Exhibit A – SSE GNOMES-4 Orbital Debris Assessment Report (ODAR)

GNOMES-4 ODAR

This report is presented as compliance with NASA-STD-8719.14 Revision C

DAS Software Version: v.3.2.2

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

Requirement #	*Launch Vehicle*				*Spacecraft*			*Comments*
	Compliant	Not Compliant	Incomplete	Standard Non-Compliant	Compliant	Not Compliant	Incomplete	
4.3-1.a	☐	☐	✓	☐	✓	☐	☐	No debris released in LEO
4.3-1.b	☐	☐	✓	☐	✓	☐	☐	No debris released in LEO
4.3-2	☐	☐	✓	☐	✓	☐	☐	No debris released near GEO
4.4-1	☐	☐	✓	☐	✓	☐	☐	
4.4-2	☐	☐	✓	☐	✓	☐	☐	
4.4-3	☐	☐	✓	☐	✓	☐	☐	No planned breakups
4.4-4	☐	☐	✓	☐	✓	☐	☐	No planned breakups
4.5-1	☐	☐	✓	☐	✓	☐	☐	
4.5-2	☐	☐	✓	☐	✓	☐	☐	
4.6-1.a	☐	☐	✓	☐	✓	☐	☐	
4.6-1.b	☐	☐	✓	☐	✓	☐	☐	Planned atmos. reentry
4.6-1.c	☐	☐	✓	☐	✓	☐	☐	No planned retrieval
4.6-2	☐	☐	✓	☐	✓	☐	☐	LEO orbit only
4.6-3	☐	☐	✓	☐	✓	☐	☐	LEO orbit only
4.6-4	☐	☐	✓	☐	✓	☐	☐	
4.7-1	☐	☐	✓	☐	✓	☐	☐	
4.8-1	☐	☐	✓	☐	✓	☐	☐	No tethers used

Space Sciences & Engineering LLC is a U.S.-based company. This ODAR follows the format recommended in NASA-STD-8719.14 Revision C and includes the content indicated in each Section 2 through 8. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

Table of Contents

1 ODAR Section 1: Program Management and Mission Overview

Project manager: Space Sciences and Engineering LLC, d/b/a PlanetiQ

Foreign government or space agency participation: No foreign government or space agency participation is anticipated.

Schedule of upcoming mission milestones:

Shipment to SpaceX: September 2023
Launch: October 2023

Mission overview: This ODAR applies to the to the GNOMES-4 satellite. GNOMES-4 is a remote sensing satellite that capture GNSS signals to remotely sense the atmosphere. GNOMES-4 is scheduled to be launched to an altitude between 505 and 545 km.

The GNOMES-4 micro-satellite bus is a three-axis controlled spacecraft that uses reaction wheels, magnetic torque rods, star trackers, magnetometers, sun sensors, and gyroscopes to enable precision 3-axis pointing. The satellite also has an electric propulsion system with approximately 400 m/s of ΔV for orbit maintenance, phasing, and de-orbit acceleration.

The GNOMES-4 spacecraft is technically equivalent to the following previously authorized satellites: GNOMES-1[1], GNOMES-2,[2] and GNOMES-3.[3] This ODAR uses the worst-case deployment orbit, 545 km, for all scenarios and analyses below.

ODAR summary: There is no debris released in normal operations; there is no credible scenario for breakups; the collision probability with other objects is compliant with NASA standards; the estimated nominal lifetime from launch to re-entry is less than 6 years at the nominal operational altitude; and the estimated lifetime if GNOMES-4 arrives dead-on-arrival at the maximum insertion orbit of 545 km circular is approximately 4.1 years.

Launch vehicle and launch site: *Falcon 9,* Cape Canaveral Space Force Station, Florida, U.S.A.

Proposed launch date: October 2023

Mission duration: Nominal lifetime of 5 years. Maximum orbit lifetime is less than 6 years by reentry from natural decay at 545 km.

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination: The GNOMES-4 satellite will deploy from the launch vehicle into a low-Earth orbit with 525 km +/-20 km altitude. The nominal operational altitude is 525 km.

Insertion and Operating Parameters:

[1] *See* Grant, ELS File No. 0011-EX-CN-2019 (granted February 19, 2020).
[2] *See* Grant, ELS File No. 0504-EX-CN-2020 (granted November 6, 2020).
[3] *See* Grant, ELS File No. 0734-EX-CN-2021 (granted March 2, 2022).

LTAN / LTDN: To be defined by SpaceX Transporter-9
Nominal insertion orbital altitude: 505 to 545 km circular
Nominal insertion inclination: 97-98 degrees
Nominal operating orbital altitude: 430-545 km
Nominal operating inclination: Sun-synchronous inclination, 97.6 degrees (+/- 0.5 degrees)

GNOMES- 4 will operate at or below its injection altitude for the mission duration. The spacecraft orbit will be allowed to naturally decay until the orbit altitude reaches 430 km. At this point, the orbit altitude will be maintained at 430 km for the remainder of the operational life of the spacecraft by periodically orbit raising to keep the orbit altitude at 430 km circular. The passive deorbit time for the GNOMES-4 spacecraft in its deployed configuration from an orbit altitude of 430 km circular is ~0.5 years. Therefore, this approach ensures that the orbital life of GNOMES-4 will not exceed 6 years. PlanetiQ will make any necessary change to inclination of GNOMES-4 for operations at 430-545 km SSO.

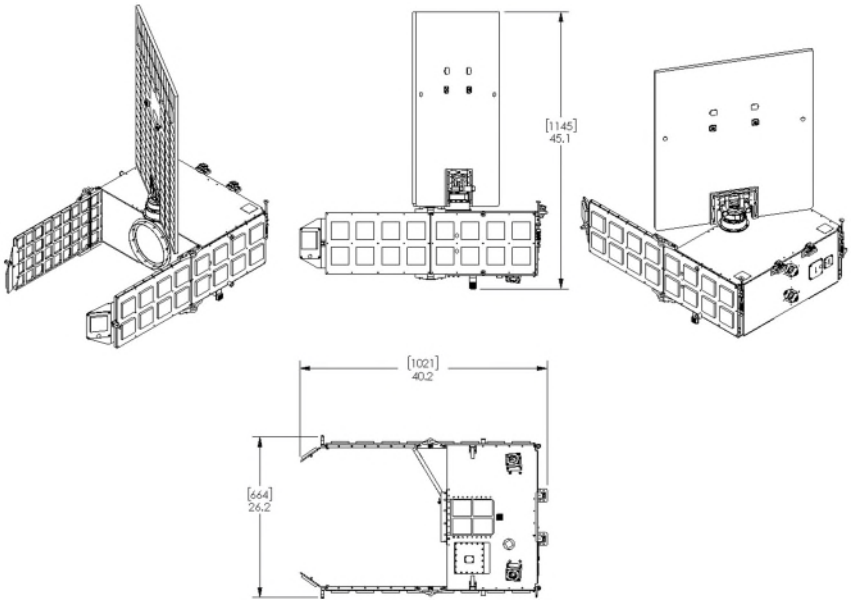
Reason for selection of operational orbit(s): The operational orbit was chosen to optimize measurement of the different atmospheric layers, while allowing frequent opportunities for ground station communication and ensuring total orbital lifetime will not exceed 6 years.

Identification of any interaction or potential physical interference with other operational spacecraft: None.

2 ODAR Section 2: Spacecraft Description

Physical description of the spacecraft: GNOMES-4 is a microsatellite, with a launch mass of approximately 41.7 kg and reentry mass of 41.5 kg. The stowed configuration of the satellite fits within a 50 cm x 66.4 cm x 83.5 cm volume envelope. After separation from the launch vehicle, the GNOMES-4 solar panel and science antennas deploy.

Detailed illustration of the entire spacecraft in the mission operation configuration with clear overall dimensional markings:



Total spacecraft mass at launch, including all propellants and fluids: 41.7 kg

Dry mass of spacecraft at launch, excluding solid rocket motor propellants: 41.5 kg

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear): The propulsion system consists of a single Enpulsion Nano R3 thruster module. The Nano R3 is a Field-Emission Electric Propulsion (FEEP) thruster using indium as its fuel source. The indium is unpressurized and is in its solid state when the system is unpowered (the melting point of indium is 156ºC). The system has flown on satellites since 2018 and produces a total thrust of 0.4 milli-newtons.

Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes: None.

Description of all fluid systems, including size, type, and qualifications of fluid containers such as propellant and pressurization tanks, including pressurized batteries: None. The indium fuel is in a solid state until on orbit and unpressurized. The batteries are standard commercial-off-the-shelf ("COTS"), unpressurized lithium-ion battery cells.

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 principal source of internal kinetic energy is the combination of the three reaction wheels. There are no credible failure scenarios in which this rotational kinetic energy could become sufficient to fragment the spacecraft.

The velocity vector will be normal to the plane of the two science antennas during science operations and communication with the ground stations. While in propulsion mode, the velocity vector will be normal to the (nominally) zenith deck.

Description of any range safety or other pyrotechnic devices: Two split spool Hold Down and Release Mechanisms (HDRMs) are used for the deployment mechanism for the solar panel. The HDRMs are non-pyrotechnic burn wires, and no debris will be released.

Description of the electrical generation and storage system: The spacecraft contains a 24-cell lithium-ion battery with three strings of eight cells each, for a voltage range of 26-33V and capacity of 10.2 A-hr. Each string is packaged individually with 8 cells held in an aluminum bracket. The LG 18650-MJ1 cells are not pressure vessels.

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

Identification of any radioactive materials onboard or made a positive statement that there are no radioactive materials onboard: No radioactive material is onboard the GNOMES-4 spacecraft.

Spacecraft operating in low-Earth orbit will be presumed trackable if each individual spacecraft is 10 cm or larger in its smallest dimension, excluding deployable components: The spacecraft will be in low-Earth orbit and has a smallest dimension measuring at least 10 cm. Thus, it is trackable.

How the operator plans to identify the spacecraft following deployment and whether spacecraft tracking will be active or passive:
Spacecraft tracking will be active. Prior to deployment an initial ephemeris is produced by the launch service that will be used to schedule a contact time window with the ground station. The accuracy of the ephemeris will depend on the launch vehicle's performance, delays, and deployment times. A more accurate ephemeris will be made available shortly after deployment. After deployment when the satellite establishes contact with the nearest available contracted ground station, active satellite tracking will be employed to enhance and maintain satellite ephemeris data. The collected data will be used to identify the spacecraft from two-line element sets once they become available by the 18th Space Control Squadron.

Whether, prior to deployment, the spacecraft will be registered with the 18th Space Control Squadron or successor entity:
Prior to deployment, the spacecraft will be registered with the 18th Space Control Squadron via their Satellite Registration Form and Space Situational Awareness (SSA) Sharing Agreement.

The extent to which the spacecraft operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators:
PlanetiQ intends to provide the 18th Space Control Squadron information regarding initial deployment, owner/operator (O/O) ephemeris, and planned maneuvers. This is intended to provide better space situational awareness and improve the accuracy of conjunction analysis (CA). The higher accuracy O/O ephemeris will improve the quality of the CA and reduce the frequency of Conjunction Data Messages (CDMs). PlanetiQ intends to share ephemeris with other operators on an as-needed basis.

Planned Proximity Operations
No planned proximity operations.

3 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: PlanetiQ has assessed the potential for any amount of debris to be released into the space environment under normal satellite operations, and has taken all possible spacecraft hardware design and operational planning measures to minimize the possibility of any such orbital debris. There are no planned intentional releases of objects from the GNOMES-4 spacecraft during any mission phase, including deployment, operations, and disposal. The GNOMES-4 spacecraft design does not incorporate any shrouds or covers to be removed upon deployment, and no shrapnel will be generated as a result of the deployment of the science antennas or solar array. GNOMES-4 spacecraft will utilize a Lightband separation system developed by Planetary Systems Corp that uses non-explosive actuators and retains all of the separation hardware.

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

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

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

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

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

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

Requirement 4.3-1. Debris passing through LEO: For missions leaving debris in orbits passing though LEO, released debris with diameters of 1 mm or larger shall satisfy both Requirement 4.3-1a and Requirement 4.3-1b: a. 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. b. The total object-time product shall be no larger than 100 object-years per mission. The object-time product is the sum of all debris of the total time spent below 2000 km altitude during the orbital lifetime of each object.
Compliance Statement: COMPLIANT There are no intentional releases.

Requirement 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 latitude), released

debris with diameters of 5 cm 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.
Compliance Statement: COMPLIANT No released debris.

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

Identification of all potential causes of spacecraft breakup during deployment and mission operations: There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.

Summary of failure modes and effects analyses of all credible failure modes which may lead to an accidental explosion: The probability of accidental explosion on orbit, either during normal operations or during end-of-life disposal, is minimal for the GNOMES-4 spacecraft. All components involved in the retention and control of energy sources are space-qualified, and energy sources will be managed autonomously, minimized, or depleted upon Earth re-entry.

In-mission 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. The battery safety systems discussed in the FMEA (see requirement 4.4-1 below) describe the combined faults that must occur for any of seven independent, mutually exclusive failure modes to lead to explosion.

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

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

- **Reaction Wheels** – reaction wheels will be spun down
- **Batteries** – batteries will not be passivated due to the low risk and low impact of a cell or cells rupturing and the extremely short lifetime at EOM.

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

The GNOMES-4 satellite battery charge circuits include overcharge protection and a parallel design to limit the risk of battery failure. 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, debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

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

Requirement 4.4-1. Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon: For each

spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts).
Compliance Statement: COMPLIANT Expected probability: 0.000

Supporting Rationale and FMEA details:

Battery Explosion:

Effect: All failure modes below 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 the selected COTS batteries is such that while the spacecraft could be expected to vent gases, debris from the battery rupture should be contained within the spacecraft due to the lack of penetration energy.

Probability: Extremely low. It is believed to be less than 0.1% probability that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

Failure mode 1: Internal short circuit.

Mitigation 1: Qualification and acceptance shock, vibration, thermal cycling, and vacuum tests followed by maximum system rate-limited charge and discharge to prove that no internal short circuit sensitivity exists.

Combined faults required for realized failure: Environmental testing AND functional charge/discharge tests must both be ineffective in discovery of the failure mode.

Failure mode 2: Internal thermal rise due to high load discharge rate.

Mitigation 2: Cells were tested in lab for high load discharge rates in a variety of flight-like configurations to determine likelihood and impact of an out-of-control thermal rise in the cell. Cells were also tested in a hot environment to test the upper limit of the cell's capability. No failures were seen.

Combined faults required for realized failure: Spacecraft thermal design must be incorrect AND external over-current detection and disconnect function must fail to enable this failure mode.

Failure mode 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).

Mitigation 3: This failure mode is negated by: a) qualification-tested short circuit protection on each external circuit, b) design of battery packs and insulators such that no contact with nearby board traces is possible without being caused by some other mechanical failure, c) obviation of

such other mechanical failures by proto-qualification and acceptance environmental tests (shock, vibration, thermal cycling, and thermal-vacuum tests).

Combined faults required for realized failure: An external load must fail/short-circuit AND external over-current detection and disconnect function failure must all occur to enable this failure mode.

Failure mode 4: Inoperable vents.

Mitigation 4: Battery vents are not inhibited by the battery holder design or the spacecraft.

Combined faults required for realized failure: The final assembler fails to install proper venting.

Failure mode 5: Crushing.

Mitigation 5: This mode is negated by spacecraft design. There are no moving parts in the proximity of the batteries.

Combined faults required for realized failure: A catastrophic failure must occur in an external system AND the failure must cause a collision sufficient to crush the batteries leading to an internal short circuit AND the satellite must be in a naturally sustained orbit at the time the crushing occurs.

Failure mode 6: Low level current leakage or short-circuit through battery pack case or due to moisture-based degradation of insulators.

Mitigation 6: These modes are negated by: a) battery holder/case design made of non-conductive plastic, and b) operation in vacuum such that no moisture can affect insulators.

Combined faults required for realized failure: Abrasion or piercing failure of circuit board coating or wire insulators AND dislocation of battery packs AND failure of battery terminal insulators AND failure to detect such failure modes in environmental tests must occur to result in this failure mode.

Failure mode 7: Excess temperatures due to orbital environment and high discharge combined.

Mitigation 7: The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that batteries do not exceed normal allowable operating temperatures under a variety of modeled cases, including worst case orbital scenarios. Analysis shows these temperatures to be well below temperatures of concern for explosions.

Combined faults required for realized failure: Thermal analysis AND thermal design AND mission simulations in thermal-vacuum chamber testing AND over-current monitoring and control must all fail for this failure mode to occur.

Requirement 4.4-2. Design for passivation after completion of mission operations while in orbit about the Earth or the Moon: Design of all spacecraft and launch vehicle orbital stages shall include the ability and a plan to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission

operations or post mission disposal or control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft.
Compliance Statement: COMPLIANT Momentum wheels will be spun down and power removed at end of operational life. Batteries will not be passivated due to the low risk and low impact of a cell or cells rupturing and the extremely short lifetime at EOM. 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, debris from the battery rupture should be contained within the spacecraft due to the lack of penetration energy to the multiple enclosures surrounding the batteries.

Requirement 4.4-3. Limiting the long-term risk to other space systems from planned breakups: Planned explosions or intentional collisions shall: a. Be conducted at an altitude such that for orbital debris fragments larger than 10 cm the object-time product does not exceed 100 object-years. For example, if the debris fragments greater than 10 cm decay in the maximum allowed 1 year, a maximum of 100 such fragments can be generated by the breakup. b. Not generate debris larger than 1 mm that shall remain in Earth orbit longer than one year.
Compliance Statement: COMPLIANT There are no planned breakups.

Requirement 4.4-4. Limiting the short-term risk to other space systems from planned breakups: Immediately before a planned explosion or intentional collision, the probability of debris, orbital or ballistic, larger than 1 mm colliding with any operating spacecraft within 24 hours of the breakup shall be verified to not exceed 10^{-6}.
Compliance Statement: COMPLIANT There are no planned breakups.

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

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, including orbital debris and meteoroids, of sufficient size to prevent post mission disposal: Because catastrophic collisions during orbital lifetime represent a direct source of debris in the space environment, PlanetiQ addresses the probability of a physical collision with large objects (>10 centimeters) in LEO, which includes other operational satellites, spent hardware, and space debris. To assess the likelihood of a collision with objects large enough to render GNOMES-4 as a source of debris over its lifetime, PlanetiQ used the DAS v.3.2.2 tool for analysis (see Section 9 for software output).

Assessment of spacecraft compliance with Requirement 4.5-1:

Requirement 4.5-1. Limiting debris generated by collisions with large objects when operating in Earth orbit: For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001.
Compliance Statement: COMPLIANT Large object impact and debris generation probabilities at: *Worst-case EOL scenario*: The worst-case scenario is the insertion of GNOMES-4 DOA at 545 km SSO. At this orbit, GNOMES-4 will naturally decay in approximately 4.1 years. The probability of accidental collision with space objects larger than 10 cm in diameter in this scenario is: 6.4976E-06

Detailed description and assessment of efficacy of any planned debris avoidance capability intended to help in meeting requirement 4.5-1

There is no significant risk of collision based on orbital parameters, propulsion capability and a backup ability to employ differential drag. The GNOMES-4 spacecraft has a propulsion system which will be the primary means to support collision avoidance.

In the case of a failure of the propulsion system, differential drag can also be employed. Studies by Planet Labs PBC and other companies have shown that differential drag can be an effective collision avoidance technique. PlanetiQ has a signed sharing SSA agreement between with The Department of Defense of the United States of America (U.S. DoD), through United States Space Command (USSPACECOM). PlanetiQ will register the GNOMES-4 spacecraft with the US Space Force's 18th Space Control Squadron, which provides active monitoring in conjunction with the Combined Space Operations Center.

In addition to working with the 18th Space Control Squadron, PlanetiQ has contracted SpaceNav to support collision avoidance. SpaceNav's technology leverages the Google Cloud Platform computing environment for data management and data processing. The system is fully redundant with two completely independent strings of data processing. There is no restriction on the number of satellites for mission users on the site. Output products from the system is automatically delivered to mission stakeholders. The standard product set consists of the following: orbit determination reports and state solutions, alert text messages, Q/A reports, CA Summary Reports, and Maneuver Planning Reports.

If at any time during the spacecraft's mission or de-orbit phase the spacecraft will operate in or transit through the orbits used by any planned or inhabitable spacecraft, including the International Space Station, describe the design and operational strategies, such as coordination, that will be used to minimize the risk of collision and avoid posing any operational constraints to the spacecraft

At the end of the satellite's operational life, PlanetiQ will employ the remaining propellant to lower the orbit altitude a minimize the orbital lifetime. Under normal operating conditions, the GNOMES-4 spacecraft will be able to be actively deorbited below the ISS.

Certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary

PlanetiQ certifies that upon receipt of a space situational awareness conjunction warning, it will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. Those mitigation measures are discussed in the section above.

Assessment of spacecraft compliance with Requirement 4.5-2:

Requirement 4.5-2. Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit: For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post mission disposal requirements is less than 0.01.
Compliance Statement: COMPLIANT The GNOMES-4 spacecraft does not have any subsystems required for a post-mission disposal maneuver in order to meet the deorbit requirement. However, PlanetiQ does intend to conduct a PMD maneuver at the end of operational life, if possible, to further expedite deorbit times.

To manage the risk of collision with small objects, the GNOMES-4 spacecraft has been designed to be tolerant of small-particle impacts, with particular care to minimize the vulnerability of critical systems. Vital components, such as the communications radios, propulsion system, and payload components are provided with physical protection in the velocity direction by the satellite bus structure and science antenna panels with minimal external exposure. These protective layers serve as shielding that will either prevent small debris and meteoroids from reaching critical components or break up incoming particles prior to penetrating to the satellite's interior.

During orbital maneuvers using the propulsion system, each satellite will orient itself to provide propulsion in either the velocity or cross-track directions. In these orientations, the vital spacecraft components are still protected by the external structure and should not pose any higher risk of collision than the nominal orientation.

In summary, the GNOMES-4 orbit exhibits a low probability of impact for debris larger than one centimeter. Protective design measures are taken to reduce the risk of catastrophic failure due to impacts with debris smaller than one centimeter.

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

Description of spacecraft disposal option selected: GNOMES- 4 will operate at or below its injection altitude for the mission duration. GNOMES spacecraft orbits will be allowed to naturally decay until the orbit altitude reaches 430 km. At this point, the orbit altitude will be maintained at 430 km for the remainder of the operational life of the spacecraft by periodically orbit raising to keep the orbit altitude at 430 km circular. After completion of its mission, the GNOMES-4 spacecraft orbit will be circularly reduced below ISS (approximately 400x400km) then the perigee would be lowered to approximately 300 km, before control authority is lost.

Identification of all systems or components required to accomplish any post mission disposal operation, including passivation and maneuvering: The GNOMES satellites do not have any subsystems required for a post-mission disposal maneuver in order to meet de-orbit requirements. However, PlanetiQ does intend to conduct a PMD at the end of mission life, if possible, to further expedite de-orbit times.

Plan for any spacecraft maneuvers required to accomplish post mission disposal: As discussed above, the GNOMES-4 spacecraft does not have any subsystems required for a post-mission disposal maneuver in order to meet de-orbit requirements. However, PlanetiQ does intend to conduct a PMD at the end of mission life, if possible, to further expedite de-orbit times. After completion of its mission, the GNOMES-4 spacecraft orbit will be circularly reduced below ISS (around 400x400 km) then the perigee would be lowered to approximately 300 km, before control authority is lost. This approach allows for de-orbit operations to complete in less than two months. A quick descent reduces the likelihood of interference with other objects in similar orbits.

Sufficient fuel will be budgeted on the GNOMES-4 spacecraft to perform maneuvers to accelerate disposal. The Enpulsion propulsion system uses a single FEEP thruster and an indium-based fuel with an Isp of 4200 seconds for the de-orbit phase of the mission. Thus, from the rocket equation[4], the minimum necessary disposal reserve for each 41.7 kg satellite is 0.09 kg.

Fuel levels will be closely monitored throughout the mission to ensure sufficient fuel remains for deorbit operations. With conservative thruster propellant loading of 0.2125 kg, there should be sufficient indium fuel on-board the GNOMES-4 spacecraft for orbital placement, station keeping, maneuvering, collision avoidance, and end-of-life disposal.

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

Spacecraft mass: 41.7 kg (launch mass)
Average cross-sectional area: 0.652 m^2
Area to mass ratio: 0.015635 m^2/kg

If appropriate, preliminary plan for spacecraft-controlled reentry: N/A

Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-4:

Requirement 4.6-1. Disposal for space structures in or passing through LEO: A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of the following three methods:

a. Atmospheric reentry option:
   - Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or

[4] $\Delta v = Isp \cdot g \cdot \ln\left(\frac{M_{total}}{M_{dry}}\right)$

- Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.

b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO – 500 km.
c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

Compliance Statement: COMPLIANT
The disposal plan of the GNOMES-4 spacecraft is COMPLIANT using the atmospheric reentry option, by either accelerated reentry with perigee lowering using the onboard propulsion system, or natural decay. The DAS v.3.2.2 output demonstrates passive deorbit in approximately 4.1 years from the worst-case injection orbit of 545 km x 545 km as shown in Section 9.

Requirement 4.6-2. Disposal for space structures near GEO: A spacecraft or orbital stage in an orbit near GEO shall be maneuvered at EOM to a disposal orbit above GEO with a predicted minimum perigee of GEO + 200 km (35,986 km) or below GEO with an apogee of GEO – 200 km (35,586 km) for a period of at least 100 years after disposal.

Compliance Statement: COMPLIANT
No orbits are planned near GEO.

Requirement 4.6-3. Disposal for space structures between LEO and GEO:

a. A spacecraft or orbital stage shall be left in an orbit with a perigee greater than 2000 km above the Earths' surface and apogee less than 500 km below GEO.
b. A spacecraft or orbital stage shall not use nearly circular disposal orbits near regions of high value operational space structures, such as between 19,200 km and 20,700 km.

Compliance Statement: COMPLIANT
No orbits planned between LEO and GEO.

Requirement 4.6-4. Reliability of post mission disposal operations in Earth orbit: NASA space programs and projects shall ensure that all post mission 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
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.

Compliance Statement: COMPLIANT
Disposal operations are not required to ensure that the GNOMES-4 spacecraft will meet reentry requirements. However, PlanetiQ does intend to conduct a PMD at the end of operational life if possible, to further expedite deorbit times.

7 ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Detailed description of spacecraft components by size, mass, material, shape, and original location on the space vehicle, if the atmospheric reentry option is selected: See DAS v.3.2.2 output in Section 9 for itemized list of spacecraft components used for reentry analysis.

Summary of objects expected to survive an uncontrolled reentry, using NASA Debris Assessment Software (DAS), NASA Object Reentry Survival Analysis Tool (ORSAT), or comparable software: The three components predicted to survive reentry are as follows: the single, large solar panel; tungsten and tantalum emitter in the propulsion system (labeled Emitter 1 in the output); and the coarse sun sensors. Each is predicted to have less than 15 Joules of kinetic energy. The total debris casualty area from the surviving components is estimated as 0 m^2.

Calculation of probability of human casualty for the expected year of uncontrolled reentry and the spacecraft orbital inclination: The risk of human casualty for GNOMES-4 spacecraft re-entering the atmosphere as calculated in DAS v.3.2.2 is 0.

Assessment of spacecraft compliance with Requirement 4.7-1:

Requirement 4.7-1. Limit the risk of human casualty: The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 Joules. a. For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000). b. For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 Joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica. c. For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000).
Compliance Statement: COMPLIANT Analysis performed using DAS v.3.2.2 shows that the risk of human casualty from surviving debris is 0. All components have 15 Joules of energy or less, or completely disintegrate before the Earth's surface upon reentry.

7.1 ODAR Section 7A: Assessment of Spacecraft Hazardous Materials

Summary of the hazardous materials contained on the spacecraft using all columns and the format in paragraph 4.7.5: N/A, no hazardous materials on the spacecraft.

8 ODAR Section 8: Assessment of Special Classes of Space Missions

Type of tether; e.g., momentum or electrodynamics: There are no tethers in the GNOMES-4 mission.

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

Determination of minimum size of object that will cause the tether to be severed: N/A

Tether mission plan, including duration and post mission disposal: N/A

Probability of tether colliding with large space objects: N/A

Probability of tether being severed during mission or after post mission disposal: N/A

Maximum orbital lifetime of a severed tether fragment: N/A

Assessment of compliance with Requirement 4.8-1:

Requirement 4.8-1. Mitigate the collision hazards of space tethers in Earth or Lunar orbits: Intact and remnants of severed tether systems in Earth and lunar orbit shall meet the requirements limiting the generation of orbital debris from on-orbit collisions (Requirements 4.5-1 and 4.5-2) and the requirements governing post mission disposal (Requirements 4.6-1 through 4.6-4) to the limits specified in those paragraphs.
Compliance Statement: COMPLIANT There are no tethers in the GNOMES-4 mission.

9 DAS v.3.2.2 Output

Requirement 4.5-1
Injection / Operational orbit: 545 km (worst-case) SSO assuming failure upon orbit insertion and passive decay

09 05 2022; 09:58:41AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = GNOMES-4
Space Structure Type = Payload
Perigee Altitude = 545.000 (km)
Apogee Altitude = 545.000 (km)
Inclination = 97.600 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0156 (m^2/kg)
Start Year = 2023.800 (yr)
Initial Mass = 41.700 (kg)
Final Mass = 41.500 (kg)
Duration = 5.000 (yr)
Station-Kept = False
Abandoned = True
Long-Term Reentry = False

OUTPUT

Collision Probability = 6.4976E-06
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

==========

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

Requirement 4.5-2: Injection / Operational orbit: 545 km (worst-case) SSO for 5 years

09 05 2022; 09:58:55AM Requirement 4.5-2: Compliant

========== End of Requirement 4.5-2 ==========
Requirement 4.6-1: Operational: 545 km (worst-case) SSO

09 05 2022; 09:58:57AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = GNOMES-4
Space Structure Type = Payload

Perigee Altitude = 545.000000 (km)
Apogee Altitude = 545.000000 (km)
Inclination = 97.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.015635 (m^2/kg)
Start Year = 2023.800000 (yr)
Initial Mass = 41.700000 (kg)
Final Mass = 41.500000 (kg)
Duration = 5.000000 (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 = 545.000000 (km)
Suggested Apogee Altitude = 545.000000 (km)

Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2027 (yr)
Requirement = 61
Compliance Status = Pass

==========

========== End of Requirement 4.6 ==========

Requirement 4.7-1

Sun synchronous operational: 545 km (worst-case) SSO

09 05 2022; 09:59:00AM
*********Processing Requirement 4.7-1

Return Status : Passed

**********INPUT****

Item Number = 1

name = GNOMES-4

quantity = 1

parent = 0

materialID = 5

type = Box

Aero Mass = 36.000000

Thermal Mass = 36.000000

Diameter/Width = 0.664000

Length = 0.835000

Height = 0.500000

name = Front Plate

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.364490

Length = 0.548800

name = Back Plate

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.364490

Length = 0.548800

name = Top Plate

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.800000

Thermal Mass = 0.800000

Diameter/Width = 0.255700

Length = 0.548800

name = Bottom Plate

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 0.800000

Thermal Mass = 0.800000

Diameter/Width = 0.255700

Length = 0.548800

name = Lightband Fasteners

quantity = 12

parent = 1

materialID = 59

type = Cylinder

Aero Mass = 0.029480

Thermal Mass = 0.029480

Diameter/Width = 0.050900

Length = 0.026400

name = Solar Panel Honeycomb

quantity = 1

parent = 1

materialID = 5

type = Flat Plate

Aero Mass = 0.703730

Thermal Mass = 0.703730

Diameter/Width = 0.700000

Length = 0.800000

name = Solar Panel Face Sheet

quantity = 1

parent = 1

materialID = 16

type = Flat Plate

Aero Mass = 0.472600

Thermal Mass = 0.472600

Diameter/Width = 0.700000

Length = 0.800000

name = Solar Cells

quantity = 1

parent = 1

materialID = 27

type = Flat Plate

Aero Mass = 0.500000

Thermal Mass = 0.500000

Diameter/Width = 0.700000

Length = 0.800000

name = Solar Array Drive Gearbox

quantity = 1

parent = 1

materialID = 5

type = Cylinder

Aero Mass = 1.180000

Thermal Mass = 1.180000

Diameter/Width = 0.097800

Length = 0.066800

name = Flexure Arm

quantity = 1

parent = 1

materialID = 54

type = Box

Aero Mass = 0.217700

Thermal Mass = 0.217700

Diameter/Width = 0.036200

Length = 0.036200

Height = 0.036200

name = Nut

quantity = 4

parent = 1

materialID = 65

type = Cylinder

Aero Mass = 0.000860

Thermal Mass = 0.000860

Diameter/Width = 0.008000

Length = 0.003900

name = Washer

quantity = 4

parent = 1

materialID = 65

type = Cylinder

Aero Mass = 0.000725

Thermal Mass = 0.000725

Diameter/Width = 0.008500

Length = 0.002900

name = Split Spool Release Mech

quantity = 2

parent = 1

materialID = 54

type = Cylinder

Aero Mass = 0.074000

Thermal Mass = 0.074000

Diameter/Width = 0.031750

Length = 0.024000

name = Solar Array Drive Motor

quantity = 1

parent = 1

materialID = 58

type = Box

Aero Mass = 0.320000

Thermal Mass = 0.320000

Diameter/Width = 0.042420

Length = 0.048000

Height = 0.042420

name = RO Antenna Frame Fixed

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 0.500000

Thermal Mass = 0.500000

Diameter/Width = 0.257050

Length = 0.435000

Height = 0.021260

name = RO Antenna Frame Rotating

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 0.500000

Thermal Mass = 0.500000

Diameter/Width = 0.257050

Length = 0.435000

Height = 0.021260

name = RO Antenna Panel Fixed

quantity = 2

parent = 1

materialID = 5

type = Box

Aero Mass = 0.780300

Thermal Mass = 0.780300

Diameter/Width = 0.254000

Length = 0.431800

Height = 0.003550

name = RO Antenna Panel Rotating

quantity = 2

parent = 1

materialID = 5

type = Box

Aero Mass = 0.780300

Thermal Mass = 0.780300

Diameter/Width = 0.254000

Length = 0.431800

Height = 0.003550

name = RO Antenna Patches Fixed

quantity = 16

parent = 1

materialID = 23

type = Box

Aero Mass = 0.090000

Thermal Mass = 0.090000

Diameter/Width = 0.073660

Length = 0.073660

Height = 0.010000

name = RO Antenna Patches Rotating

quantity = 16

parent = 1

materialID = 23

type = Box

Aero Mass = 0.090000

Thermal Mass = 0.090000

Diameter/Width = 0.073660

Length = 0.073660

Height = 0.010000

name = RO Antenna Wiring

quantity = 4

parent = 1

materialID = 19

type = Cylinder

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.004060

Length = 0.500000

name = RO Deployment Mechanism

quantity = 2

parent = 1

materialID = 40

type = Box

Aero Mass = 0.040000

Thermal Mass = 0.040000

Diameter/Width = 0.013000

Length = 0.175400

Height = 0.013000

name = RO Deployment Plunger

quantity = 4

parent = 1

materialID = 40

type = Cylinder

Aero Mass = 0.020000

Thermal Mass = 0.020000

Diameter/Width = 0.031700

Length = 0.019000

name = RO Antenna Hinges

quantity = 4

parent = 1

materialID = 40

type = Box

Aero Mass = 0.100000

Thermal Mass = 0.100000

Diameter/Width = 0.042600

Length = 0.127000

Height = 0.013300

name = POD Antenna

quantity = 2

parent = 1

materialID = 23

type = Box

Aero Mass = 0.213100

Thermal Mass = 0.213100

Diameter/Width = 0.101600

Length = 0.127000

Height = 0.025400

name = POD Wiring

quantity = 2

parent = 1

materialID = 19

type = Cylinder

Aero Mass = 0.075000

Thermal Mass = 0.075000

Diameter/Width = 0.003300

Length = 1.000000

name = Propulsion Module
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.804000
Thermal Mass = 0.418000
Diameter/Width = 0.098000
Length = 0.099000
Height = 0.095000

name = Reservoir
quantity = 1
parent = 28
materialID = 54
type = Cylinder
Aero Mass = 0.184000
Thermal Mass = 0.184000
Diameter/Width = 0.056000
Length = 0.045000

name = Emitter
quantity = 1
parent = 28
materialID = 67
type = Box
Aero Mass = 0.002000
Thermal Mass = 0.002000
Diameter/Width = 0.016000
Length = 0.016000
Height = 0.013300

name = Prop Electronics Board
quantity = 1
parent = 28
materialID = 50
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.018600

name = Pyxis Payload
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 5.600000
Thermal Mass = 2.000000
Diameter/Width = 0.175900
Length = 0.180300
Height = 0.162600

name = Fasteners
quantity = 100
parent = 32
materialID = 59
type = Cylinder
Aero Mass = 0.001000
Thermal Mass = 0.001000
Diameter/Width = 0.004000
Length = 0.015000

name = Printed Wire Assemblies
quantity = 7
parent = 32
materialID = 50
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.150000
Length = 0.150000
Height = 0.020000

name = Oscillator
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.146400
Thermal Mass = 0.146400
Diameter/Width = 0.050000
Length = 0.050000
Height = 0.030000

name = XB-1 Avionics Module
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.388000
Thermal Mass = 3.088000
Diameter/Width = 0.127000
Length = 0.165100
Height = 0.104100

name = Controller Board
quantity = 1
parent = 36
materialID = 50
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.097000
Length = 0.097000
Height = 0.005000

name = Power Board
quantity = 1
parent = 36
materialID = 50
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.097000
Length = 0.097000
Height = 0.005000

name = Configuration Board
quantity = 1
parent = 36
materialID = 50
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.097000
Length = 0.097000
Height = 0.005000

name = Software Radio Board
quantity = 1
parent = 36
materialID = 50
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.097000
Length = 0.097000
Height = 0.005000

name = GPS Receiver Board
quantity = 1
parent = 36
materialID = 50
type = Box
Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.097000

Length = 0.097000

Height = 0.005000

name = Backplane

quantity = 1

parent = 36

materialID = 50

type = Box

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.097000

Length = 0.097000

Height = 0.005000

name = Reaction Wheel Box

quantity = 1

parent = 1

materialID = 5

type = Box

Aero Mass = 2.145000

Thermal Mass = 1.350000

Diameter/Width = 0.099870

Length = 0.099870

Height = 0.099870

name = Reaction Wheel Housing

quantity = 3

parent = 43

materialID = 5

type = Box

Aero Mass = 0.064000

Thermal Mass = 0.064000

Diameter/Width = 0.064000

Length = 0.069090

Height = 0.024890

name = Electronics Board

quantity = 1

parent = 43

materialID = 50

type = Box

Aero Mass = 0.018000

Thermal Mass = 0.018000

Diameter/Width = 0.060000

Length = 0.060000

Height = 0.050000

name = Flywheel

quantity = 3

parent = 43

materialID = 54

type = Cylinder

Aero Mass = 0.195000

Thermal Mass = 0.195000

Diameter/Width = 0.065000

Length = 0.020000

name = Torque Rods

quantity = 3

parent = 1

materialID = 54

type = Cylinder

Aero Mass = 0.345000

Thermal Mass = 0.345000

Diameter/Width = 0.022300

Length = 0.127000

name = Star Tracker Housing

quantity = 2

parent = 1

materialID = 5

type = Box

Aero Mass = 0.301000

Thermal Mass = 0.266000

Diameter/Width = 0.054610

Length = 0.100000

Height = 0.050000

name = Star Tracker Lense

quantity = 2

parent = 48

materialID = 77

type = Box

Aero Mass = 0.035000

Thermal Mass = 0.035000

Diameter/Width = 0.027000

Length = 0.039000

Height = 0.026000

name = Coarse Sun Sensor

quantity = 3

parent = 1

materialID = 1

type = Box

Aero Mass = 0.008000

Thermal Mass = 0.008000

Diameter/Width = 0.026600

Length = 0.026600

Height = 0.006300

name = GPS Antenna

quantity = 1

parent = 1

materialID = 23

type = Box

Aero Mass = 0.016000

Thermal Mass = 0.016000

Diameter/Width = 0.047000

Length = 0.047000

Height = 0.008000

name = X-Band Antenna

quantity = 1

parent = 1

materialID = 23

type = Box

Aero Mass = 0.013000

Thermal Mass = 0.013000

Diameter/Width = 0.050000

Length = 0.050000

Height = 0.002700

name = S-Band Antenna

quantity = 1

parent = 1

materialID = 23

type = Box

Aero Mass = 0.049000

Thermal Mass = 0.049000

Diameter/Width = 0.076200

Length = 0.076200

Height = 0.004400

name = TT&C Wiring

quantity = 2

parent = 1

materialID = 19

type = Cylinder

Aero Mass = 0.025000

Thermal Mass = 0.025000

Diameter/Width = 0.004000

Length = 0.609000

name = Battery Module

quantity = 3

parent = 1

materialID = 5

type = Box

Aero Mass = 0.669000

Thermal Mass = 0.147000

Diameter/Width = 0.081900

Length = 0.105500

Height = 0.043600

name = Battery Cells

quantity = 24

parent = 55

materialID = 54

type = Cylinder

Aero Mass = 0.049000

Thermal Mass = 0.049000

Diameter/Width = 0.018400

Length = 0.065200

name = Battery Side PWB

quantity = 3

parent = 55

materialID = 50

type = Box

Aero Mass = 0.030000

Thermal Mass = 0.030000

Diameter/Width = 0.040000

Length = 0.075000

Height = 0.010000

name = Battery Top PWB

quantity = 3

parent = 55

materialID = 50

type = Box

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.040000

Length = 0.100000

Height = 0.010000

name = Battery Bottom PWB

quantity = 3

parent = 55

materialID = 50

type = Box

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.040000

Length = 0.100000

Height = 0.010000

name = Faseners

quantity = 200

parent = 1

materialID = 57

type = Cylinder

Aero Mass = 0.001000

Thermal Mass = 0.001000

Diameter/Width = 0.004000

Length = 0.015000

name = Harness Connectors

quantity = 31

parent = 1

materialID = 5

type = Box

Aero Mass = 0.003000

Thermal Mass = 0.003000

Diameter/Width = 0.013000

Length = 0.219700

Height = 0.007600

name = Cable Harness

quantity = 17

parent = 1

materialID = 19

type = Cylinder

Aero Mass = 0.063000

Thermal Mass = 0.063000

Diameter/Width = 0.006000

Length = 0.250000

**********OUTPUT****

Item Number = 1

name = GNOMES-4

Demise Altitude = 77.994707

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Front Plate

Demise Altitude = 77.356619

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Back Plate

Demise Altitude = 77.356619

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Top Plate

Demise Altitude = 77.354950

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bottom Plate

Demise Altitude = 77.354950

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Lightband Fasteners

Demise Altitude = 76.404990

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Panel Honeycomb

Demise Altitude = 77.405595

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Panel Face Sheet

Demise Altitude = 0.000000

Debris Casualty Area = 1.877476

Impact Kinetic Energy = 3.572665

****

name = Solar Cells

Demise Altitude = 77.870566

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Array Drive Gearbox

Demise Altitude = 64.625335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Flexure Arm

Demise Altitude = 69.072302

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Nut

Demise Altitude = 76.172908

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Washer

Demise Altitude = 76.277167

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Split Spool Release Mech

Demise Altitude = 70.678697

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Array Drive Motor

Demise Altitude = 68.732908

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Frame Fixed

Demise Altitude = 77.553004

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Frame Rotating

Demise Altitude = 77.553004

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Panel Fixed

Demise Altitude = 75.930539

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Panel Rotating

Demise Altitude = 75.930539

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Patches Fixed

Demise Altitude = 75.875517

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Patches Rotating

Demise Altitude = 75.875517

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Wiring

Demise Altitude = 77.087898

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Deployment Mechanism

Demise Altitude = 76.957380

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Deployment Plunger

Demise Altitude = 75.793987

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = RO Antenna Hinges

Demise Altitude = 75.910540

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = POD Antenna

Demise Altitude = 75.839790

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = POD Wiring

Demise Altitude = 77.193416

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Propulsion Module

Demise Altitude = 74.912088

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reservoir

Demise Altitude = 67.809898

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Emitter

Demise Altitude = 0.000000

Debris Casualty Area = 0.299031

Impact Kinetic Energy = 0.132152

****

name = Prop Electronics Board

Demise Altitude = 73.433653

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Pyxis Payload

Demise Altitude = 72.414931

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Fasteners

Demise Altitude = 71.810081

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Printed Wire Assemblies

Demise Altitude = 70.510198

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Oscillator

Demise Altitude = 73.794633

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = XB-1 Avionics Module

Demise Altitude = 66.361287

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Controller Board

Demise Altitude = 66.078335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Power Board

Demise Altitude = 66.078335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Configuration Board

Demise Altitude = 66.078335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Software Radio Board

Demise Altitude = 66.078335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = GPS Receiver Board

Demise Altitude = 66.078335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Backplane

Demise Altitude = 66.078335

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel Box

Demise Altitude = 69.473849

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel Housing

Demise Altitude = 68.325202

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Electronics Board

Demise Altitude = 69.400598

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Flywheel

Demise Altitude = 61.855760

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Torque Rods

Demise Altitude = 67.042110

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker Housing

Demise Altitude = 74.810633

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Star Tracker Lense

Demise Altitude = 74.279899

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Coarse Sun Sensor

Demise Altitude = 0.000000

Debris Casualty Area = 0.921083

Impact Kinetic Energy = 1.384823

****

name = GPS Antenna

Demise Altitude = 77.219827

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = X-Band Antenna

Demise Altitude = 77.342122

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = S-Band Antenna

Demise Altitude = 76.773060

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TT&C Wiring

Demise Altitude = 77.611701

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery Module

Demise Altitude = 76.419353

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery Cells

Demise Altitude = 72.605565

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery Side PWB

Demise Altitude = 75.897800

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery Top PWB

Demise Altitude = 75.739470

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery Bottom PWB

Demise Altitude = 75.739470

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Faseners

Demise Altitude = 77.181642

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Harness Connectors

Demise Altitude = 77.936998

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Cable Harness

Demise Altitude = 76.285180

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

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