	Non-credible risk of human casualty
4.8-1	Not applicable	No tether mission

2 ODAR Section 1: Program Management and Mission Overview

2.1 Program Management

Program Manager: David Garcia
Mission Manager: Enrique Pacheco

Foreign government or space agency participation: None
Summary of NASA's responsibility under the governing agreement(s): N/A

Schedule of upcoming mission milestones:

- Shipment of Spacecraft: 2nd week of October 2019
- Launch: Window start 2nd week of November 2019

2.2 Mission Summary Description

The overall goal of the SAI-1 mission is to test and operate a prototype spacecraft bus in a space environment, to provide space heritage, and performance feedback for the design.

SAI-1 is a 2U satellite CubeSat with an overall dimension of 10 cm X 10 cm X 20 cm, fully compliant with the CubeSat Design Specification Rev. 13 (California Polytechnic State University). It is intended as a technology demonstrator at LEO for the NanoConnect platform and its subsystems. Also the satellite will carry as payload the Space AI Communications Card (SAI-CC) that is an advanced SDR communications card designed to be used on CubeSats missions. The main purpose is to test the main operational aspects of the card (computing element, sensors, IMU) and the transmission performance using the allocated frequency. The mission is a join effort with ICN-UNAM that is providing the subsystems for the platform, ICN-UNAM will test the platform referred as Nanoconnect-2 as a technology demonstrator. The platform includes a new type of solar cells provided by a USA company.

2.3 Launch Vehicle and Launch Site

The satellite will be delivered to Maverick Space Systems, Inc., that is acting as the Launch Service Provider to Space AI, no later than October 10 and after environmental testing they will deliver no later that October 10 to ISRO to be integrated to the PSLV rocket, the launch site will be on Satish Dhawan Space Center (SDSC) SHAR in Sriharikota, India.

2.4 Launch Date and Mission Duration

The experimental SAI-1 is a free flying mission and is schedule to flight on second week of November on the flight C48. The intended mission duration is 1 year.

2.5 Launch Profile

The flight is schedule according to ISRO schedule for the mission and we will deliver the satellite to them for integration inside a 2U like-PPOD ISRO made container. The PSLV launch vehicle will transport multiple mission payloads to orbit and The SAI-1 spacecraft will be deployed into in a circular LEO orbit of 555KM at 37 degrees. The launch vehicle will determined the moment for the satellite to be dispensed. The SAI-1 spacecraft will be activated based on the deploy switches, this will activate the computer and a safety timer, once the timer reach the end, the satellite will initiate the first set of operations. The satellite will deploy a set of four UHF antennas and will activate the transmitter to indicate it's alive and operational.

Nominal Orbital Altitude: 555 km
Eccentricity: expected to be as close to 0.0000
Inclination: 37°

2.6 Spacecraft Maneuver Capability

The SAI-1 will not have any active device for operational manoeuvres; neither have any kind of propellant. The spacecraft will decay naturally from operational orbits within the stated orbital parameters in a natural orbital decay in less than 3 years.

2.7 Reason for selection of operational orbits

The SAI-1 Mission will fly as a secondary payload on an ISRO flight were the primary payloads belong to other organizations. This is not a primary mission of Space AI. All other portions of the launch vehicle are not the responsibility of Space AI, and is not the lead launch organization. The orbital parameters was provided by the launcher organization, the selection was based purely on the soonest launch opportunity available.

2.8 Identification of interactions

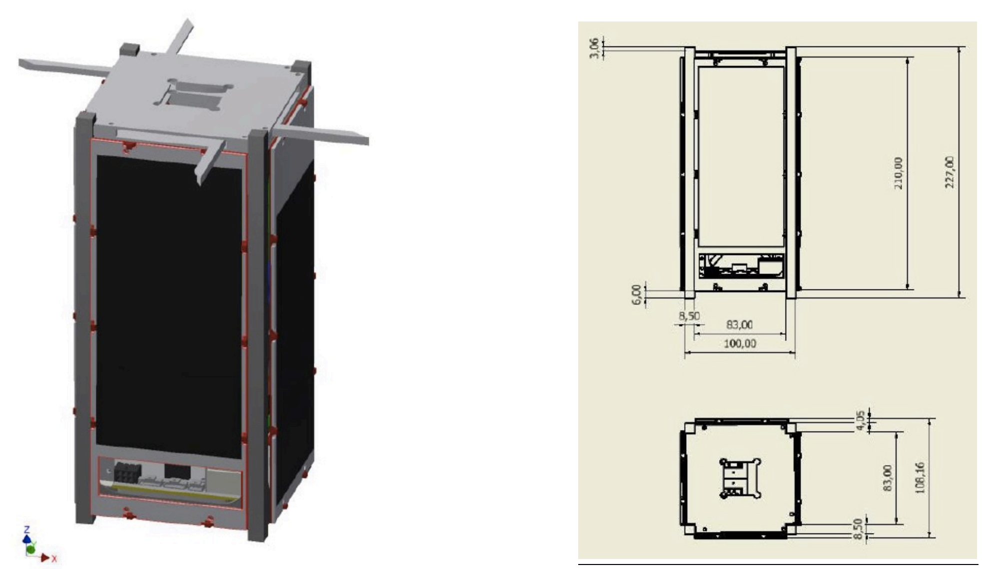
The SAI-1 Mission will not expect to have or produce any physical interference with other operational spacecraft.

3 ODAR Section 2: Spacecraft Description

3.1 SAI – 1 Spacecraft Description

SAI-1 is a 2U satellite CubeSat made giving an overall dimension of 10 cm X 10 cm X 20 cm, fully compliant with the CubeSat Design Specification Rev. 13 (California Polytechnic State University). The platform satellite is based on the NanoConnect system that is a platform developed by the ICN-UNAM and that this will be the first mission, for that will be a technology demonstrator at LEO for the NanoConnect platform and its subsystems. The satellite main mission will be to test the Space AI Communications Card that is an advanced SDR communications card designed to be used on CubeSats missions, also will be attached to a nano capacitor antenna developed by NCap. The only deployable system is the antennas for UHF comms. Figure 1 present the satellite with the antennas deployed and the dimensions on stove configuration. The SAI-1 includes the following subsystems:

1. Lightweight Flexible Gallium Arsenide Solar Cells panels
2. OBC board
3. Housekeeping board
4. COMMS board and deployable comms antennas
5. Battery pack based on: Tenergy 3.7V 2600mAh Lithium-Ion 18650 Flat Top Rechargeable Battery (MH48285) – ISO9001-2000 & UL Certified
7. Attitude determination sensors
8. Thermal architecture validation sensors
9. Space AI Communications Card
10. NCap Nanocapacitor wideband antenna



(a) (b)

Figure 1. SAI-1 – Nanoconnect-2 (a) and dimensions (b)

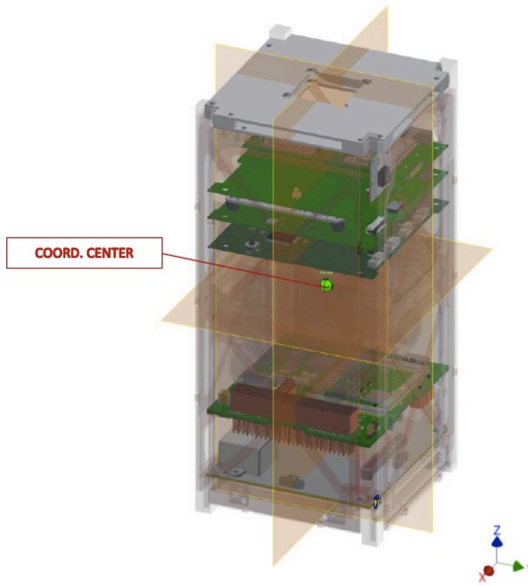


Figure 2. SAI-1 – Nanoconnect-2 internal configuration

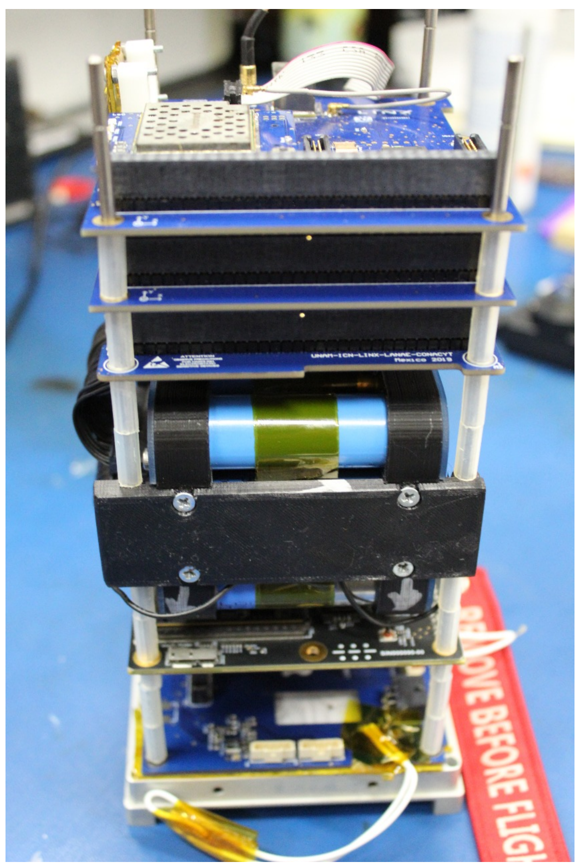


Figure 3. Engineering model of the SAI-1 – Nanoconnect Satellite

3.2 Total satellite mass at launch, including all propellants and fluids.

The table 1 shown the detailed mass description, the satellite does not have any propellant or fluid.

Table1 . Detailed Component Mass Description

Component	Description	Unit	Mass [g]	Sub-total	Total (g)
M1	Structure 2U Aluminum	1	437	437	437
M2	PCB Conectors	1	78	78	78
M3	PCB IOT	1	96	96	96
M4	Battery pack	1	100	100	796
	Battery	12	58	696	
M5	PCB HK	1	57	57	57
M6	PCB OBC	1	91	91	91
M7	PCB Beacon + PCB COMM	1	74	74	74
M8	PCB Flexible SolarPanel	1	75	75	75
M9	PCB Flexible SolarPanel	1	75	75	75
M10	PCB Flexible SolarPanel	1	75	75	75
M11	PCB Flexible SolarPanel	1	75	75	75
M12	Antenna System	1	120	120	120
M13	Cable Conec Batt	1	23	23	21
M14	Cable Batt-HK	1	23	23	23
M15	SAI CC	1	132	132	132
M16	SAI NCap Antenna	1	50	50	50
					2,275

3.3 Dry mass of satellites at launch

2.275 Kg.

3.4 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

The Satellite does not have any fluid (liquid or gas).

3.5 Description of all propulsion systems (cold gas, mono-propellant, bipropellant, electric, nuclear)

The Satellite does not have any propulsion system.

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

The satellite will not have any active or passive attitude control as its know, there is one motor align with axis Z in order to be able to produce a rotational effect on the satellite to improve the solar cells performance.

3.7 Description of any range safety or other pyrotechnic devices.

There is none devices of this type. The spacecraft deploy its antennas using a burn wire system. System power is locked off during launch with a safety mechanism to prevent premature deployment. The antenna spring constants are very low and can be held in place with minum force.

3.8 Description of the electrical generation and storage system.

Battery pack based on: Tenergy 3.7V 2600mAh Lithium-Ion 18650 Flat Top Rechargeable Battery (MH48285) – ISO9001-2000 & UL Certified[1]. The detailed specifications are:
Chemistry: Li-ion
Nominal Voltage (V): 3.7V
Capacity (mAh): 2600
Max Continuous Discharge Current: 5.2A
Weight: 46.5±1 g
Height: 65.2mm
Diameter: 18.4mm
Charge Cut-Off Voltage: 4.20 ± 0.05V
End Voltage: 2.75V
Internal Impedance: ≤ 65mΩ

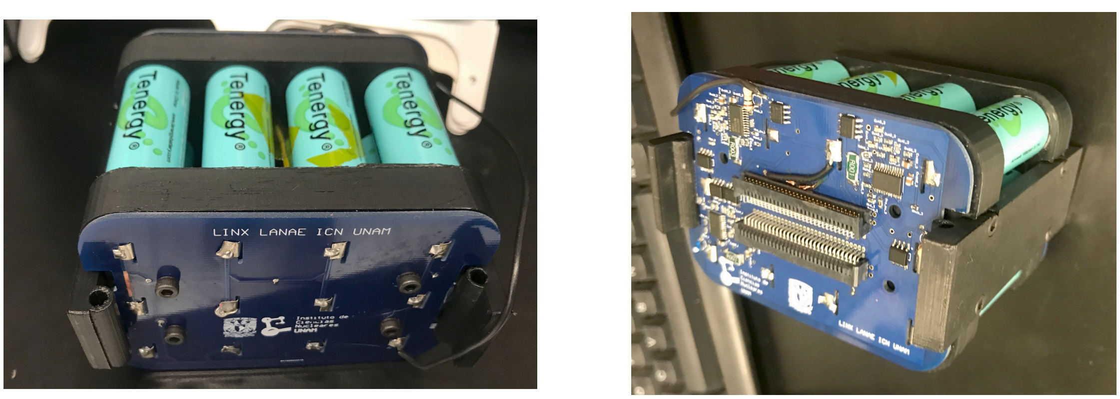


Figure 4. Battery Pack

[1] https://power.tenergy.com/tenergy-li-ion-18650-cylindrical-3-7v-2600mah-flat-top-rechargeable-battery-ul-listed-mh48285/

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

The Satellite does not have any other stored energy source.

3.10 Identification of any hazard or radioactive materials on board.

The primary SAI-1 structure is made of aluminum 6061 anodized. All the boards as been custom made using all standard commercial off the shelf (COTS) materials, electrical components and PCBs. The solar cells are made of Gallium Arsenide mounted over a lightweight flexible panel made of space qualified polimer, are are cover for this same polimer.

There is no pressure vessels, hazardous or exotic materials, including radioactive materials.

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

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

None.

4.2 Rationale/necessity for release of each object.

Non applicable.

4.3 Time of release of each object, relative to launch time.

Non applicable.

4.4 Release velocity of each object with respect to spacecraft.

Non applicable.

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

Non applicable.

4.6 Calculated orbital lifetime of each object, including time spent in LEO.

Non applicable.

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

Assessment of Compliance of 4.3-1a*, All debris released during the deployment, operation, and disposal phases shall be limited to a maximum orbital lifetime of 25 years from date of release:*

COMPLIANT – NO planned debris release in LEO for normal operations.

Assessment of Compliance of 4.3-1b*, The total object-time product shall be no larger than 100 object-years per mission. For the purpose of this standard, satellites smaller than a 1U standard CubeSat are treated as mission-related debris and thus are bound by this definition to collectively follow the same 100 object-years per mission deployment limit:*

COMPLIANT – NO planned debris release in LEO for normal operations

Assessment of Compliance of 4.3-2*, Debris passing near GEO: For missions leaving debris in orbits with the potential of traversing GEO (GEO altitude +/- 200 km and +/- 15 degrees inclination), released debris with diameters of 5 mm or greater shall be left in orbits which will ensure that within 25 years after release the apogee will no longer exceed GEO - 200 km or the perigee will not be lower than GEO + 200 km , and also ensures that the debris is incapable of being perturbed to lie within that GEO +/- 200 km and +/- 15° zone for at least 100 years thereafter. For the purpose of this standard, satellites smaller than a 1U standard CubeSat are treated as mission-related debris and thus are bound by this definition to follow this requirement:*

COMPLIANT – NO planned debris release in near GEO for normal operations

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

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

There are NO plans for designed spacecraft breakups, explosions, or intentional collisions on the SAI-1 mission.

There is only one potential causes of spacecraft breakup during activation after deployment and mission operations caused by a Lithium-ion battery cell failure.

5.2 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. There are 7 possible scenarios of independent, mutually exclusive failure that can lead to an explosion of a Li-On battery cell.[2] :

Failure Scenario 1: Internal short circuit.
Failure Scenario 2: Internal thermal rise due to high load discharge rate.
Failure Scenario 3: Excessive discharge rate or short-circuit due to external device failure or terminal contact with conductors not at battery voltage levels (due to abrasion or inadequate proximity separation).
Failure Scenario 4: Inoperable vents.
Failure Scenario 5: Destruction by collapsing.
Failure Scenario 6: Low level current leakage or short-circuit through battery pack case or due to moisture-based degradation of insulators.
Failure Scenario 7: Excess temperatures due to orbital environment and high discharge combined.

All failure scenarios might result in battery explosion with the possibility of orbital debris generation. However, 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.

[2] Astro Digital Ignis Orbital Debris Assessment Report (ODAR) ASTRO-DIGITAL-IGNIS-ODAR-1.0

The probability is extremely low, given that multiple independent (not common mode) faults must occur for each failure scenario to cause the ultimate effect (explosion). In addition, due the short orbital lifetimes the effect of an explosion on the far-term LEO environment is negligible.

Energy management system and battery system has over-current switch protection, overcurrent bus protection, and battery under and over-voltage protection built into the system in order to mitigate any possibility of failure. In addition and extensive environmental and functional testing for all the circuits, batteries and structural supports involved on this systems has produced a very reliable system.

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

There are NO plans for designed spacecraft breakups, explosions, or intentional collisions on the SAI-1 mission.

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

Twelve (12) Tenergy 3.7V 2600mAh Lithium-Ion Battery cells.

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

The SAI-1 satellite includes the ability to disconnect the batteries from the charging current of the solar arrays. At EOL, this feature can be used to completely passivate the batteries by removing all energy from them. 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, the 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.

Additional even on the extreme case that the batteries cannot be disconnected from the solar panels still meet Req 4.4-2 by virtue of the HQ OSMA policy regarding CubeSat battery disconnect stating;

> *"CubeSats as a satellite class need not disconnect their batteries if flown in LEO with orbital lifetimes less than 25 years."*[3]

[3] Orbital Debris Assessment for The CubeSats on the ELaNa-XIX Mission per NASA-STD 8719.14ª (FCC) Rev C

5.6 Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4.

Assessment of Compliance of 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 (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 launch vehicle does not exceed 0.001 (excluding small particle impacts.).*

COMPLIANT – On board energy source (batteries) incapable of debris producing failure

Assessment of Compliance of 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 and a plan to either 1) deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or postmission disposal or 2) control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft. The design of depletion burns and ventings should minimize the probability of accidental collision with tracked objects in space:*

COMPLIANT – On board energy source (batteries) incapable of debris producing failure

Assessment of Compliance of 4.4-3*, Limiting the long-term risk to other space systems from planned breakups for Earth*

NOT APPLICABLE – No planned breakups

Assessment of Compliance of 4.4-4*, Limiting the short-term risk to other space systems from planned breakups for Earth orbital missions*

NOT APPLICABLE – No planned breakups

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

6.1 Calculation of spacecraft probability of collision with space objects larger than 10 cm in diameter during the orbital lifetime of the spacecraft.

Calculation of spacecraft probability of collision with space objects larger than 10 cm in diameter during the orbital lifetime of the SAI-1 takes into account both the mean cross-sectional area and orbital lifetime.

The largest mean cross-sectional area (CSA) is that of the satellite with the antennas deployed, however the mass and volume on these are so thin and small that will not be able to account as a filling area and for that make a contribution to the cross sectional area. For that, for this calculation we only take the maximum dimensions of the satellite as the largest maximum possible CSA. The minimum value will be taking in account the nominal solid dimensions, according to the following formula values:

The values used and estimated are:

Mean CSA_{max} = [2*(10.8x10.8) + 4*(10.8x22.7)]/4 = 303.48 cm^2

Mean CSA_{min} = [2*(10x10) + 4*(10x20)]/4 = 250.0 cm^2

Mass = 2.275Kg

CSA_{max} = 0.0303 m^2 Ratio-area-to-$mass_{max}$= 0.0133

CAS_{min} = 0.0250 m^2 Ratio-area-to-$mass_{min}$= 0.0109

Probability of $Collision_{max}$ = 0.00000

Probability of $Collision_{min}$ = 0.00000

6.2 Calculation of spacecraft probability of collision with space objects, including orbital debris and meteoroids, of sufficient size to prevent postmission disposal.

There will be no post-mission disposal operation. As such the identification of all systems and components required to accomplish post-mission disposal operation, including passivation and maneuvering, is not applicable. The only action will be to disconnect de batteries from the solar panels, however this will not have an impact on the postmission disposal that must occur for a natural orbit decay.

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

Assessment of Compliance of 4.5-1*, Limiting debris generated by collisions with large objects when 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 does not exceed 0.001. For spacecraft and orbital stages passing through the protected region +/- 200 km and +/-15 degrees of geostationary orbit, the probability of accidental collision with space objects larger than 10 cm in diameter shall not exceed 0.001 when integrated over 100 years from time of launch:*

COMPLIANT – Probability well below 0.001

Assessment of Compliance of 4.5-2*, Limiting debris generated by collisions with small objects when operating in Earth 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 maneuver requirements does not exceed 0.01.:*

NOT APPLICABLE – There is not postmission disposal actions

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

7.1 Description of spacecraft disposal option selected.

The satellite will de-orbit naturally by atmospheric re-entry.

7.2 Identification of all systems or components required to accomplish any postmission disposal maneuvers. Plan for any spacecraft maneuvers required to accomplish postmission disposal.

No actions are required to accomplish postmission disposal.

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

Mass = 2.275Kg
Worst case scenario is with minimal CSA.

$CSA_{min} = 0.025\ m^2$ Ratio-area-to-mass= 0.0109

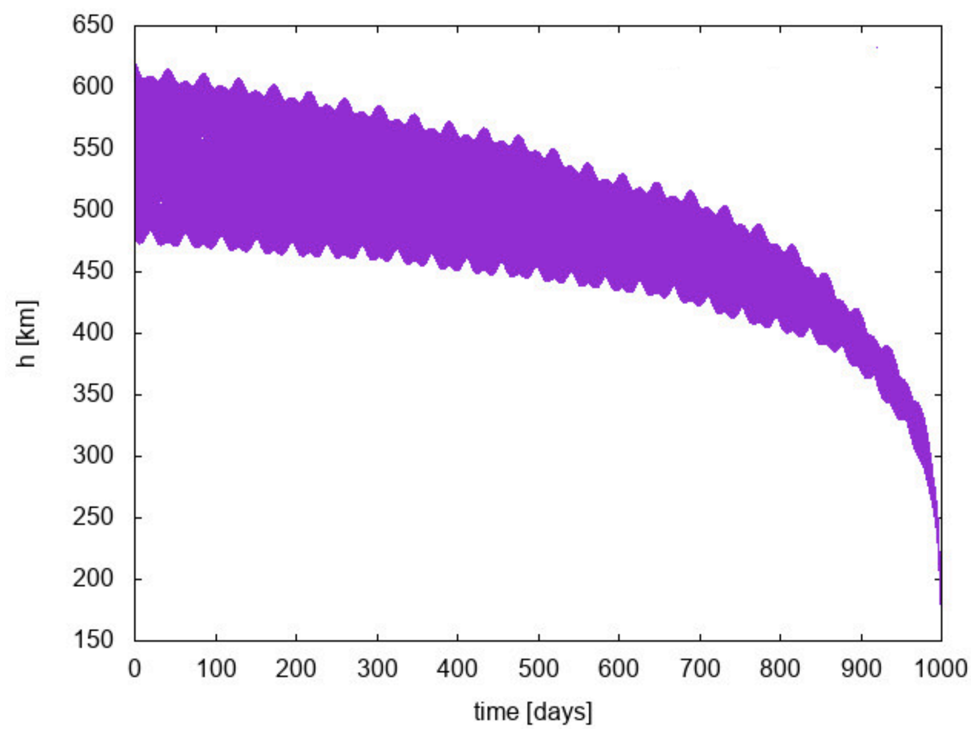


Figure 5. Satellite de-orbit naturally by atmospheric re-entry calculations.

The simulations consider a launch happening in November 10th, 2019, for Agust the 24th, 2022, the satellite will be at 180Km. The estimated orbital life time will be near 3 years.

7.4 If appropriate, preliminary plan for spacecraft controlled reentry.

Non applicable.

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

Assessment of Compliance of 4.6-1 Option (a)*, Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission:*

COMPLIANT – The satellite will re-entry inside the 25 years period.

Assessment of Compliance of 4.6-1 Option (b)*, Storage orbit option: Maneuver the space structure into an orbit with perigee altitude above 2000 km and ensure its apogee altitude will be below 19,700 km, both for a minimum of 100 years:*

NOT APPLICABLE – Option (a) selected

Assessment of Compliance of 4.6-1 Option (c)*, Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission:*

NOT APPLICABLE – Option (a) selected

Assessment of Compliance of 4.6-2*, Disposal for space structures near GEO:*

NOT APPLICABLE – NO GEO ORBIT

Assessment of Compliance of 4.6-3*, Disposal for space structures between LEO and GEO:*

NOT APPLICABLE – NO MEO ORBIT

Assessment of Compliance of 4.6-4*, Reliability of postmission disposal maneuver operations in Earth orbit: NASA space programs and projects shall ensure that all postmission disposal operations to meet Requirements 4.6-1, 4.6-2, and/or 4.6-3 are designed for a probability of success as follows:*

a. Be no less than 0.90 at EOM, and

b. For controlled reentry, the probability of success at the time of reentry burn must be sufficiently high so as not to cause a violation of Requirement 4.7-1 pertaining to limiting the risk of human casualty:

COMPLIANT – The probability will be over the 0.90 at EOM.

8 ODAR Section 7: Assessment of Spacecraft Reentry Hazards.

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

The following steps are suggested to be used to identify and evaluate a components potential reentry risk relative to the 4.7-1 requirement of having less than 15 J of kinetic energy and a 1:10,000 probability of a human casualty in the event the survive reentry.

a) Low melting temperature (less than 1000 °C) components are identified as materials that would never survive reentry and pose no risk to human casualty. This is confirmed through DAS analysis that showed materials with melting temperatures equal to or below that of copper (1080 °C) will always demise upon reentry for any size component up to the dimensions of a 1U CubeSat.
b) The remaining high temperature materials are shown to pose negligible risk to human casualty through a bounding DAS analysis of the highest temperature components, stainless steel (1500°C). If a component is of similar dimensions and has a melting temperature between 1000 °C and 1500°C, it can be expected to posses the same negligible risk as stainless steel components.

Table1 . Highest Melting Point Materials Description

Component	Material	Melt Temperature (° C)[4]	Mass(g)
Antennas	Stainless Steel	1426.85	0.96
Screws	Stainless Steel	1426.85	2
Solar Cells	Gallium Arsenide (GaAs)	1236.85	100

Based on these guidelines, there are no materials capable to survive the re-entry or will not have the dimensions to poses a risk under the parameters of the analysis conducted.

[4] NASA/TP-2016-218600-REV1. Debris Assessment Software User's Guide Version 2.1.

8.2 Assessment of spacecraft compliance with Requirement 4.7-1.

***Assessment of Compliance of 4.7-1**, 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).

COMPLIANT – Well below the 1:10,000 risk

9 ODAR Section 7A: Assessment of Spacecraft Hazardous Materials.

9.1 Summary of the hazardous materials contained on the spacecraft.

There are no hazardous materials on the satellite.

10 ODAR Section 8: Assessment for Tether Missions.

10.1 Type of tether; e.g., momentum or electrodynamics.

None . There are no tethers used on the SAI-1 mission.

10.2 Description of tether system, including at a minimum (1) tether length, diameter, materials, and design (single strand, ribbon, multi-strand mesh), and (2) end-mass size and mass.

Non applicable.

10.3 Determination of minimum size of object that could sever the tether.

Non applicable.

10.4 Tether mission plan, including duration and postmission disposal.

Non applicable.

10.5 Probability of tether colliding with large space objects.

Non applicable.

10.6 Probability of tether being severed during mission or after postmission disposal.

Non applicable.

10.7 Maximum orbital lifetime of a severed tether fragment.

Non applicable.

10.8 Assessment of compliance with Requirement 4.8-1.

***Assessment of Compliance of 4.8-1**, Tethers:*

NOT APPLICABLE – NO Tethers mission

11 REFERENCES.

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[4] Justin Treptow, NASA/KSC/VA-G2. Orbital Debris Assessment for The CubeSats on the ELaNa-XIX Mission per NASA-STD 8719.14ª (FCC) Rev C. ELVL-2017-0044671. February 27, 2018.

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