SIMPL (Satlet Initial Mission Proofs and Lessons) Orbital Debris Assessment Report

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NOVAWURKS, INC.

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SPACE FOR EVERYONE

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V2	11/25/14	Revised Draft for FCC	A.C.S.
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2.0 SELF-ASSESSMENT OF THE ODAR USING THE FORMAT IN THE APPENDIX A.2 OF NASA-STD-8719.14

A self assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STF-8719.14. In the final ODAR document, this assessment will reflect any inputs received from OSMA as well.

Orbital Debris Self-Assessment Report Evaluation: NovaWurks SIMPL

Requirement	Compliance Assessment	Comments
4.3-1a	Compliant	
4.3-1b	Compliant	
4.3-2	Compliant	
4.4-1	Compliant	
4.4-2	Compliant	
4.4-4	Compliant	
4.5-1	Compliant	
4.5-2	Compliant	
4.6-1 (a)	Compliant	
4.6-1 (b)	Compliant	
4.6-1 (c)	Compliant	
4.6-2	Compliant	
4.6-3	Compliant	
4.6-4	Compliant	
4.6-5	Compliant	
4.7-1	Compliant	
4.8-1	Not Applicable	

Table 2-1

ASSESSMENT REPORT FORMAT

ODAR Technical Sections Format Requirements: This ODAR follows the format recommended in NASA-STD-8719.14, Appendix A.1 and includes the content indicated at a minimum in each section 2 through 8 below for the NovaWurks SIMPL (Satlet Initial Mission Proofs and Lessons) satellite. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

3.0 ODAR SECTION 1: PROGRAM MANAGEMENT AND MISSION OVERVIEW

Principal Investigator: Talbot Jaeger

Program Manager: Thomas Sanders

Schedule: NovaWurks will have LEO flight-qualified HISats ready early Q4 2014 with deliveries to integrator in mid-November for testing and integration. The schedule supports a cargo vehicle resupply launch as early as August 2015.

Mission Overview

NovaWurks is planning to demonstrate an on-orbit assembly, ISS deployment, and LEO flight of the NovaWurks Hyper-Integrated Satlet (HISat) system. The proposed research utilizes a cargo vehicle flight to the ISS with at least six HISats and a small interface experiment packaged individually. The ISS crew will assemble the HISats into a package of aggregated cells, also known as a PAC.

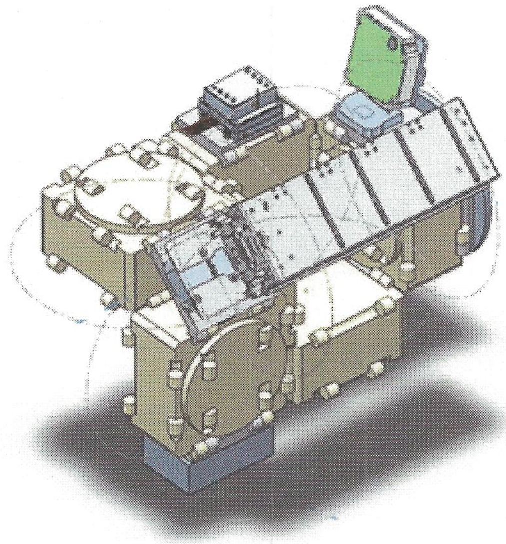

Figure 1 SIMPL – Assembled

After assembly, the PAC will be mounted on the JAXA Multi-Purpose Experiment Platform (MPEP), and placed on the JEM airlock slide table for transfer outside the ISS.

The SIMPL PAC will be deployed from the ISS for free flying operations. An approach similar to prior cubesat deployments will be utilized where a crewmember operates the JEM Remote Manipulating System (JRMS) – to grapple and position the PAC for deployment. As a free flyer, the PAC will conduct experiments for at least two weeks with a goal of maintaining operations through the duration of its orbital lifetime.

The NovaWurks SIMPL will be placed in a near circular orbit of 419 x 411 Km at an inclination of 51.65 degrees. The orbit parameters may change closer to release due to ISS orbit degradation or raising.

Launch Vehicle and Launch Site: Atlas V, Kennedy Space Center – Cape Canaveral, FL

Proposed Launch date: Nov. 19th 2015

Mission Duration: Maximum Nominal Operations: 2 Weeks, Post-Operations Orbit lifetime: 5.45 years until reentry via atmospheric orbital decay. (Estimated)

Launch and Deployment profile:

- Flight Day 1 (Launch): After a 10-minute flight sequence, Atlas V will launch the Cygnus CRS Orb-4 capsule into orbit on the same plane as the space station, but significantly below it. Cygnus will deploy its solar arrays after separation from Atlas V. After a series of checks, ground controllers will command Dragon to begin increasing its altitude. [HISats are soft-packed inside the Cygnus pressurized cargo area.]
- Flight Day 2 & 3: Cygnus will continue to increase its altitude to match that of the space station.
- Flight Day 4: NASA will make a go/no-go decision for Cygnus to berth with the station. Cygnus will first autonomously approach within 12 metres (39 ft) below the space station, where it will stop and hold. Astronauts aboard the station will then command Cygnus to a "free drift" mode, where they will then capture it with the station's robotic arm attached to the station's Nadir node.

- Flight Day 5 to Day 36: ISS Astronauts will open Cygnus hatch, unload the payload and fill it with disposal cargo.
- Flight Day TBD by ISS Crew Schedule: ISS astronauts will assemble the HISats into a PAC which will be mounted on the JAXA Multi-Purpose Experiment Platform (MPEP), and placed on the JEM airlock slide table for transfer outside the ISS.
- Flight Day TBD by JEM airlock Schedule: The SIMPL is transferred to the ISS exterior where a crewmember operates the JEM Remote Manipulating System (JRMS) – to grapple and position the PAC for deployment.
- Flight Day TBD by orbital deployment constraints: The NovaWurks SIMPL will be released into a near circular orbit of 419 x 411 Km at an inclination of 51.65 degrees with deployment occurring in an approach where it will not interact or interfere with the ISS.

4.0 ODAR SECTION 2: SPACECRAFT DESCRIPTION

Physical description of the spacecraft

The assembled PAC conforms to the limitations of the JAXA MPEP occupying a volume no greater than 50 x 50 x 33 cm and weighing approximately 64.3. Kg. Attached to the PAC is a deployable solar panel, two radio units (with one deployable whip antenna) and one camera unit (See Figure 1).

Each HISat has a load bearing aluminum structure approximately 20 x 20 x 10 cm in dimension.

Total spacecraft mass at launch, including all propellants and fluids: 64.3 Kg

Dry mass of spacecraft at launch, excluding solid rocket motor propellants: 60.7 Kg

Description of all propulsion systems:

Each HISat contains an integral propulsion system of thrusters, valves, valve drivers, propellant, and propellant storage. The system is rated for 0-155 PSI service with a non-toxic propellant. All pressurized components are designed to 4x MEOP and according to MIL SPEC 1522A standards. A leak before burst design of each pressurized component ensures that there will be no brittle failures or burst conditions.

The HISat thrusters do not utilize heating elements and will not produce supersonic gas flow in any portion of the system.

HISat Pressure Vessels

Each HISat has two pressure vessels; the Main Outer Housing and the inner cylindrical tank. All pressure vessels consist of an aluminum pressure vessel verified to meet 1552A burst requirements and to exhibit a leak-before-burst failure mode. The safety factor for the outer housing was verified to be 2.6 while the inner cylindrical tank was verified to be 3. The tank is rated for 155 PSIA service with a designed 4x MEOP and 7.5x NOP.

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

The only fluid/propellant used in HISats is the cold gas propellant. The propellant is a commonly used commercial refrigerant which has been accepted by the safety panel for ISS missions. The refrigerant poses no dangerous or hazardous condition for on-orbit and launch operations. It is a clear, colorless liquid and vapor with a faint ethereal odor and is a gas at ambient temperatures with the boiling point below -20°, freezing point above -100°C. It is non-flammable with 100% volatiles and is considered stable.

The total mass of the fluid in the PAC is 3 Kg and the nominal pressure is 87 PSI at room temperature with a service pressure of 0-155 PSI. The fluid is loaded into each HISat before launch and checked for leakage above the specified acceptable level. Moreover, the propellant will vaporize once released from the attitude thrusters in the vacuum conditions of the space environment.

Fluids in Pressurized Batteries: There are no fluids in the pressurized batteries. The PAC uses unpressurized standard COTS Lithium-Ion battery cells.

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

Two active attitude control actuators are available in the PAC. There are cold gas thrusters, previously described, available and five reaction wheels which provide attitude stabilization and directional control. The actuators are supported by a suite of available sensors including sun sensors, star sensors, and gyroscopes. The nominal attitude will allow the PAC to fly in a passively stable orientation as shown in the figure below. Active attitude control will be utilized to point and maintain the PAC in attitudes differing from this passively stable orientation.

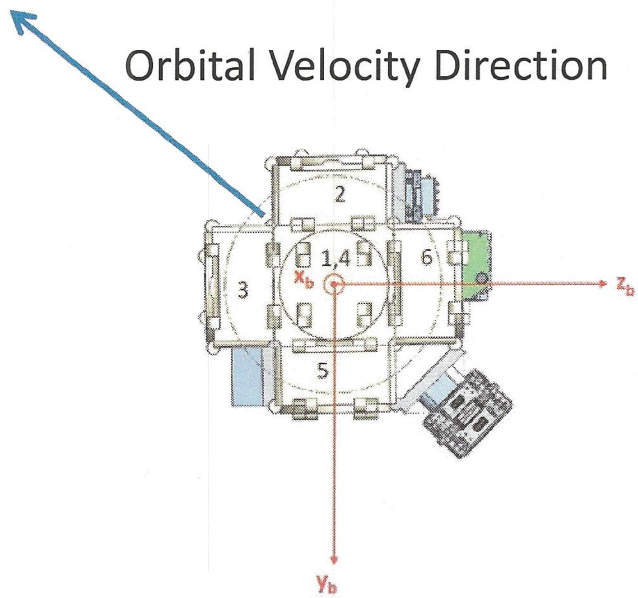

Figure 2 PAC – Passive Orientation

The passive orientation is defined by two unit vectors $[0, \pm\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}]$ relative to the orbital velocity direction. One of the two unit vectors $[0, \pm\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}]$ serves as primary axes pointing to the Sun. The secondary axis is arbitrary.

Description of any range safety or other pyrotechnic devices: There are no pyrotechnic devices used on the PAC. There are two non explosive initiators which are used to deploy a whip antenna and the solar panels. The NEIs are classified as Category B – Non Hazardous as defined in the AFSPCMAN91-710 Section 13.6.6.

Description of the electrical generation and storage system: The PAC uses COTS Lithium-ion battery cells (108 total for the PAC) which are charged before payload integration to provide electrical energy during the mission. The batteries are charged using the mounted solar panels and an internal circuit on each HISat provides distributed power. The energy generated from the solar panels will be distributed into each HISat. The design meets the requirements of AFSPCMAN91-710 sections 19.2.1-19.2.5.

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

Identification of any radioactive materials on board: No radioactive materials on board

5.0 ODAR SECTION 3: ASSESSMENT OF SPACECRAFT DEBRIS RELEASED DURING NORMAL OPERATIONS

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

There are no objects expected to be released from the spacecraft at any time after launch.

Rationale/necessity for release of each object: N/A

Time of release of each object, relative to launch time: N/A

Release velocity of each object with respect to spacecraft: N/A

Expected orbital parameters (apogee, perigee, and inclination) of each object after release: N/A

Calculated orbital life time of each object, including time spent in Low Earth Orbit (LEO): N/A

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2: Compliant

6.0 ODAR SECTION 4: ASSESSMENT OF SPACECRAFT INTENTIONAL BREAKUPS AND POTENTIAL FOR EXPLOSIONS

Potential causes of spacecraft breakup during deployment and mission operations:

There is no credible scenario which would result in the spacecraft to break up in normal deployment and operations.

Summary of failure modes and effects analysis of all credible failure modes which may lead to an accidental explosion:

A malfunction of the HISat battery protection circuit could possibly lead to a short circuit resulting in overheating and a remote possibility of a battery cell explosion. The failure modes and effects analysis is described in the assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4 below.

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

There are no plans for any designed spacecraft breakup in the SIMPL mission.

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

The batteries cells will not be passivated due to the low risk and low impact of explosive rupturing. The maximum total energy stored in each battery is 12 kJ. The pressure vessels will be passivated at EOM by expelling all of the propellants which remain after the mission operations.

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

Each HISat contains built in battery charge circuits which protect the cells from overcharge and also feature parallel configurations to limit the risk of battery failure. If the cells however, do explosively rupture, all of the debris will be contained by the previously described pressure vessels due to the lack of penetration energy.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:

4.4-1 Limiting the Probability of Accidental Explosion

There are a few very low probability failure modes which may theoretically reach a battery explosion condition. The following conditions are listed below:

Short Circuit

Flight batteries undergo extensive acceptance testing from the lot of batteries which are acquired from the vendor. In order to mitigate the possibility of internal short circuits, the cells will be tested through various environmental and functional testing. (Vibration, Shock, Thermal Vacuum)

HISat circuits are designed to be fail-safe in order to prevent the possibility of a short circuit and safety factors in the mechanical designs ensure that the possibility of structural failure is negligible.

Internal thermal rise due to high load discharge rate:

The HISat batteries are thermally managed. Cells are tested in a higher than normal temperature environment to verify any anomalies before launch.

All HISat batteries are contained in a pressure vessel. The risk of explosion from any high pressure/temperature failure scenario is mitigated by the leak before burst design of the tank. Therefore, three failures must occur for a possible explosion scenario. 1) A short circuit 2) Active thermal management malfunction 3) Leak before burst design error.

Excessive discharge or short circuit due to external device failure

HISat battery holders are chamfered to prevent case insulation penetration of the cells. A Chrotherm thermal pad is placed on the top and bottom of each cell to prevent shorting and to provide good thermal conductivity.

Inoperable Vents

No design feature blocks the cell vents.

Crushing

The batteries are not subject to any crushing risk beyond catastrophic HISat crushing from an external source.

Low Level current leakage or short-circuit through battery pack case or due to moisture-based degradation of insulators

There is no moisture present in the cell area due to the presence of the coolant. The coolant does not conduct electricity and has been tested for many hours with the cells with no anomalies.

Excess temperatures due to orbital environment and high discharge combined

The active thermal system maintains operational temperature of the PAC through circulation of the coolant therefore excess temperatures due to orbital environment and high discharge combined do not present an explosion hazard.

In addition to the FMEA, the manufacturer has performed various tests on each cell which did not result in any fire or explosion. Details of these tests are in the charts below.

No.	Items	Test Method and Condition	Criteria
1	Vibration Test	After standard charging, fixed the cell to vibration table and subjected to vibration cycling that the frequency is to be varied at the rate of 1Hz per minute between 10Hz an 55Hz, the excursion of the vibration is 1.6mm. The cell shall be vibrated for 30 minutes per axis of XYZ axes.	No leakage No fire
2	Drop Test	The cell is to be dropped from a height of 1 meter twice onto concrete ground.	No explosion, No fire, no leakage.

Item	Battery Condition	Test Method	Requirements
Crush	Fresh, Fully charged	Crush between two flat plates. Applied force is about 13kN(1.72Mpa) for 30min.	No explosion, No fire
Short Circuit (20℃)	Fresh, Fully charged	Each test sample battery, in turn, is to be short-circuited by connecting the (+) and (-) terminals of the battery with a Cu wire having a maximum resistance load of 0.1 Ω .Tests are to be conducted at room temperature(20±2℃).	No explosion, No fire The Temperature of the surface of the Cells are lower than 150℃
Short Circuit (60℃)	Fresh, Fully charged	Each test sample battery, in turn, is to be short-circuited by connecting the (+) and (-) terminals of the battery with a Cu wire having a maximum resistance load of 0.1 Ω .Tests are to be conducted at temperature(60±2℃).	No explosion, No fire The Temperature of the surface of the Cells are lower than 150℃
Impact	Fresh, Fully charged	A 56mm diameter bar is inlayed into the bottom of a 10kg weight. And the weight is to be dropped from a height of 1m onto a sample battery and then the bar will be across the center of the sample.	No explosion, No fire
Over-Discharged	Fresh, Fully charged	Discharge at a current of 1 C_5A for 2.5h.	No explosion, No fire
Over-charged	Fresh, Fully charged	Charge at a current of 3 C_5A to 10V.	No explosion, No fire

Table 1 Battery Manufacturer Test Results

In addition to the manufacturer tests, NovaWurks has conducted similar tests with the same results from the manufacturer to verify the safety of the cells. To ensure that the spacecraft does not pose a hazard, an extreme case was tested in which the battery pack was short-circuited in the flight configuration. No explosion, fire or leakage was observed due to the passivation strategy integral to the design of the batteries and the spacecraft.

7.0 ODAR SECTION 5: ASSESSMENT OF SPACECRAFT POTENTIAL FOR ON-ORBIT COLLISIONS

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

An analysis was run in NASA DAS for Requirement 4.5-1. The program input required cross sectional area which was calculated from SIMPL's passively stable orientation and the orbit duration determined from the science and engineering tool provided. As shown in the results from the analysis below, the collision probability is 0 or negligible; therefore SIMPL is compliant for this requirement.

03 16 2015; 11:16:58AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = SIMPL
Space Structure Type = Payload
Perigee Altitude = 400.060000 (km)
Apogee Altitude = 407.900000 (km)
Inclination = 51.650000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass Ratio = 0.002637 (m^2/kg)
Start Year = 2015.500000 (yr)
Initial Mass = 64.250000 (kg)
Final Mass = 60.660000 (kg)
Duration = 5.405000 (yr)
Station-Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)
PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

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

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

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

Table 2 DAS Inputs and Outputs for 4.5-1

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

NASA DAS was used to determine the probability of whether collisions with small objects would compromise the spacecraft's ability for de-orbit operations. In the SIMPL mission, delta V maneuvers are not necessary to meet the 25 year de-orbit requirement. However, propellant venting is required for passivation purposes. In order for the propellant venting to malfunction, the internal electronics boards would need to be affected before compromising de-orbit abilities. Two areas of each HISat were analyzed, the carousel top which and the rest of the carousel body which shielded by the outer aluminum housing. The results of the analysis shown below indicate compliance to requirement 4.5-2.

```
==============
Run Data
==============

**INPUT**

        Space Structure Name = SIMPL
        Space Structure Type = Payload
        Perigee Altitude = 400.060000 (km)
        Apogee Altitude = 407.900000 (km)
        Inclination = 51.650000 (deg)
        RAAN = 0.000000 (deg)
        Argument of Perigee = 0.000000 (deg)
        Mean Anomaly = 0.000000 (deg)
        Final Area-To-Mass Ratio = 0.002637 (m^2/kg)
        Start Year = 2015.500000 (yr)
        Initial Mass = 64.250000 (kg)
        Final Mass = 60.660000 (kg)
        Duration = 5.405000 (yr)
        Station-Kept = False
        Abandoned = True
        PMD Perigee Altitude = -1.000000 (km)
        PMD Apogee Altitude = -1.000000 (km)
        PMD Inclination = 0.000000 (deg)
        PMD RAAN = 0.000000 (deg)
        PMD Argument of Perigee = 0.000000 (deg)
        PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

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

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

```
=================================================
Spacecraft = SIMPL
Critical Surface = Carousel Shielded by Housing
=================================================

**INPUT**

        Apogee Altitude = 407.900000 (km)
        Perigee Altitude = 400.060000 (km)
        Orbital Inclination = 51.650000 (deg)
        RAAN = 0.000000 (deg)
        Argument of Perigee = 0.000000 (deg)
        Mean Anomaly = 0.000000 (deg)
        Final Area-To-Mass = 0.002637 (m^2/kg)
        Initial Mass = 60.660000 (kg)
        Final Mass = 60.660000 (kg)
        Station Kept = No
        Start Year = 2015.500000 (yr)
        Duration = 5.405000 (yr)
        Orientation = Random Tumbling
        CS Areal Density = 3.562000 (g/cm^2)
        CS Surface Area = 0.135000 (m^2)
        Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
        CS Pressurized = Yes
        Outer Wall 1   Density: 1.350000 (g/cm^2)  Separation: 1.000000 (cm)

**OUTPUT**

        Probabilty of Penitration = 0.000255
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range
```

Table 3 DAS Inputs and Outputs for 4.5-2

8.0 ODAR SECTION 6: ASSESSMENT OF SPACECRAFT POST-MISSION DISPOSAL PLANS AND PROCEDURES

Description of spacecraft disposal option selected:

The SIMPL disposal strategy is to perform passivation, natural orbital decay, and an uncontrolled re-entry. The SIMPL's orbit will naturally decay within 25 years (~ 5.4 years estimated) after mission operations satisfying requirement 4.6-1a. If any cold-gas propellant remains in the tank at end of operations, it will be vented in fashion were the thrust vectors will cancel and provide no drastic attitude changes. SIMPL will be oriented in a passively stable attitude which requires no systems or components to be active.

All RF communications will be ceased at end of operations. The APRS service and Main TT&C transceiver can be disable upon request. The TT&C transceiver is also in a "speak when spoken to" mode and will not transmit until an authorized encrypted ground command is received.

Passivation will be performed to deplete residual fuel, discharge batteries and disable RF transmissions.

Identification of all systems or components required to accomplish any post mission disposal operation, including passivation and maneuvering:

The cross sectional area of the passively stabilized orientation is estimated to be 0.1752 m^2 and the final mass is 60.7 kg giving us an area to mass ratio of 0.00264 m^2/kg.

Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5

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

Using the area to mass ratio, an orbit lifetime analysis was run using the NASA DAS program. The output of the program is shown in the figure below. SIMPL complies with requirement 4.6-1 selecting the atmospheric reentry option by deorbiting within 5.4 years.

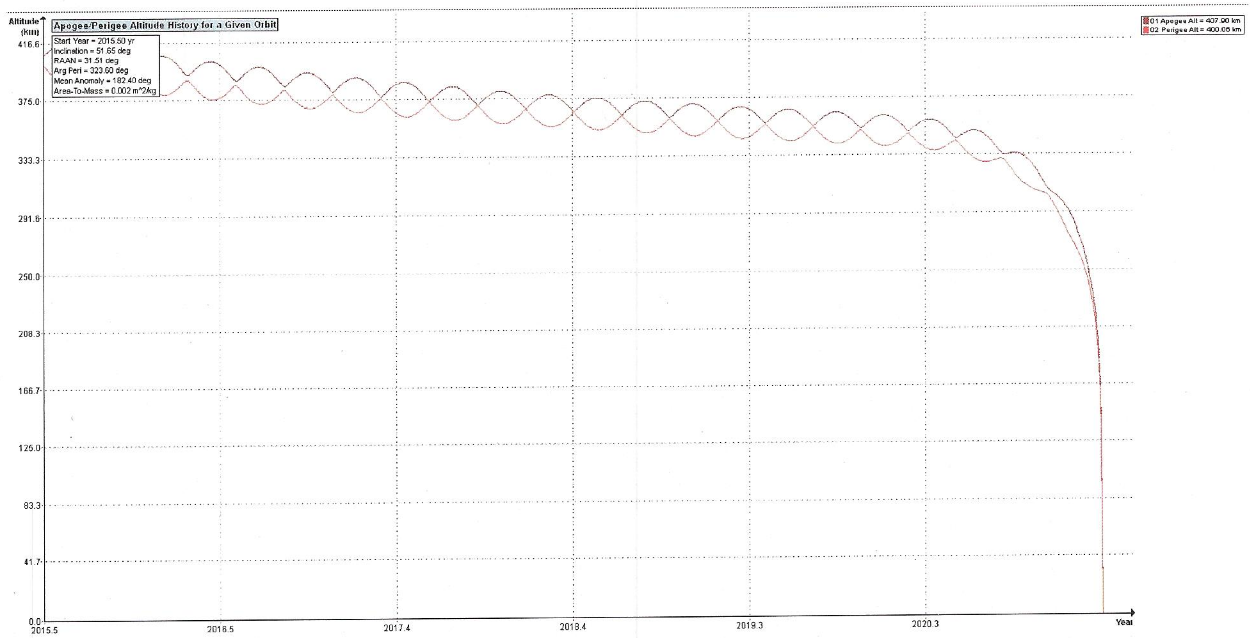

Table 4 DAS Orbit Degradation Chart

Requirements 4.6-2 and -3 are not applicable to SIMPL due to its orbit type.

Requirement 4.6-4 addresses the reliability of post mission disposal operations in Earth orbit. Since the SIMPL orbital lifetime requirement is met without any PAC operations, it is not relevant to reliability predictions.

9.0 ODAR SECTION 7: ASSESSMENT OF SPACECRAFT REENTRY HAZARDS

Requirement 4.7-1a states that for an uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001. (1:10,000) Component information was inputted into NASA DAS as accurately as possible with some values overestimated to provide margin and due to the limitations of the program. Program computations showed that the risk of human casualty from debris was 1:17300 thus satisfying the requirement 4.7-1.

Output

Object Name	Compliance Status	Risk of Human Casualty	SubComponent Object	Demise Altitude (km)	Total Debris Casualty Area ...	Kinetic Energy (J)
SIMPL	Compliant	1:17800			3.30	
			Solar Array	77.0	0.00	0
			Solar Converter	73.5	0.00	0
			Converter Boa...	73.1	0.00	0
			TT&C Antenna	77.0	0.00	0
			Housing 1	73.4	0.00	0

Table 5 DAS Results for Req. 4.7-1

Although the re-entry hazards analysis in DAS shows that SIMPL is compliant with the 1:10,000 requirement, there are few subcomponents where the demise altitude is at 0 Km. The following components are low mass and do not expect to pose a hazard or risk of human casualty.

Copper Pressure Seal – 14 grams with a debris casualty area of 3.3 m^2. Kinetic Energy: 0 J

The copper pressure seal is a thin, hollowed square of non-alloyed pure copper.

Gear – 2 grams with a debris casualty area of 2.23 m^2. Kinetic Energy: 0 J

The gears are cylindrical and utilized for propellant pumps internal to the spacecraft. They are constructed of silicon carbide.

Magnets – 5 grams with a 0 m^2 debris casualty area. Kinetic Energy: 0 J

Magnets are used in the stator portion of the reaction wheel motor. Each magnet is constructed from neodymium alloys.

Motor Frame –: 363 grams with a debris casualty area of 3.39 m^2, Kinetic Energy: 119 J

The motor frame is the stator portion of the reaction wheel motor and is constructed from steel.

Higher fidelity analysis will be performed to ensure that the motor frame which imparts kinetic energy upon impact will not pose a hazard.

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

name = SIMPL
Demise Altitude = 77.997457
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Solar Array
Demise Altitude = 76.956371
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Solar Converter
Demise Altitude = 73.532863
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Converter Board
Demise Altitude = 73.141683
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = TTC Antenna
Demise Altitude = 77.005918
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Housing 1
Demise Altitude = 73.430918
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************************************
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Demise Altitude = 71.520878
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name = Baseband board
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name = Lid
Demise Altitude = 76.429847
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name = Batteries
Demise Altitude = 71.691878
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name = Avionics
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name = Screws
Demise Altitude = 75.673488
Debris Casualty Area = 0.000000
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name = Valve
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name = Connector
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name = Battery Mount
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name = Bearings
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name = Motor Frame
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Demise Altitude = 0.000000
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name = Pumps
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name = Gear1
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name = Screws Type 4
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name = Radio #1 Plate
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name = Radio #2 Plate
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name = Radio #2 Housing
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name = Board 1
Demise Altitude = 73.544871
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name = Board 2
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Impact Kinetic Energy = 0.000000

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name = Board 3
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************************************
name = Antenna
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name = Board 4
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============== End of Requirement 4.7-1
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Table 6 DAS Inputs and Outputs for Req. 4.7-1

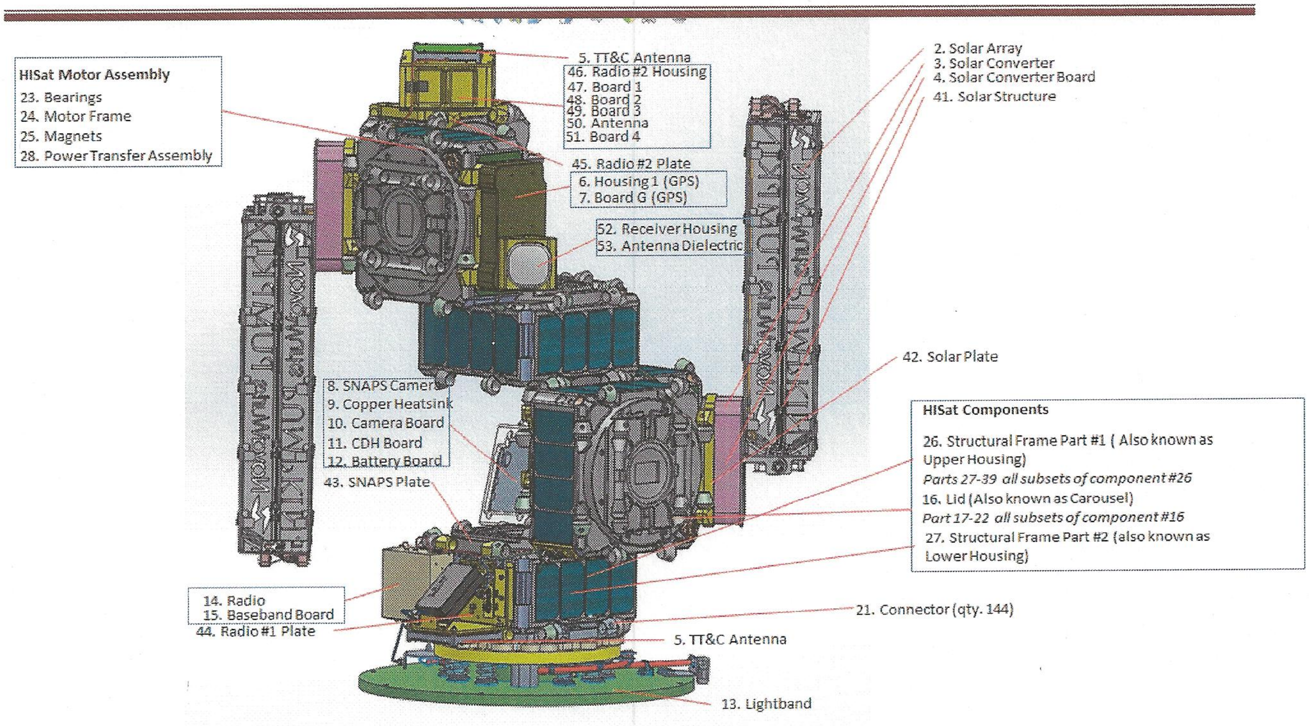

Figure 3 DAS Component Locations

10.0 ODAR SECTION 8: ASSESSMENT FOR TETHER MISSIONS

SIMPL does not have any Tether subsystems or Tethering capability, therefore this section is not applicable.

11.0 ACRONYMS AND ABBREVIATIONS

ADCS	Attitude Determination and Control subsystem
AFSPCMAN	Air Force Space Command Manual
COTS	Commercial Off The Shelf
DAS	Debris Assessment Software
Delta-V	delta velocity
EPS	Electric Power System
FMEA	Failure Modes Effects Analysis
LEO	Low Earth Orbit
LV	Launch Vehicle
MEOP	Maximum Expected Operating Pressure
NEI	Non-Explosive Initiator
NOP	Normal Operating Pressure
PACS	Package of Aggregated Cellular Satlets

S/C	Spacecraft
SIMPL	Satlet Initial Mission Proofs and Lessons
SGLS	Space-Ground link system
TBC	To Be Coordinated
TBD	To Be Determined
UDA	User Defined Adapter