EXHIBIT B

TURION SPACE CORP. ORBITAL DEBRIS ASSESSMENT REPORT FOR DROID.001 SATELLITE

This report is presented in compliance with NASA-STD-8719.14C, APPENDIX A.

Document data is not restricted.

This document contains no proprietary, ITAR, or export-controlled information.

Debris Assessment Software (DAS) version used in analysis: v3.2.1

Revision Record				
Revision:	Date:	Affected Pages:	Changes:	Author(s):
1.0	5/21/2022	All –Initial		P. Wiatr

TABLE OF CONTENTS

ODAR Self-Assessment Evaluation:

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

ODAR Requirement	Compliant or N/A	Not Compliant	Incomplete
4.3-1.a	x		
4.3-1.b	x		
4.3-2	x		
4.4-1	x		
4.4-2	x		
4.4-3	x		
4.4-4	x		
4.5-1	x		
4.5-2	x		
4.6-1(a)-c	x		
4.6-2	x		
4.6-3	x		
4.6-4	x		
4.7-1	x		
4.8-1	x		

Assessment Report Format:

This ODAR follows the format recommended in NASA-STD-8719.14C, Appendix A.1, sections 1 through 8 for the Turion Space satellite (DROID.001). Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

1. Program Management and Mission Overview

Turion Space is a U.S. company headquartered in Irvine, California.

Program Manager

- Ingrid Roldan

Foreign Government or Space Agency Participation

- None

Mission Overview

DROID.001 is expected to launch in April 2023 into a circular sun-synchronous, low-Earth orbit (LEO). It will be launched in an inclined (97.5 deg) orbit between 525 km and 575 km and will operate for 4.5 years. Once deployed, DROID.001 will maneuver to its destination altitude of 550 km using its on-board propulsion system. DROID.001 will be equipped with an electric propulsion system, reaction wheels, a Global Positioning System (GPS) receiver, star trackers, sun sensors, magnetorquers, and inertial measurement unit (IMU).

Launch

Turion Space has contracted with Exolaunch to broker the DROID.001 launch. DROID.001 is planned to launch on a SpaceX Falcon 9 rocket.

Mission Duration

The anticipated lifetime of DROID.001 is less than 6 years in LEO.

Deployment Profile

DROID.001 is expected to deploy from the launch vehicle with the following orbital parameters:

Table 1. Orbital Parameters

	Apogee	Perigee	Inclination
Max Insertion Orbit	575 km	575 km	97.5° ± 0.1°
Min Insertion Orbit	525 km	525 km	97.5° ± 0.1°
Operational Orbit	550 km	550 km	97.5° ± 0.1°
Post Mission Disposal Orbit	350 km	350 km	97.5° ± 0.1°

The nominal operational orbit for DROID.001 is a circular sun-synchronous at an altitude of 550 km. Once deployed from the spacecraft, DROID.001 will maneuver to 550 km where it will remain until end of mission (EOM).

2. Spacecraft Description

Physical description of the spacecraft

The DROID.001 satellite is based on the NanoAvionics 42U microsatellite bus. Basic physical dimensions are 0.847 x 0.438 x 0.407 meters (solar arrays deployed) with a wet mass of approximately 32 kg. The satellite is composed of the NanoAvionics bus, two deployable solar panels, and a payload. The payload is a remote sensing camera provided by HEO Robotics. The solar panels generate 70W Orbit Average Power (OAP) of electrical DC power, which is stored in a 161Wh commercial off-the-shelf (COTS) Li-Ion unpressurized battery assembly. The solar array is deployed using a Dyneema loop burn wire hold-down mechanism. The bus is 3-axis stabilized, employing star trackers and sun sensors for attitude knowledge and reaction wheels and magnetorquers for attitude control.

Detailed illustrations of the DROID.001 spacecraft are provided in the figures below.

Figure 1. DROID.001 Space Vehicle External View

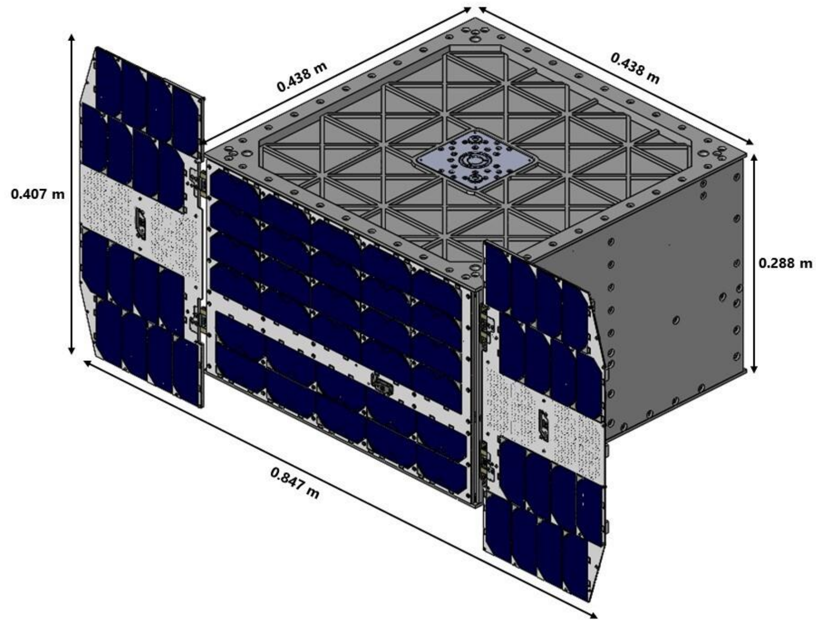
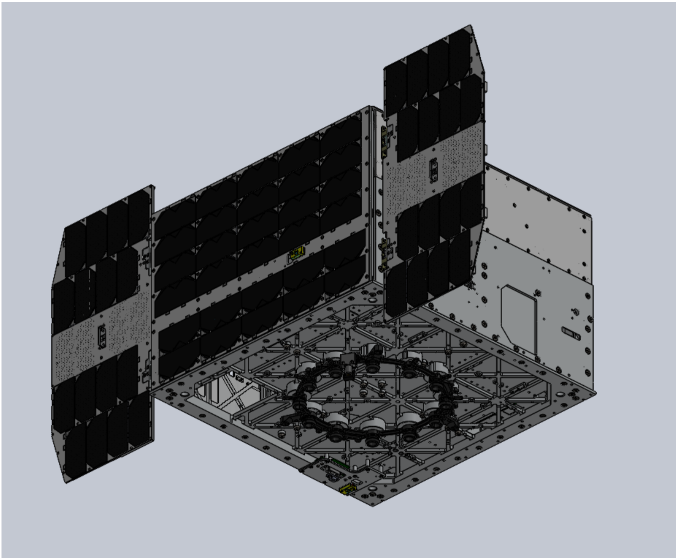


Figure 2. DROID.001 Space Vehicle External View



Spacecraft Mass

- Wet Mass: 32 kg
- Dry Mass: 31.78 kg

Description of propulsion system

The propulsion system includes one Enpulsion Nano AR.[3] It is a field-emission electric propulsion (FEEP) thruster with 0.22 kg of propellant mass, a total impulse greater than 5 kNs, a delta-V of ~200m/s, a nominal thrust of 350 µN, a dynamic thrust range of 10 to 350 µN, and a dynamic specific impulse range of 2,000 to 6,000 s. The propellant for this system is non-toxic Indium, which is inert, and is stored as a solid, unpressurized, and non-chemical energy. The Indium propellant is solid at room temperature and remains in solid state when contained in the unpowered Enpulsion thruster system. The FEEP technology does not release any persistent liquids.

The Indium in the Enpulsion system is a solid ingot of metal. The only way for the Indium to flow out of the thruster is for the heater to melt the ingot and allow it to flow out of the thrust head. The path from the tank to the space requires the Indium to pass through extremely small pores in the tungsten emitter tips, and the only way for the Indium to flow through these tips is for it to be vaporized into extremely small particles (e.g., only a few atoms wide and incapable of posing orbital debris concerns) to power the propulsion system.

Fluids Planned to be On-board

None, besides the Indium described above.

Attitude Control System:

The GNC subsystem has a sensor suite comprised of two star trackers, one IMU (containing three gyros and three accelerometers), one GPS receiver, one three-axis magnetometer, and six sun sensors. The actuator suite is comprised of one electric ion thruster, four reaction wheels, and twelve magnetorquers. The GNC subsystem has several operational modes that enable the spacecraft to perform its mission:

- A *detumbling mode* is used to reduce angular rates below a threshold after launch vehicle separation or after a hardware failure in the guidance, navigation, and control (GNC) subsystem. The magnetometer is used to sense the orientation of the Earth's magnetic field and the magnetorquers are used to generate torques opposing the rotation of the spacecraft.

- A *pointing mode* is used to orient the spacecraft in either the velocity, anti-velocity, nadir, ground tracking, or inertially fixed directions. This mode is used for orbit maneuvers, proximity operations, ground communication, and payload activities.
- A *safe mode* is used to maximize solar power generation while also allowing communications with the ground network. Safe mode is entered either by ground command or autonomously by the flight software when it detects a low battery state of charge. During this mode, the spacecraft will maintain its solar panels pointing towards the sun and will also track selected ground stations when they come within line-of-sight.

During normal operations, the four reaction wheels provide redundant 3-axis attitude control while the magnetorquers are used to maintain wheel speeds below their maximum limits. The nominal spacecraft orientation has the solar panels in the zenith direction (+R for radial), the HEO camera in the nadir direction (-R), the launch vehicle separation ring in the velocity direction (+T for tangential), and the propulsion system thrusting in the anti-velocity direction (-T)

Description of any range safety or other pyrotechnic devices
None.

Space vehicle separation will be accomplished using a debris-free low-shock release system as designed by approved integrators for our launch. Integrators install the Exolaunch CarboNIX 8 separation system onto the DROID.001 spacecraft. The CarboNIX 8 is a debris-free deployment mechanism.

Solar array deployment will also be achieved using a Dyneema loop burn wire hold-down mechanisms that does not release any debris. Solar arrays will be deployed via a spring-based system, folded out.

Description of the electrical generation and storage system
Standard COTS Li-Ion battery cells are charged before payload integration and provide 161Wh of electrical energy during the eclipse portion of the satellite's orbit. A series of triple junction solar

cells generate an average on-orbit power of approximately 70 W. The charge/discharge cycle is managed by the electronic power system which is monitored by the flight computer.

Identification of any other sources of stored energy not noted above

Reaction wheels store kinetic energy but can be disconnected from power at end of the operational lifetime.

Identification of any radioactive material on board

None

Address the trackability of the 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 is in low-Earth orbit and has a smallest dimension measuring at least .288 x .438 m (or 28.8 x 43.8 cm) without solar panels deployed. This dimension is greater than 10 cm and, therefore, trackable.

The statement shall also disclose the following:

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 Turion Space 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:
Turion Space 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 SSA 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. Turion Space intends to share ephemeris with other operators on an as-needed basis.

Planned Proximity Operations
None

3. Spacecraft Debris Released During Normal Operations

Assessment of Spacecraft Compliance with Requirements 4.3-1 and 4.3-2

Requirement 4.3-1: Mission Related Debris Passing Through LEO

- **Compliance statement:** No release of debris will occur during the lifetime of DROID.001. All deployments use a Dyneema loop burn wire hold-down mechanism that does not generate any debris. Additionally, there is no probable scenario for unintentional debris generation.

Requirement 4.3-2: Mission Related Debris Passing Near GEO

- **Compliance statement:** This requirement is not applicable to this mission profile.

4. Spacecraft Intentional Breakups and Potential for Explosions

Potential causes of spacecraft breakup during deployment and mission operations

There is no credible scenario that would result in spacecraft breakup during normal deployment operations.

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

The spacecraft has no chemical propellants or pressurized vessels. The battery safety systems are discussed in the assessment of spacecraft compliance with ODAR requirement 4.4-1, which describes the combined faults required for the mutually exclusive failures that lead to battery venting. The batteries are COTS batteries equipped with safety vent features that release excessive pressure build-up, precluding explosions.

Plan for any designed spacecraft breakup

There are no planned breakups.

List of components which shall be passivated at EOM including method of passivation and amount which cannot be passivated

- **Propulsion System** – residual propellant will be expended via EOM burns to reduce the orbit altitude as much as possible.
- **Reaction Wheels** – reaction wheels will be spun down and the spacecraft will be controlled via toque rods.
- **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 Non-Passivation

In the unlikely event that a battery cell ruptures, the small size, mass, and potential energy of these batteries is such that debris from the battery rupture would be contained within the vessel due to the lack of penetration energy. Additionally, under nominal, planned operating conditions, the remaining orbital lifetime of the DROID.001 spacecraft will be three months.

Furthermore, by not passivating the batteries, the DROID.001 spacecraft can still be commanded in the event that a conjunction warning is received during the final months on orbit.

Assessment of Spacecraft Compliance with Requirements 4.4-1 through 4.4-4

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

- *For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).*

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 these small batteries, coupled with the multiple enclosures surrounding the batteries, will ensure most if not all 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 0.01% given that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion). The DROID.001 spacecraft uses Panasonic NCR18650B battery cells which have extensive flight heritage. Each battery cell is UL/UN certified with individual over-voltage and over-current protection. Furthermore, the spacecraft integrator, NanoAvionics, conducts battery verification testing as outlined in its report NA-023-BVT-

000-R000.[1] This testing includes Lot Sampling Testing, Acceptance Testing, and Final Checkout after Assembling the CubeSat.

- **Failure Mode 1:** Internal cell short circuit
  - **Mitigation:** 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 **<u>AND</u>** 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:** Battery cells were UL/UN tested in lab for high load discharge rates by short circuiting the terminal to determine the feasibility of an out-of-control thermal rise in the cell.
  - **Combined faults required for realized failure:** Spacecraft thermal design must be incorrect **<u>AND</u>** 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:** This failure mode is negated by:
    - Qualification tested short circuit protection on each external circuit;
    - Design of battery packs and insulators such that no contact with nearby board traces is possible without being caused by some other mechanical failure; and
    - Obviation of such other mechanical failures by proto-qualification and acceptance environmental tests (shock, vibration, thermal cycling, and thermal-vacuum tests).

[1] This report is on file with applicant.

- **Combined faults required for realized failure:** An external load must fail/short-circuit **AND** external over-current detection **AND** disconnect function must all occur to enable this failure mode.
- **Failure Mode 4:** Inoperable vents
  - **Mitigation:** Battery venting is not inhibited by the battery holder design or the spacecraft design. The battery can vent gases to the external environment.
  - **Combined faults required for realized failure:** The cell manufacturer and the satellite integrator must fail to install proper venting.
- **Failure Mode 5:** Crushing
  - **Mitigation:** Failure mode prevented by design. No moving parts appear near the battery assembly. Battery cells are UL/UN tested for crush and impact.
  - **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:** 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 for this failure mode.
- **Failure Mode 7:** Excess battery cell temperature due to orbital environment and high discharge combined
  - **Mitigation:** The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that the 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. Battery cells are UL/UN thermal tested without fire or explosion.

- **Combined faults required for realized failure:** Incorrect 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 Earth or the Moon

- *Design of all spacecraft and launch vehicle orbital stages shall include the ability to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or post-mission disposal or control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).*
- **Compliance statement:** All remaining propellant will be consumed to lower the DROID.001 orbit altitude to the extent possible. The reaction wheels will be spun down to passivate the DROID.001 satellite. The electric power system is designed to allow for the disconnection of all output channels. In this EOM mode, all subsystems, except for the electric power system (EPS), will be cut off from power.

Requirement 4.4-3: Limiting the long-term risk to other space systems from planned breakups

- **Compliance statement:** This requirement is not applicable. There are no planned breakups.

Requirement 4.4-4: Limiting the short-term risk to other space systems from planned breakups

- **Compliance statement:** This requirement is not applicable. There are no planned breakups.

5. Spacecraft Potential for On-Orbit Collisions

In addition to the below requirements being met, it should be noted that DROID.001's propulsion system will allow Turion Space to react to potential collision events and avoid collisions.

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

- *For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001 (Requirement 56506).*
- **Compliance statement:** Large object impact and debris generation probability: 0.0000042417

Requirement 4.5-2: Limiting the probability of damage from 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 (Requirement 56507).*
- **Compliance Statement:**

  At the end of the 4.5-year operational period, the DROID.001 spacecraft will conduct a post-mission disposal (PMD) maneuver to lower the orbit altitude below the International Space Station (ISS) (at approximately 51.6 deg, 408 km) and other inhabited spacecraft (such as Tiangong, at approximately 41.48 deg, 389.2 km) and assure deorbit within a total satellite lifetime of 6 years. To ensure success of the planned PMD maneuver, the following critical surfaces were identified:

  - Flight computer
  - EPS controller cards (x4)
  - Propulsion subsystem
  - Star tracker control unit

  While additional subsystems are required for the PMD maneuver, they all contain embedded redundancy and therefore do not qualify as critical surfaces. Because the DROID.001 bus employs a variety of pointing configurations during each orbit to point solar arrays, camera, and antennas, the random tumbling orientation was assumed for this analysis. The computed probability of collision with small objects is 0.0092544, which does not exceed the requirement of 0.01.

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 DROID.001's orbital parameters, an electric propulsion system,[2] and a backup ability to employ differential drag should the propulsion system fail.

At the worst-case 575km altitude (assuming DROID.001 remains in its stowed configuration due to a hardware malfunction (DOA)), the satellite will deorbit in 15.054 years. For functioning scenarios, the deorbit timeline drops to 5.6 years given the propulsion system onboard the spacecraft. The propulsion system is capable of generating 350 uN of thrust. A 66-minute burn would generate 0.055 m/s of delta-V resulting in a potential lowering of the orbit altitude from 550km to 549.9km. This reduction in orbit altitude translates to increasing the inline separation distance by 0.49km / orbit. With ~96 minute orbital period, if the burn is executed 48 hours before TCA then 46.9 hours of drift would introduce ~14.541km of inline separation. Typically, a 5km separation distance provides a sufficiently low probability of collision (PC). Of course, in cases where the time to execute the first burn is less than 48 hours prior to the time of closest approach (TCA), a longer burn or a series of burns can be executed to achieve an adequately low PC

In the case of a failure of the propulsion system, differential drag can also be employed. Studies by Planet and other companies have shown that differential drag can be an effective collision avoidance technique. The effective surface area of the satellite can change from 0.126 to 0.292 m^2 by adjusting the orientation of the DROID.001 spacecraft. Furthermore, Turion Space will register DROID.001 with the US Space Force's 18th Space Control Squadron, which provides active monitoring in conjunction with the Combined Space Operations Center.

[2] DROID.001 has a propulsion system which will be the primary means to support collision avoidance.

Turion will contact and work with any entity who owns a spacecraft that have the potential to collide with a DROID.001 satellite to avoid collision.

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

During the de-orbit phase, the DROID.001 spacecraft will transfer the spacecraft from an altitude greater than that of the ISS and other inhabitable spacecraft to an altitude below that of the ISS and other inhabitable spacecraft; thus, this phase may transit through an orbit used by the ISS or another spacecraft. The delta-V from the maximum insertion orbit of 575km down to a 350km circular orbit (safely below the ISS and other inhabitable spacecraft) is ~125 m/s (roughly 63% of the rated delta-V of the propulsion subsystem). Therefore, under nominal operating conditions, the DROID.001 spacecraft will be actively deorbited, maintaining a circular orbit, until it is safely below the operational orbits of the ISS and other inhabitable spacecraft.

The DROID.001 spacecraft can employ differential drag as described above in the extremely rare case that the propulsion system fails. Under these unlikely circumstances, Turion will work with the 18th Space Control Squadron to plan and execute deorbit maneuvers while DROID.001 passes below the orbits of the ISS and other inhabitable spacecraft to minimize the risk of collision.

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

Upon receipt of a SSA conjunction warning, Turion certifies that it will attempt to contact the operator of any active spacecraft involved in such a warning, share ephemeris data and other appropriate operational information with any such operator, and modify the spacecraft's attitude, orbit and/or operations to avoid a collision. If the operator of the other spacecraft does not have maneuvering capabilities or is not expedient in response, the operator for DROID.001 will upload potential maneuvers via application programming interface to the 18th Space Control Squadron to avoid a collision. High-risk events will be mitigated to at least one and a half orders of magnitude below the collision probability mitigated action threshold of 1E-5. As shown above, a 66-minute burn 48 hours prior to TCA results in greater than 14 km of in-track offset between a pair of orbiting objects. The example reflects a small fraction of the available control authority for the DROID.001 spacecraft.

6. Spacecraft Post-mission Disposal Plans and Procedures

Description of spacecraft disposal option selected

Consistent with NASA-STD 8719.4C, DROID.001 will be disposed of via atmospheric reentry. The operational altitude in LEO lends to natural forces that will quickly lead to atmospheric reentry once the operations, including station-keeping with maneuvers, are ceased.

At EOM, DROID.001 will maneuver to a disposal altitude of 350 km where the system will be passivated and allowed to eventually deorbit.[3] The orbit of DROID.001 will decay because of atmospheric drag, and the satellite will eventually de-orbit by atmospheric reentry. In the case where there is propellant in excess of what is needed to maneuver to the disposal altitude, it will be used in a series of propulsive maneuvers to further accelerate orbital decay and reentry.

Systems or Components Required to Accomplish Post-mission Disposal Maneuvers

A number of subsystems are required to execute the planned PMD maneuver. However, only those subsystems without redundancy are considered. Those subsystems are listed below:

- Flight computer
- EPS controller (x4)

[3] All remaining propellant will be consumed to lower the circular orbit until either propellant is fully consumed or control authority of the DROID.001 is exceeded by drag forces. Current calculations suggest that the PMD orbit will be not higher than 350km circular.

- Star tracker controller unit
- Propulsion subsystem

In the worst-case scenario where DROID.001 is delivered to a 575 x 575 km orbit and remains in its stowed configuration due to a DOA, it will reenter in approximately 15.054 years.

Post-mission Disposal Maneuver Plan

To accelerate reentry, DROID.001 will perform a PMD maneuver via a series of apogee and perigee burns in the anti-velocity direction to lower the satellite to a maximum disposal orbit of approximately 350 x 350 km. In the case that DROID.001 reaches 350 km and has not expended all of its fuel, the remaining fuel will be used to lower the spacecraft further, accelerating the deorbit.

Calculation of area-to-mass ratio after post-mission disposal

The final area-to-mass ratio is calculated using the dry mass of the vehicle and the average cross-sectional area. Average cross-sectional area is calculated using the equation for estimated average cross-sectional area for non-convex shapes from NASA-STD-8179.14C: $A_{avg} = (A_{max} + A_1 + A_2)/2$, where A_{max} is the maximum cross-sectional area, and A_1 and A_2 are the cross-sectional areas for the two viewing directions orthogonal to the maximum cross sectional area viewing direction.

DROID.001 Final (Deployed-configuration) area-to-mass ratio calculation:

- Spacecraft mass: 32.0 kg (wet mass)
- Cross-sectional area: 0.3053 m^2 (average)
- Area-to-mass ratio: 0.009541 m^2/kg (final)

Calculation of area-to-mass ratio for worst-case deorbit scenarios

Additional analysis is provided below for the two worst-case deorbit scenarios (those for deorbit time with the vehicle at the maximum altitude launch deployment with undeployed solar panels and for the vehicle at maximum altitude during the approach maneuver with deployed solar panels). The average cross-sectional area for these two cases is calculated using the same equation from NASA-STD-8179.14C, as previously provided.

DROID.001 Initial (Undeployed) area-to-mass ratio calculation:

- Spacecraft mass: 32.0 kg (wet mass)
- Cross-sectional area: 0.2221 m^2 (average)
- Area-to-mass ratio: 0.00694 m^2/kg (final)

Assessment of spacecraft compliance with ODAR requirements 4.6-1 to 4.6-4

Requirement 4.6-1(a): Disposal for space structures in or passing through LEO

- **Compliance statement:** The DROID.001 satellite reentry is COMPLIANT. After executing a PMD/EOM maneuver, DROID.001 will re-enter the Earth's atmosphere 0.334 years after the completion of mission and 5.66 years after launch.

The DAS prediction for orbit lifetime following the described PMD/EOM maneuver is 0.334 years as show in Figure 3. In the event of a hardware failure or other anomaly during operations at the nominal 550 km circular altitude, DROID.001 would naturally deorbit within 10.984 years.

Figure 3. Orbital Decay Profile with PMD/EOM Maneuver

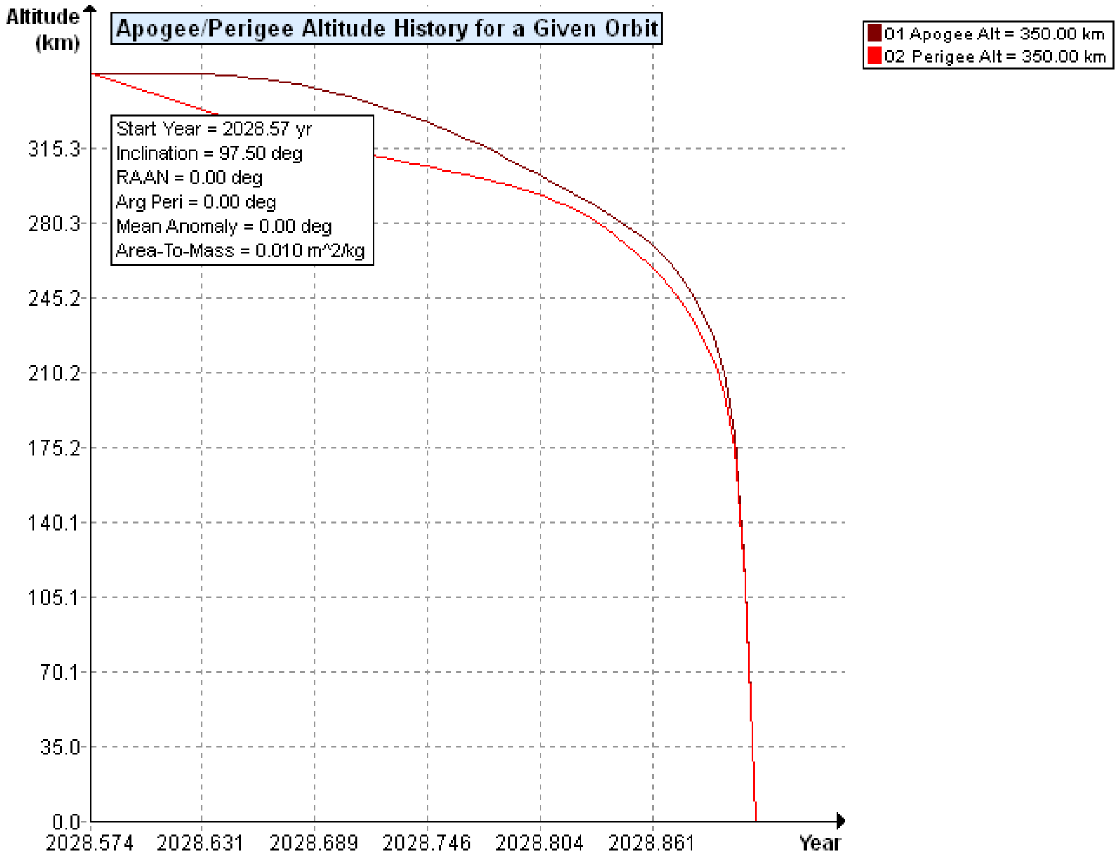
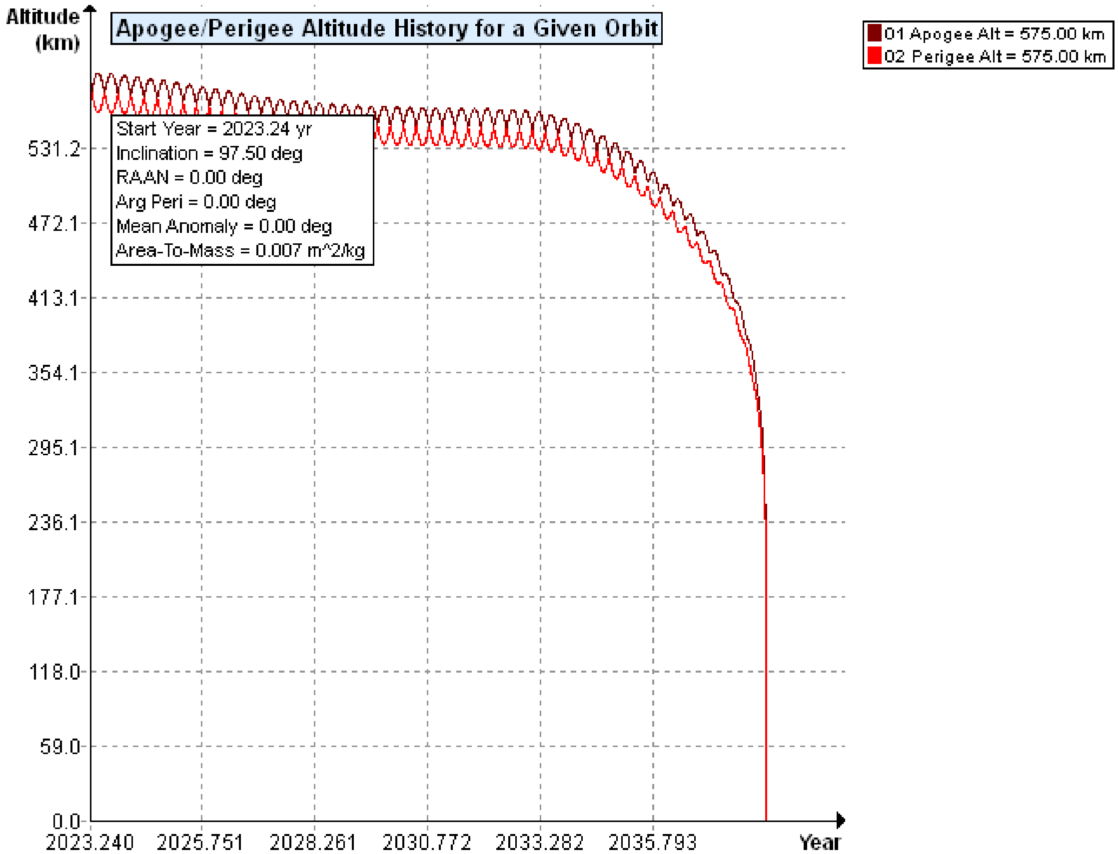


Figure 4. Orbital Decay Profile for DOA Scenario



Requirement 4.6-2: Disposal for space structure near GEO

- **Compliance statement:** Not applicable

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

- **Compliance statement:** Not applicable

Requirement 4.6-4: Reliability of post-mission disposal operations

- **Compliance statement:** An EOM maneuver is not required to ensure deorbit within 25 years.

7. Spacecraft Reentry Hazards

Summary of objects expected to survive uncontrolled reentry

For DROID.001, no spacecraft components are expected to survive uncontrolled reentry with an impact energy of greater than 15J per the DAS v3.2.1. See activity log below. Given no components reenter, the risk of human casualty is 0 and the total debris casualty area is 0.0 m^2 and falls within the permissible 1:10,000 risk.

Compliance Assessment for Requirement 4.7-1

Limit the risk of human casualty.

Requirement 4.7-1(a):

- *The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules. For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).*
- **Compliance statement:** The calculated risk of human casualty is 0.

Requirement 4.7-1(b):

- **Compliance statement:** Not applicable because controlled reentry is not an element of the EOM disposal plan

Requirement 4.7-1(c):

- **Compliance statement:** Not applicable because controlled reentry is not an element of the EOM disposal plan

Analysis using DAS v3.2.1

05 21 2022; 08:18:03AM Project Data Saved To File

05 21 2022; 08:18:08AM Processing Requirement 4.3-1: Return Status : Not Run

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

No Project Data Available

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

=============== End of Requirement 4.3-1 ===============

05 21 2022; 08:18:12AM Processing Requirement 4.3-2: Return Status : Passed

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

No Project Data Available

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

=============== End of Requirement 4.3-2 ===============

05 21 2022; 08:23:42AM Processing Requirement 4.5-1: Return Status : Passed

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

Run Data

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

INPUT

Space Structure Name = Droid.001

Space Structure Type = Payload

Perigee Altitude = 575.000 (km)

Apogee Altitude = 575.000 (km)

Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass Ratio = 0.0095 (m^2/kg)

Start Year = 2023.249 (yr)

Initial Mass = 32.000 (kg)

Final Mass = 31.780 (kg)

Duration = 4.500 (yr)

Station-Kept = True

PMD Perigee Altitude = 350.000 (km)

PMD Apogee Altitude = 350.000 (km)

PMD Inclination = 97.500 (deg)

PMD RAAN = 0.000 (deg)

PMD Argument of Perigee = 0.000 (deg)

PMD Mean Anomaly = 0.000 (deg)

OUTPUT

Collision Probability = 4.2417E-06

Returned Message: Normal Processing

Date Range Message: Normal Date Range

Status = Pass

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

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

05 21 2022; 08:24:22AM Project Data Saved To File

05 21 2022; 08:29:07AM Requirement 4.5-2: Compliant

===

Spacecraft = Droid.001

Critical Surface = Flight Computer

===

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.400 (g/cm^2)

CS Surface Area = 0.0003 (m^2)

Vector = (0.000000 (u), 1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 0.550 (cm)

OUTPUT

Probability of Penetration = 8.7236E-04 (8.7274E-04)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = Droid.001

Critical Surface = EPS Card #1

===

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.400 (g/cm^2)

CS Surface Area = 0.0003 (m^2)

Vector = (0.000000 (u), 1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 0.550 (cm)

OUTPUT

Probability of Penetration = 8.7236E-04 (8.7274E-04)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = Droid.001

Critical Surface = EPS Card #2

===

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.400 (g/cm^2)

CS Surface Area = 0.0003 (m^2)

Vector = (0.000000 (u), 1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 0.550 (cm)

OUTPUT

Probability of Penetration = 8.7236E-04 (8.7274E-04)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = Droid.001

Critical Surface = EPS Card #3

===

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.400 (g/cm^2)

CS Surface Area = 0.0003 (m^2)

Vector = (0.000000 (u), 1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 0.550 (cm)

OUTPUT

Probability of Penetration = 8.7236E-04 (8.7274E-04)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

==

Spacecraft = Droid.001

Critical Surface = EPS Card #4

==

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.400 (g/cm^2)

CS Surface Area = 0.0003 (m^2)

Vector = (0.000000 (u), 1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 0.550 (cm)

OUTPUT

Probability of Penetration = 8.7236E-04 (8.7274E-04)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

==

Spacecraft = Droid.001

Critical Surface = Propulsion

==

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.400 (g/cm^2)

CS Surface Area = 0.0100 (m^2)

Vector = (0.000000 (u), -1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 0.550 (cm)

OUTPUT

Probability of Penetration = 2.1405E-09 (2.1405E-09)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = Droid.001

Critical Surface = Star Tracker Control

===

INPUT

Apogee Altitude = 575.000 (km)

Perigee Altitude = 575.000 (km)

Orbital Inclination = 97.500 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0095 (m^2/kg)

Initial Mass = 31.780 (kg)

Final Mass = 31.780 (kg)

Station Kept = Yes

Start Year = 2023.249 (yr)

Duration = 4.500 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.100 (g/cm^2)

CS Surface Area = 0.0021 (m^2)

Vector = (0.000000 (u), 1.000000 (v), 0.000000 (w))

CS Pressurized = No

Outer Wall 1   Density: 1.400 (g/cm^2) Separation: 1.550 (cm)

Outer Wall 2   Density: 1.400 (g/cm^2) Separation: 1.000 (cm)

OUTPUT

Probability of Penetration = 4.9217E-03 (4.9339E-03)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

05 21 2022; 08:41:54AM   *********Processing Requirement 4.7-1

Return Status : Passed

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

Item Number = 1

name = Droid.001

quantity = 1

parent = 0

materialID = 9

type = Box

Aero Mass = 31.780001

Thermal Mass = 31.780001

Diameter/Width = 0.438000

Length = 0.438000

Height = 0.288000

name = Reaction Wheels

quantity = 4

parent = 1

materialID = 8

type = Box

Aero Mass = 0.235000

Thermal Mass = 0.235000

Diameter/Width = 0.065000

Length = 0.077000

Height = 0.038000

name = S-band 1

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.195000

Thermal Mass = 0.195000

Diameter/Width = 0.872000

Length = 0.930000

Height = 0.166500

name = S-band 2

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 0.253000

Thermal Mass = 0.253000

Diameter/Width = 0.872000

Length = 0.930000

Height = 0.166500

name = Magnetorquer Coil

quantity = 12

parent = 1

materialID = 5

type = Cylinder

Aero Mass = 0.031000

Thermal Mass = 0.031000

Diameter/Width = 0.022000

Length = 0.083900

name = S-band Antenna

quantity = 2

parent = 1

materialID = 5

type = Box

Aero Mass = 0.200000

Thermal Mass = 0.200000

Diameter/Width = 0.100000

Length = 0.100000

Height = 0.010000

name = Separation System

quantity = 1

parent = 1

materialID = 5

type = Cylinder

Aero Mass = 0.280000

Thermal Mass = 0.280000

Diameter/Width = 0.267100

Length = 0.249600

name = Payload 1

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 2.300000

Thermal Mass = 2.300000

Diameter/Width = 0.123000

Length = 0.254000

Height = 0.112000

name = Battery

quantity = 14

parent = 1

materialID = 5

type = Cylinder

Aero Mass = 0.045000

Thermal Mass = 0.045000

Diameter/Width = 0.064140

Length = 0.025000

name = Solar Panel Structural Frame

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.180000

Thermal Mass = 0.180000

Diameter/Width = 0.197700

Length = 0.406700

Height = 0.004000

name = X-band Transmitter

quantity = 1

parent = 1

materialID = -1

type = Box

Aero Mass = 0.275000

Thermal Mass = 0.275000

Diameter/Width = 0.090000

Length = 0.095000

Height = 0.017400

name = X-band Antenna

quantity = 1

parent = 1

materialID = 5

type = Box

Aero Mass = 0.053000

Thermal Mass = 0.053000

Diameter/Width = 0.082600

Length = 0.098000

Height = 0.003000

name = Propulsion System

quantity = 1

parent = 1

materialID = 9

type = Box

Aero Mass = 1.440000

Thermal Mass = 1.440000

Diameter/Width = 0.098000

Length = 0.099000

Height = 0.097300

name = Flight Computer

quantity = 1

parent = 1

materialID = 23

type = Flat Plate

Aero Mass = 0.062000

Thermal Mass = 0.062000

Diameter/Width = 0.090000

Length = 0.096000

name = Payload Controller

quantity = 1

parent = 1

materialID = 23

type = Flat Plate

Aero Mass = 0.085000

Thermal Mass = 0.085000

Diameter/Width = 0.090000

Length = 0.096000

name = Magnetometer

quantity = 1

parent = 1

materialID = 5

type = Box

Aero Mass = 0.000597

Thermal Mass = 0.000597

Diameter/Width = 0.020000

Length = 0.025000

Height = 0.001090

name = Star Tracker

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.362500

Thermal Mass = 0.205000

Diameter/Width = 0.066000

Length = 0.095000

Height = 0.056000

name = Star Track Processing Unit

quantity = 1

parent = 17

materialID = 9

type = Box

Aero Mass = 0.315000

Thermal Mass = 0.315000

Diameter/Width = 0.089000

Length = 0.117000

Height = 0.024500

name = Sun Sensor

quantity = 6

parent = 1

materialID = 9

type = Box

Aero Mass = 0.002200

Thermal Mass = 0.002200

Diameter/Width = 0.011000

Length = 0.022000

Height = 0.006300

name = IMU

quantity = 1

parent = 1

materialID = 5

type = Box

Aero Mass = 0.055000

Thermal Mass = 0.055000

Diameter/Width = 0.035900

Length = 0.038600

Height = 0.021500

name = Bay Dividing Plate

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 1.576000

Thermal Mass = 1.576000

Diameter/Width = 0.427000

Length = 0.427000

name = Wall Plate 1

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 0.783000

Thermal Mass = 0.783000

Diameter/Width = 0.280000

Length = 0.426500

name = Wall Plate 2

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 0.842000

Thermal Mass = 0.842000

Diameter/Width = 0.280000

Length = 0.426500

name = Wall Plate 3

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 0.854000

Thermal Mass = 0.854000

Diameter/Width = 0.280000

Length = 0.426500

name = Wall Plate 4

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 0.945000

Thermal Mass = 0.945000

Diameter/Width = 0.280000

Length = 0.426500

name = Primary Support Rib

quantity = 1

parent = 1

materialID = 9

type = Box

Aero Mass = 0.367000

Thermal Mass = 0.367000

Diameter/Width = 0.095000

Length = 0.472000

Height = 0.012000

name = Secondary Support Rib 1

quantity = 1

parent = 1

materialID = 9

type = Box

Aero Mass = 0.282000

Thermal Mass = 0.282000

Diameter/Width = 0.095000

Length = 0.210000

Height = 0.030000

name = Secondary Support Rib 2

quantity = 1

parent = 1

materialID = 9

type = Box

Aero Mass = 0.430000

Thermal Mass = 0.430000

Diameter/Width = 0.095000

Length = 0.210000

Height = 0.030000

name = Lib Plate

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 2.154000

Thermal Mass = 2.154000

Diameter/Width = 0.438000

Length = 0.438000

name = Bracket 1

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.110000

Thermal Mass = 0.110000

Diameter/Width = 0.034500

Length = 0.095000

Height = 0.030000

name = Bracket 2

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.086600

Thermal Mass = 0.086600

Diameter/Width = 0.030000

Length = 0.095000

Height = 0.030000

name = Bracket 3

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.184000

Thermal Mass = 0.184000

Diameter/Width = 0.031500

Length = 0.157000

Height = 0.031500

name = Bracket 4

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.143000

Thermal Mass = 0.143000

Diameter/Width = 0.031500

Length = 0.157000

Height = 0.031500

name = Bracket 5

quantity = 1

parent = 1

materialID = 9

type = Box

Aero Mass = 0.475000

Thermal Mass = 0.475000

Diameter/Width = 0.068000

Length = 0.093000

Height = 0.050000

name = Mounting Plate

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 0.094000

Thermal Mass = 0.094000

Diameter/Width = 0.102000

Length = 0.105000

name = Bracket 6

quantity = 2

parent = 1

materialID = 9

type = Box

Aero Mass = 0.093000

Thermal Mass = 0.093000

Diameter/Width = 0.065000

Length = 0.073000

Height = 0.037200

name = Mounting Plate 2

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 0.244000

Thermal Mass = 0.244000

Diameter/Width = 0.150000

Length = 0.150000

name = GPS Interface Board

quantity = 1

parent = 1

materialID = 23

type = Box

Aero Mass = 0.032000

Thermal Mass = 0.032000

Diameter/Width = 0.054000

Length = 0.058100

Height = 0.014520

name = GPS Antenna

quantity = 1

parent = 1

materialID = 5

type = Cylinder

Aero Mass = 0.037000

Thermal Mass = 0.037000

Diameter/Width = 0.048000

Length = 0.016000

name = Fixed Solar Panel

quantity = 1

parent = 1

materialID = 23

type = Flat Plate

Aero Mass = 0.440000

Thermal Mass = 0.440000

Diameter/Width = 0.280000

Length = 0.426500

name = Deployable Solar Panel

quantity = 2

parent = 1

materialID = 23

type = Flat Plate

Aero Mass = 0.377000

Thermal Mass = 0.377000

Diameter/Width = 0.197700

Length = 0.406700

name = Primary Base Plate

quantity = 1

parent = 1

materialID = 9

type = Flat Plate

Aero Mass = 2.709000

Thermal Mass = 2.709000

Diameter/Width = 0.438000

Length = 0.438000

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

Item Number = 1

name = Droid.001

Demise Altitude = 77.995071

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheels

Demise Altitude = 74.094383

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = S-band 1

Demise Altitude = 77.846817

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = S-band 2

Demise Altitude = 77.762276

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Magnetorquer Coil

Demise Altitude = 76.760910

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = S-band Antenna

Demise Altitude = 74.490334

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Separation System

Demise Altitude = 77.310318

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Payload 1

Demise Altitude = 71.139229

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery

Demise Altitude = 76.410439

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Solar Panel Structural Frame

Demise Altitude = 77.432976

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = X-band Transmitter

Demise Altitude = 76.625984

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = X-band Antenna

Demise Altitude = 76.843155

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Propulsion System
Demise Altitude = 68.599060
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Flight Computer
Demise Altitude = 77.146950
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload Controller
Demise Altitude = 76.836517
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Magnetometer
Demise Altitude = 77.872162
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Star Tracker
Demise Altitude = 75.888046
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Star Track Processing Unit

Demise Altitude = 72.021904

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Sun Sensor

Demise Altitude = 77.518822

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = IMU

Demise Altitude = 75.112656

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bay Dividing Plate

Demise Altitude = 74.374207

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Wall Plate 1

Demise Altitude = 76.019707

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Wall Plate 2

Demise Altitude = 75.858856

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Wall Plate 3

Demise Altitude = 75.824089

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Wall Plate 4

Demise Altitude = 75.595207

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Primary Support Rib

Demise Altitude = 76.286568

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Secondary Support Rib 1

Demise Altitude = 76.202370

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Secondary Support Rib 2

Demise Altitude = 75.274658

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Lib Plate

Demise Altitude = 73.132767

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Bracket 1

Demise Altitude = 76.005753

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Bracket 2

Demise Altitude = 76.340088

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = Bracket 3

Demise Altitude = 75.619484

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bracket 4

Demise Altitude = 76.125206

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bracket 5

Demise Altitude = 72.783127

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Mounting Plate

Demise Altitude = 76.497643

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bracket 6

Demise Altitude = 76.419228

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Mounting Plate 2

Demise Altitude = 75.730873

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
name = GPS Interface Board
Demise Altitude = 77.262901
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = GPS Antenna
Demise Altitude = 75.809624
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Fixed Solar Panel
Demise Altitude = 77.174553
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Deployable Solar Panel
Demise Altitude = 77.106117
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Primary Base Plate
Demise Altitude = 71.829819
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

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

8. ================ End of Requirement 4.5-2 ================Special Classes of Space Missions

Not applicable.

END OF ODAR FOR TURION SPACE