Attachment 2

YAC-1 Orbital Debris Assessment Report (ODAR)

YAC-1-ODAR-1.2

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

Loft Orbital Solutions Inc. (Loft Orbital)

321 11th Street
San Francisco, CA 94103

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Debris Assessment Software (DAS) version used in analysis: v3.2.7

Revision Record				
Revision:	Date:	Affected Pages:	Changes:	Author(s):
1.0	8/22/2023	All – Initial	DAS Software Results Orbit Lifetime Analysis	D. Morse

1.1	7/31/2024	All	Updated to DAS 3.2.6, changed operating orbit	D. Morse
1.2	11/4/2024	Small changes throughout	Updated operational orbit	D. Morse
1.3	5/22/2026	Small changes throughout	Updated to DAS 3.2.7, updated operational orbit for six satellites	D. Morse

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 Loft Orbital satellite ("YAC-1"). Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

1. Program Management and Mission Overview

Loft Orbital (Loft) is a U.S. company headquartered in San Francisco, California.

Program Manager

- Jake Ingram

Senior Management

- Alexander B. Greenberg (Co-founder & Chief Operating Officer)

Foreign Government or Space Agency Participation

- None

Mission Overview

This ODAR supports the Loft Orbital application seeking authority to operate six of ten YAC-1 spacecraft at a 638.7 +/- 5 km x 624 +/- 5 km orbital altitude with an inclination of ~97.911 degrees at an LTDN of 10:30 (+/- 5 minutes).[1] The constellation is expected to be launched on multiple SpaceX Transporter missions. The exact deployment orbit altitudes will not be known until shortly before the launch, but the launch agreement offers a range of approximately 500-600 km with an insertion accuracy of ±20 km, resulting in an effective launch insertion range of 480-620 km. Following deployment, the YAC-1 spacecraft will be relocated to their operational orbit. The transition to the operational orbit depends upon the parameters of the insertion orbit.

Analysis indicates that the maximum time to achieve the planned operational orbit could be as much as 365 days (under worst-case conditions) and will involve a significant duration in a “drift” orbit to achieve the desired LTDN must be drifted. At the end of mission (EOM), the spacecraft will be deorbited to a circular orbit of approximately 440 km and then passivated.

Launch

[1] The other four satellites will operate under existing authorized orbital parameters.

Eight of the YAC-1 spacecraft have been launched and are in-orbit. The remaining satellites are expected to launch on rideshare missions soon.

Operating Parameters

The six spacecraft are expected to operate at the following new target orbital parameters:[2]

- Apogee: 638.7 km nominal ± 5 km
- Perigee: 624 km nominal ± 5 km
- Target Inclination: 97.911° ± 1.0°
- LTDN: 10:30 ± 5 minutes

YAC-1 has on-board propulsion and therefore does actively change its orbit. During the mission, station keeping will be employed to maintain the orbital configuration.

Mission Duration

The anticipated operational lifetime of YAC-1 is 7.0 years (with a goal of 10 years) after which a post-mission disposal (PMD) maneuver will be conducted to bring the orbit altitude to 440 km circular (above the ISS orbit).

2. Spacecraft Description

Physical description of the spacecraft

Physical description of the constellation: The YAC-1 spacecraft are based on the AOS Arrow bus originally developed by Airbus for the OneWeb broadband telecommunications company. Basic physical dimensions are 1200 mm x 1052 mm x 1036 mm with a mass of approximately 216 kg. The satellite is composed of the Airbus OneWeb bus and the Loft Payload Hub. The solar panels generate 500-550W of orbit average electric power which is stored in a 51Ah COTS Li-Ion unpressurized battery assembly. The bus is 3-axis stabilized, employing star trackers, magnetometers, GPS, and sun sensors for attitude knowledge and reaction wheels and torque rods for attitude control. The YAC-1 spacecraft is depicted in Figure 1.

[2] *See supra* note 1.

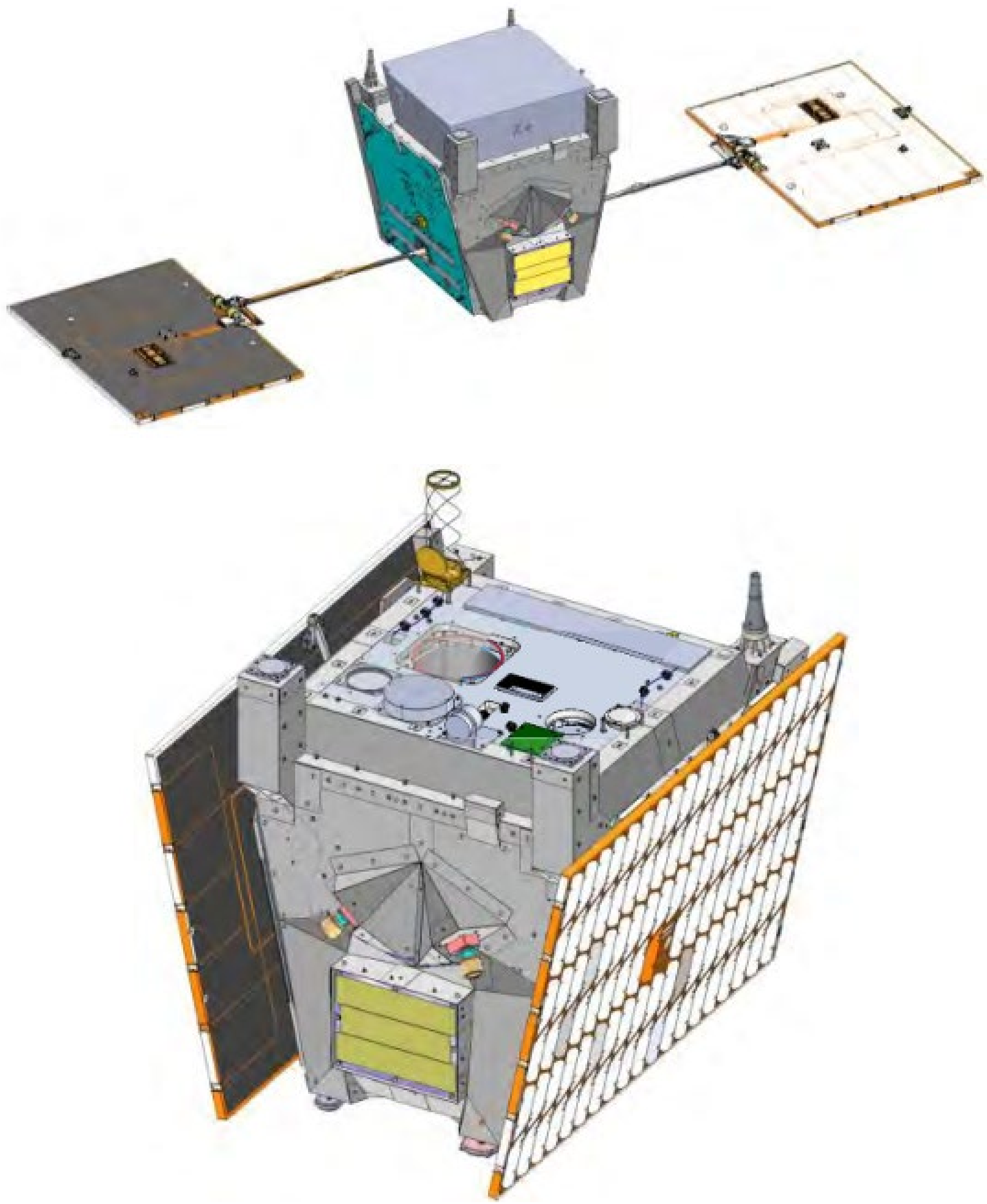

Figure 1. YAC-1 Spacecraft Configuration

Spacecraft Mass

- Wet Mass: 216 kg

- Dry Mass: 202 kg (tank is capable of handling up to 14kg of propellant, and this analysis assumes a worst-case scenario of carrying a full propellant load)

Description of propulsion system

The YAC-1 spacecraft will include a BUSEK, BHT-350 Xenon-Ion Hall Effect Thruster (Xenon HET). The Xenon tank capacity is 14 kg max tank capacity (incl. residuals), and these spacecraft are expected to carry a full tank of 14 kg of propellant. The HET total impulse is 133 kNs and provides a thrust of 13.6 mN @ 954.8s of ISP, assuming 14 kg of propellant.

Fluids Planned to be On-board

0.351 kg of ammonia in sealed heat pipes.

Up to 14 kg Xenon propellant, max of 14 kg assumed for the YAC-1 spacecraft.

Fluids in Pressurized Batteries: None

The YAC-1 satellite uses unpressurized standard COTS Lithium-Ion batteries. Total unit dimensions are 338 mm x 275 mm x 120 mm and mass of 9.648 kg.

Attitude Control System:

The long axis of the YAC-1 spacecraft can be oriented parallel to the nadir vector during imaging or other payload operations, but the satellite will typically be oriented in a nadir-pointing attitude.

The YAC-1 spacecraft attitude will be controlled initially by torque rods, which will allow the satellite to be aligned relative to the Earth's magnetic field. These will allow the satellite to detumble and align with the magnetic field.

- A *safe mode* is optimized for solar power generation from the satellite. The spacecraft's deployable panel will be oriented towards the sun. This mode will make use of magnetometers, sun sensors, reaction wheels, and magnetic torquers to orient the spacecraft correctly.

- A *targeted tracking mode* will allow the satellite Nadir panel to be directed at any location on the Earth's surface. This mode will make use of reaction wheels and a star tracker to orient the spacecraft.
- An *LVLH mode* keeps the Nadir panel pointed towards the Earth's surface. This mode will make use of reaction wheels and a star tracker to orient the spacecraft. This is the primary ACS mode of the YAC-1 spacecraft during nominal operations.

Description of any range safety or other pyrotechnic devices

None. The YAC-1 spacecraft will be separated from the launch vehicle using a deployer with debris free actuation.

Description of the electrical generation and storage system

Standard COTS Li-Ion battery cells are charged before payload integration and provide 51 Ah of electrical energy during the eclipse portion of the satellite's orbit. Six strings of 18/19 GaAs solar cells generate average on-orbit power of approximately 500-550 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 will be disconnected from power at the 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 10 cm. Thus, it is 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 Loft Orbital 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 $18^{th}/19^{th}$ Space Defense Squadron (SDS).

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 $18^{th}/19^{th}$ SDS 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:

Loft intends to provide the $18^{th}/19^{th}$ SDS 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). Loft Orbital 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 YAC-1. 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 credibleto 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

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 (7) independent, mutually exclusive failure modes to lead to explosion. In addition to the battery protection mentioned above, the YAC-1 battery unit features two temperature sensors which monitor battery cells for high temperatures.

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

- **Reaction Wheels** – reaction wheels will be spun down and the spacecraft will be controlled via toque rods.

- **Sealed Heat Pipes** – no passivation is planned or required.
- **Batteries** – batteries will be drawn down and then isolated from the EPS to passivate at EOM, once satellite has been deorbited and any remaining propellant has been vented.

Rationale for Non-Passivation

N/A

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).*

***Compliance Statement*:**

Required Probability: 0.001

Expected probability: 0.000; COMPLIANT.

Supporting Rationale and FMEA details:

Battery explosion:

Effect: All failure modes below might theoretically 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, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

Probability: Extremely Low. It is believed to be a much 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.

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 effects 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 which are 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 overcurrent 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:** YAC-1's battery charge circuits include overcharge protection and a parallel design to limit the risk of battery failure. However, in the unlikely event that battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

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

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: 1.5860E-04

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:**

Small Object Impact and Debris Generation Probability: Because the spacecraft must rely upon propulsion to meet the 5-year deorbit, a collision with small objects analysis was conducted to demonstrate that the probability of collision with small objects has less than a 0.01 probability of preventing a deorbit maneuver at the end of life. This analysis makes conservative assumptions regarding which components have critical surfaces and the effective cross-sectional areas of these critical surfaces. The bus supplier provided a deorbit reliability analysis. From this analysis, all single point failure components were included in the collision with small object analysis. The satellite will be operated during the majority of the mission in a 3-axis stabilized orientation with the +X panel in the direction of motion (referred to as V in the NASA DAS User Guide). Also, the +Z panel (referred to as U in the NASA DAS User Guide) reflects the Zenith surface of the satellite, thus the -Z panel reflects the Nadir surface. The highest critical surface risk of collision with small objects is the battery which is mounted outside of the +X panel. One could easily argue that the battery assembly should not even be included in this analysis, given that it is composed of a large number of redundant battery cells. Out of an abundance of caution, the battery assembly was included in the analysis and further the cross-sectional area of the battery assembly critical surface reflects 50% of the cross-sectional area of battery assembly box. While it would stand to reason that there may be some circuits in the battery assembly which could disable the spacecraft if penetrated by a small object, the fraction of the overall surface area which would reflect an actual critical surface would likely reflect no more than 1-5% of the surface area of the entire battery assembly.

This same general approach was also used for the following electronic components: flight computer (which is also redundant), other electronics (most of which are not critical surfaces), propulsion system, GPS, TT&C, SADA, and PCDU. For each of these electronic assemblies, the assumed area of the critical surface was the cross-section area of the assembly. The list of components/assemblies containing or reflecting a critical surface, the mounting location, and the effective surface area used in the DAS model are listed below in Figure 1. The collision probability with small objects was estimated by the DAS software to be no more than 0.0060267 assuming a worst-case 10-year mission life followed by a post-mission disposal (PMD) maneuver down to 440 km circular orbit altitude.

Component	Mounting Location	Interior vs. Exterior	Surface Area (m^2)
Propellant Tank	-X Panel	Interior	0.08
Thruster	-X Panel	Exterior	0.015
XFS	-X Panel	Interior	0.015
PPU	-X Panel	Interior	0.08
GPS Antennas	+Z Panel	Exterior	0.0032
GPS LNA	+Z Panel	Interior	0.0032
TT&C Antenna	+Z/-Z Panel	Exterior	0.01
Flight Computer	+Z Panel	Interior	0.004
Other Electronics	+Z Panel	Interior	0.02
PCDU	+Z Panel	Interior	0.047
Battery	+X Panel	Exterior	0.069
TT&C Hybrid Coupler	+X Panel	Exterior	0.0012
SADA	+Z Panel	Interior	0.0072

Figure 1 Collision With Small Objects - Critical Surfaces

Since the YAC-1 satellites require propulsion in order to meet the 5-year deorbit requirement, a further analysis is required to demonstrate that the reliability of being able to conduct a PMD is at least 90% with a goal of 99%. The bus supplier conducted a detailed deorbit reliability analysis and determined that the bus reliability is 97% at end of mission. Details of the deorbit reliability analysis are provided in Figure 2 below.

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

Loft will engage with USSPACECOM to coordinate collision avoidance activities.

	Space-Track Criteria	Emergency Criteria
Notification Method	Conjuction Data Message (CDM)	Conjuction Data Message (CDM) & Close Approach Notification (CAN) email
Near Earth: HAC	TCA ≤ 3 days and Overall miss ≤ 1 km and Probability of Collision ≥ 1E-07	TCA ≤ 3 days and Overall miss ≤ 1 km and Probability of Collision ≥ 1E-04
Near Earth O/O Ephemeris	TCA ≤ 3 days and Overall miss ≤ 1 km and Probability of Collision ≥ 1E-07	TCA ≤ 3 days and Overall miss ≤ 1 km and Probability of Collision ≥ 1E-04

Loft has analyzed the updated processes and protocols at USSPACECOM with the 18th and 19th Space Defense Squadrons roles and responsibilities. In the context of receiving CDM and CAN emails, and in close coordination with USSSPACECOM and other operators, Loft intends to alter the orbit altitude at TCA of the YAC-1 spacecraft to facilitate conjunction/collision avoidance.

Prior to launch, Loft will coordinate with the 18th/19th SDS to share critical information about the propulsion capabilities and the differential drag capabilities of the YAC-1 satellites. Following launch and deployment, Loft will conduct a complete checkout of each YAC-1 satellite, including evaluation of the HET propulsion system. Depending upon the outcome of each initial checkout, Loft will update 18th/19th SDS about the maneuvering capabilities of the YAC-1 satellites.

Upon receipt of a conjunction data message (CDM), Loft will submit updated ephemeris information to Space-track.org for review by 18th/19th SDS. This will take place within four hours of receipt of the CDM message. If the CDM indicates that the risk of conjunction is with another operational satellite, Loft will also contact the other satellite operations team within 8 hours of receipt of the CDM, realizing that the other team may not respond promptly. The purpose of this outreach, for each CDM, is to maximize the time for responsive action and to allow for a wider range of responses. CDM are typically issued 72 hours prior to the time of closest approach (TCA).

Response when a risk threshold is reached:

Upon submission of updated YAC-1 ephemeris data to 18th/19th SDS, the assessment on probability of collision (Pc) will be refined at 18th/19th SDS. If the Pc drops based on higher fidelity orbit information, then no further actions will be needed in response to that CDM. Loft assumes that an updated Pc will be received within 8 hours of providing update ephemeris, given the 8-hour cycle for Concern List screenings. Assuming a CDM 72-hours before TCA, the Loft process should allow a refined determination if action is required 60 hours before TCA. In light of the fact that the proposed orbit change maneuvers must be started at least 2.5 hours before TCA, this provides 57.5 hours to coordinate optimum maneuver planning between all affected parties and to monitor the evolution of the Pc calculations to determine if any collision avoidance maneuver is even warranted.

If the Pc stays the same or increases, after 18th/19th SDS incorporates the latest ephemeris into its evaluation, then Loft will take further actions, which will be predicated on collaboration with any other affected satellite operators and based on analysis of the projected new space track of the appropriate YAC-1 satellite that would come from proposed collision avoidance maneuvers. Loft will adjust its projected orbit to avoid collisions. If the other satellite operator identified by the CDM concurs with Loft that its satellite's orbit should be adjusted, and that is the only object that is the subject of the CDM, then Loft will take no action and monitor the situation to accommodate the other satellite operator's collision avoidance maneuver.

When Loft determines that the proper course of action is to adjust the orbit/trajectory of the applicable YAC-1 satellite, it will take the following steps:

The first step is to review the current threat risk with updated information from 18th/19th SDS. The threshold for initiating the following maneuvers is: Pc > 1e-4. In the event that the Pc exceeds that threshold, then Loft will work through the options below, at each point checking with 18th/19th SDS to ensure that the proposed response will not cause any further risks of collision prior to engaging in the actions:

- Loft will conduct two 20-minute propulsion maneuvers, phased ½ half orbit apart to either raise or lower the orbit altitude by up to 500 m (whichever will be most effective at reducing Pc) at the Time of Closest Approach (TCA). These propulsion maneuvers can be executed as late as 1.5 orbits (less than 2.5 hours) before TCA. Moving the orbit altitude by 500 m should be sufficient to reduce Pc < 1e-4 in most or all circumstances. Of course, Loft will conduct a maneuver based upon guidance from the 18th/19th SDS which in most cases may require far less delta-V to reduce the Pc to an optimum (or sufficiently safe) value.
- In the event that the Loft YAC-1 propulsion capability is not operational, Loft orbital will coordinate with the 18th/19th SDS to provide information regarding the YAC-1 satellite's ability to employ differential drag to alter its trajectory. Obviously, such an approach will be slower and significantly less effective than employing electric propulsion, but the YAC-1 satellites have deployable solar arrays which enable a significant difference between the minimum and maximum drag configurations.

Throughout this process, Loft will remain in active communication with 18th/19th SDS to ensure that its responses are reviewed and assessed. Loft will continue to take steps throughout the process to avoid conjunctions between YAC-1 satellites and other space objects.

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

After the end of its operational life, the YAC-1 spacecraft will be actively deorbited to just above the ISS orbit, passivated, and allowed to passively deorbit through the ISS orbit[3]. As can be seen in Figure 3 below, the orbit stays nearly circular, thus limiting the period of time when conjunctions with the ISS may occur.

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 space situational awareness conjunction warning, Loft 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 in order to avoid a collision. The YAC-1 spacecraft have maneuvering capabilities and will employ those capabilities to adjust their orbit to address potential conjunctions, as described above.

6. Spacecraft Post-mission Disposal Plans and Procedures

Description of spacecraft disposal option selected

Consistent with NASA-STD 8719.4C, the YAC-1 spacecraft will be disposed of via atmospheric reentry, following a post-mission disposal (PMD) maneuver. The PMD maneuver should take approximately 3-6 months to complete.

Systems or Components Required to Accomplish Post-mission Disposal Maneuvers

The subsystems required for deorbit are listed in the reliability analysis shown below in Figure 2.

[3] Loft understands that NASA would prefer not to have spacecraft actively deorbit through the ISS orbit as this reduces NASA's ability to accurately predict conjunctions with the ISS.

Subsystem/Equipment	Red	m	n	p	Deorbitation	Conf change wrt SK
TOTAL BUS					0,970 434	
AOCS					0,998 845	
Reaction Wheel (RW)	HOT	3	4	1	0,998 948	
Magnetometer (MM)	COLD	1	2	1	1,000 000	
Magnetotorquer (MT)	COLD	1	2	1	1,000 000	
Star Tracker (OH)	HOT	1	2	1	0,999 897	
Coarse Sun Sensor (CSS)	COLD	1	2	2	1,000 000	
GPS	COLD	1	2	1	0,999 999	
GPS LNA	SPF	1	1	1	0,999 987	
GPS Antenna	SPF	1	1	1	0,998 828	
Processing					0,999 803	
OBC	HOT	1	2	1	0,999 828	x
OBC	HOT	1	2	1	0,999 976	
Power Supply					0,990 174	
PCDU: SA sections	HOT	5	6	1	0,999 997	
PCDU: whole distrib	SPF	1	1	1	0,993 593	
PCDU: TM/TC channels	HOT	1	2	1	0,999 997	
Battery					0,999 819	
Solar Array	HOT	5	6	1	0,999 917	
SADA-A	COLD	1	2	1	0,999 999	
SADA-B	SPF	1	1	2	0,996 829	
Mechanism					0,998 819	
SADS	SPF	1	1	1	0,998 728	
TT&C (Ground / Space)					0,999 203	
TTC (Rx + Tx channels)	HOT	1	2	1	0,999 281	
Coupler	SPF	1	1	1	0,999 986	
TM/TC antenna	SPF	1	1	2	0,999 936	
Thermal Control					0,999 999	
Heaters (bus unit)	HOT	1	2	9	1,000 000	
Heaters (PAM)	HOT	1	2	3	1,000 000	
Thermistors	HOT	1	2	22	0,999 999	
PROPULSION					0,983 335	
PPU	SPF	1	1	1	0,997 474	
HET (thruster)	SPF	1	1	1	0,991 890	
XFS	SPF	1	1	1	0,993 887	
Tank	SPF	1	1	1	0,999 972	

Figure 2 Deorbit Reliability Analysis

Post-mission Disposal Maneuver Plan

At end of mission, the YAC-1 spacecraft will be deorbited to a 440 km circular orbit.

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.

YAC-1 area-to-mass ratio calculation:

- Spacecraft mass: 216 kg (wet mass)
- Cross-sectional area: 2.607 m^2 (average)
- Area-to-mass ratio: 0.012071 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 YAC-1 satellite reentry is COMPLIANT. From the PMD orbit of 440 x 440 km, the YAC-1 spacecraft will passively deorbit in ~6 months with orbit history as shown in Figure 3.

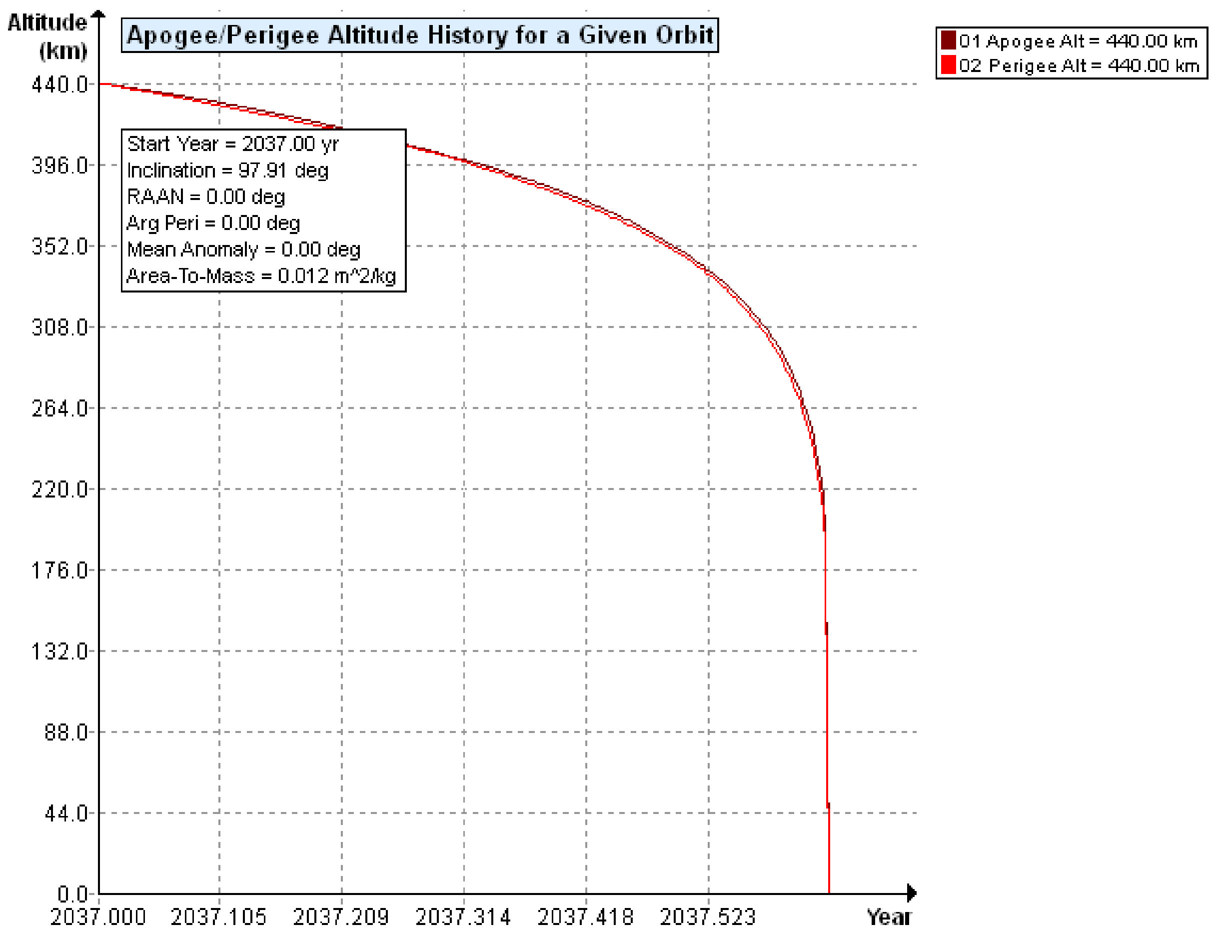

Figure 3. Orbital Decay Profile from PMD Orbit

From the maximum deployment orbit of 643.7 km x 629 km SSO, the passive deorbit time is under 21.5 years[4]. The start date of 2027 was selected to capture a reasonable beginning of mission time at the operational orbit.

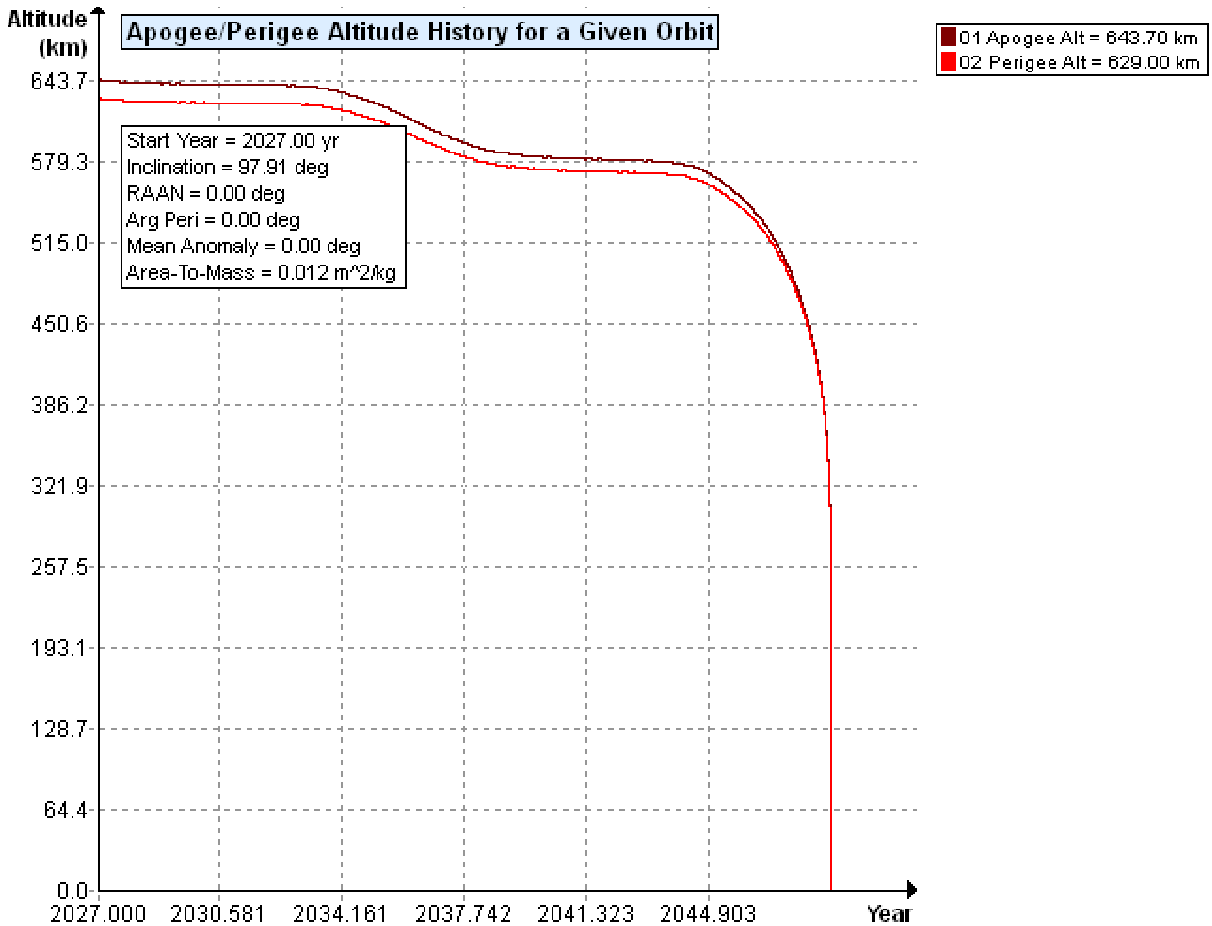

Figure 4. Orbital Decay Profile from Operational Orbit

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

[4] This analysis is intended to reflect the outcome should a YAC-1 spacecraft lose the ability to conduct a PMD maneuver after deployment.

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

- **Compliance Statement:** As shown in Figure 2 above, the reliability of the PMD maneuver at the end of mission is 97%.

7. Spacecraft Reentry Hazards

Summary of objects expected to survive uncontrolled reentry

DAS v3.2.7 reports that YAC-1 is compliant with the requirement with acceptable risk of human casualty. As shown below, one component, the Titanium Bipods, may survive reentry with energy greater than 15 joules.

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 1:54,700.
- The Titanium bipods (x3) will reach the Earth's surface with a combined casualty area of 1.43m^2 and a kinetic energy of ~190J.
    - Titanium was selected for the bipods for its mechanical properties taking into account various design requirements and constraints.

Requirement 4.7-1(b):

- **Compliance Statement:** Not applicable since controlled reentry is not an element of the end of mission disposal plan.

Requirement 4.7-1(c):

- **Compliance Statement:** Not applicable since controlled reentry is not an element of the end of mission disposal plan.

8. Special Classes of Space Missions

Not applicable.

Analysis using DAS v3.2.7

07 03 2026; 10:40:53AM Project Data Saved To File

07 03 2026; 10:40:59AM Processing Requirement 4.3-1: Return Status : Not Run

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

No Project Data Available

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

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

07 03 2026; 10:41:01AM Processing Requirement 4.3-2: Return Status : Passed

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

No Project Data Available

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

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

07 03 2026; 11:22:22AM Processing Requirement 4.5-1: Return Status : Passed

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

Run Data

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

****INPUT****

Space Structure Name = M0

Space Structure Type = Payload

Perigee Altitude = 629.000 (km)

Apogee Altitude = 643.700 (km)

Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass Ratio = 0.0121 (m^2/kg)

Start Year = 2026.600 (yr)

Initial Mass = 216.000 (kg)

Final Mass = 202.000 (kg)

Duration = 7.000 (yr)

Station-Kept = True

PMD Perigee Altitude = 440.000 (km)

PMD Apogee Altitude = 440.000 (km)

PMD Inclination = 97.911 (deg)

PMD RAAN = 0.000 (deg)

PMD Argument of Perigee = 0.000 (deg)

PMD Mean Anomaly = 0.000 (deg)

Long-Term Reentry = False

****OUTPUT****

Collision Probability = 1.5860E-04

Returned Message: Normal Processing

Date Range Message: Normal Date Range

Status = Pass

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

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

07 03 2026; 11:23:14AM Project Data Saved To File

07 03 2026; 11:34:41AM Requirement 4.5-2: Compliant

===

Spacecraft = M0

Critical Surface = Tank

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0800 (m^2)

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

CS Pressurized = Yes

Outer Wall 1 Density: 0.360 (g/cm^2) Separation: 0.100 (cm)

Outer Wall 2 Density: 1.080 (g/cm^2) Separation: 1.000 (cm)

****OUTPUT****

Probability of Penetration = 4.1626E-07 (4.1626E-07)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = Thruster

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 1.350 (g/cm^2)

CS Surface Area = 0.0150 (m^2)

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

CS Pressurized = No

****OUTPUT****

Probability of Penetration = 5.1386E-07 (5.1386E-07)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = Computer

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0040 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 1.620 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2   Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 1.1391E-07 (1.1391E-07)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = OtherElectronics

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0200 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 1.620 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2   Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 5.6954E-07 (5.6954E-07)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = Battery

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0034 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 1.947 (g/cm^2) Separation: 1.000 (cm)

****OUTPUT****

Probability of Penetration = 5.3686E-03 (5.3831E-03)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = PCDU

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0469 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 1.620 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2   Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 1.3349E-06 (1.3349E-06)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = GpsAntenna1

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.360 (g/cm^2)

CS Surface Area = 0.0016 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 0.540 (g/cm^2) Separation: 0.500 (cm)

****OUTPUT****

Probability of Penetration = 1.1542E-05 (1.1542E-05)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = GpsAntenna2

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.360 (g/cm^2)

CS Surface Area = 0.0016 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 0.540 (g/cm^2) Separation: 0.500 (cm)

****OUTPUT****

Probability of Penetration = 1.1542E-05 (1.1542E-05)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = TTCAntenna

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.360 (g/cm^2)

CS Surface Area = 0.0100 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 0.540 (g/cm^2) Separation: 0.500 (cm)

****OUTPUT****

Probability of Penetration = 7.2137E-05 (7.2140E-05)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = XFS

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.360 (g/cm^2)

CS Surface Area = 0.0150 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 1.776 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2   Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 1.4130E-08 (1.4130E-08)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = PPU

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0800 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 1.620 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2   Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 7.1754E-08 (7.1754E-08)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = SADA

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.540 (g/cm^2)

CS Surface Area = 0.0072 (m^2)

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

CS Pressurized = No

Outer Wall 1 Density: 2.730 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2 Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 2.7081E-08 (2.7081E-08)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = Coupler

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.270 (g/cm^2)

CS Surface Area = 0.0012 (m^2)

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

CS Pressurized = No

Outer Wall 1 Density: 1.620 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2 Density: 0.270 (g/cm^2) Separation: 2.000 (cm)

****OUTPUT****

Probability of Penetration = 4.8611E-04 (4.8622E-04)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = TTCAntenna2

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.360 (g/cm^2)

CS Surface Area = 0.0100 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 0.540 (g/cm^2) Separation: 0.500 (cm)

****OUTPUT****

Probability of Penetration = 7.2137E-05 (7.2140E-05)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

===

Spacecraft = M0

Critical Surface = GPSLNA

===

****INPUT****

Apogee Altitude = 643.700 (km)

Perigee Altitude = 629.000 (km)

Orbital Inclination = 97.911 (deg)

RAAN = 0.000 (deg)

Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)

Final Area-To-Mass = 0.0121 (m^2/kg)

Initial Mass = 202.000 (kg)

Final Mass = 202.000 (kg)

Station Kept = Yes

Start Year = 2026.600 (yr)

Duration = 7.000 (yr)

Orientation = Fixed Oriented

CS Areal Density = 0.360 (g/cm^2)

CS Surface Area = 0.0032 (m^2)

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

CS Pressurized = No

Outer Wall 1   Density: 0.270 (g/cm^2) Separation: 1.000 (cm)

Outer Wall 2   Density: 0.270 (g/cm^2) Separation: 0.500 (cm)

****OUTPUT****

Probability of Penetration = 5.2681E-06 (5.2681E-06)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

=============== End of Requirement 4.5-2 ===============

07 03 2026; 11:35:36AM   Processing Requirement 4.6 Return Status : Passed

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

Project Data

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

****INPUT****

Space Structure Name = M0

Space Structure Type = Payload

Perigee Altitude = 629.000000 (km)

Apogee Altitude = 643.700000 (km)

Inclination = 97.911000 (deg)

RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)

Mean Anomaly = 0.000000 (deg)

Area-To-Mass Ratio = 0.012071 (m^2/kg)

Start Year = 2026.600000 (yr)

Initial Mass = 216.000000 (kg)

Final Mass = 202.000000 (kg)

Duration = 7.000000 (yr)

Station Kept = True

Abandoned = False

Long-Term Reentry = False

****OUTPUT****

Suggested Perigee Altitude = 440.000000 (km)

Suggested Apogee Altitude = 440.000000 (km)

Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2034 (yr)

Requirement = 61

Compliance Status = Pass

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

****INPUT****

Space Structure Name = M0-DOA

Space Structure Type = Payload

Perigee Altitude = 629.000000 (km)

Apogee Altitude = 643.700000 (km)

Inclination = 97.911000 (deg)

RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)

Mean Anomaly = 0.000000 (deg)

Area-To-Mass Ratio = 0.012071 (m^2/kg)

Start Year = 2026.600000 (yr)

Initial Mass = 216.000000 (kg)

Final Mass = 202.000000 (kg)

Duration = 7.000000 (yr)

Station Kept = True

Abandoned = True

PMD Perigee Altitude = 629.000000 (km)

PMD Apogee Altitude = 643.700000 (km)

PMD Inclination = 97.911000 (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 = 629.000000 (km)

Suggested Apogee Altitude = 643.700000 (km)

Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2049 (yr)

Requirement = 61

Compliance Status = Pass

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

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

07 03 2026; 11:35:40AM *********Processing Requirement 4.7-1

Return Status : Passed

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

Item Number = 1

name = M0

quantity = 1

parent = 0

materialID = 5

type = Box

Aero Mass = 202.000000

Thermal Mass = 202.000000

Diameter/Width = 1.000000

Length = 1.000000

Height = 1.000000

name = Spacecraft_OW

quantity = 1

parent = 1

materialID = 5

type = Box

Aero Mass = 124.599000

Thermal Mass = 15.000000

Diameter/Width = 0.750000

Length = 0.750000

Height = 0.750000

name = Walls

quantity = 6

parent = 2

materialID = 5

type = Flat Plate

Aero Mass = 1.685000

Thermal Mass = 1.685000

Diameter/Width = 0.780000

Length = 0.780000

name = Payload Antenna

quantity = 2

parent = 2

materialID = 5

type = Box

Aero Mass = 12.350000

Thermal Mass = 12.350000

Diameter/Width = 0.400000

Length = 0.700000

Height = 0.100000

name = Electronic Boxes

quantity = 6

parent = 2

materialID = 5

type = Box

Aero Mass = 2.385000

Thermal Mass = 2.385000

Diameter/Width = 0.125000

Length = 0.375000

Height = 0.063000

name = SPT Thruster Baseplate

quantity = 1

parent = 2

materialID = 66

type = Flat Plate

Aero Mass = 0.037000

Thermal Mass = 0.037000

Diameter/Width = 0.120000

Length = 0.140000

name = SPT XFS Steel

quantity = 1

parent = 2

materialID = 58

type = Box

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.100000

Length = 0.150000

Height = 0.050000

name = SPT Ceramic

quantity = 1

parent = 2

materialID = 40

type = Cylinder

Aero Mass = 0.040000

Thermal Mass = 0.040000

Diameter/Width = 0.030000

Length = 0.022000

name = Tank Carbon

quantity = 1

parent = 2

materialID = -1

type = Cylinder

Aero Mass = 2.332000

Thermal Mass = 0.745000

Diameter/Width = 0.160000

Length = 0.500000

name = Tank Shell

quantity = 1

parent = 9

materialID = 5

type = Cylinder

Aero Mass = 1.587000

Thermal Mass = 1.587000

Diameter/Width = 0.156000

Length = 0.500000

name = Reaction Wheel

quantity = 4

parent = 2

materialID = 58

type = Cylinder

Aero Mass = 2.500000

Thermal Mass = 2.500000

Diameter/Width = 0.065000

Length = 0.095000

name = Battery

quantity = 1

parent = 2

materialID = 5

type = Box

Aero Mass = 9.500000

Thermal Mass = 9.500000

Diameter/Width = 0.230000

Length = 0.300000

Height = 0.100000

name = SADA

quantity = 1

parent = 2

materialID = 58

type = Cylinder

Aero Mass = 0.700000

Thermal Mass = 0.700000

Diameter/Width = 0.022000

Length = 0.230000

---

name = Optical Bench

quantity = 1

parent = 2

materialID = 8

type = Box

Aero Mass = 11.190000

Thermal Mass = 11.190000

Diameter/Width = 0.645000

Length = 0.658000

Height = 0.066000

name = Bipod

quantity = 3

parent = 2

materialID = 65

type = Box

Aero Mass = 0.560000

Thermal Mass = 0.560000

Diameter/Width = 0.127000

Length = 0.187000

Height = 0.056000

name = Heat Pipe

quantity = 4

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.023000

Thermal Mass = 0.023000

Diameter/Width = 0.097000

Length = 0.487000

name = Thermal Strap

quantity = 16

parent = 2

materialID = 8

type = Box

Aero Mass = 0.157000

Thermal Mass = 0.157000

Diameter/Width = 0.036000

Length = 0.170000

Height = 0.033000

name = VNIR - Baffle Tube

quantity = 12

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.134000

Thermal Mass = 0.134000

Diameter/Width = 0.145000

Length = 0.211000

name = VNIR - Primary Cell

quantity = 12

parent = 2

materialID = 72

type = Cylinder

Aero Mass = 0.429000

Thermal Mass = 0.429000

Diameter/Width = 0.120000

Length = 0.076000

name = VNIR - Spider

quantity = 12

parent = 2

materialID = 72

type = Cylinder

Aero Mass = 0.279000

Thermal Mass = 0.279000

Diameter/Width = 0.133000

Length = 0.092000

name = VNIR - Interface Ring to Bench

quantity = 12

parent = 2

materialID = 8

type = Box

Aero Mass = 0.221000

Thermal Mass = 0.221000

Diameter/Width = 0.166000

Length = 0.166000

Height = 0.033000

name = SWIR - Baffle Tube

quantity = 2

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.148000

Thermal Mass = 0.148000

Diameter/Width = 0.102000

Length = 0.195000

name = SWIR - Optical Barrel Tube

quantity = 2

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.105000

Thermal Mass = 0.105000

Diameter/Width = 0.073000

Length = 0.081000

name = SWIR - Mount Extension

quantity = 2

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.179000

Thermal Mass = 0.179000

Diameter/Width = 0.098000

Length = 0.075000

name = TIR - Baffle

quantity = 2

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.214000

Thermal Mass = 0.214000

Diameter/Width = 0.122500

Length = 0.118000

name = TIR - Baffle Interface

quantity = 2

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.255000

Thermal Mass = 0.255000

Diameter/Width = 0.140000

Length = 0.112000

name = TIR - OTA Barrel

quantity = 2

parent = 2

materialID = 8

type = Cylinder

Aero Mass = 0.202000

Thermal Mass = 0.202000

Diameter/Width = 0.089000

Length = 0.101000

name = TIR - Telescope Interface Ring

quantity = 2

parent = 2

materialID = 8

type = Box

Aero Mass = 0.217000

Thermal Mass = 0.217000

Diameter/Width = 0.137000

Length = 0.137000

Height = 0.040000

name = PayloadElectronics

quantity = 1

parent = 2

materialID = 8

type = Box

Aero Mass = 6.000000

Thermal Mass = 6.000000

Diameter/Width = 0.360000

Length = 0.437000

Height = 0.064000

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

Item Number = 1

name = M0

Demise Altitude = 77.999999

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Spacecraft_OW

Demise Altitude = 74.925540

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Walls

Demise Altitude = 73.833410

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Payload Antenna

Demise Altitude = 66.491224

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Electronic Boxes

Demise Altitude = 70.489236

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SPT Thruster Baseplate

Demise Altitude = 74.205700

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SPT XFS Steel

Demise Altitude = 66.048848

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SPT Ceramic

Demise Altitude = 72.304076

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Tank Carbon

Demise Altitude = 74.616698

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Tank Shell

Demise Altitude = 72.205216

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Reaction Wheel

Demise Altitude = 54.073212

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Battery

Demise Altitude = 61.095415

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SADA

Demise Altitude = 65.117640

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Optical Bench

Demise Altitude = 66.228627

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Bipod

Demise Altitude = 0.000000

Debris Casualty Area = 1.429239

Impact Kinetic Energy = 190.711833

****

name = Heat Pipe

Demise Altitude = 74.899466

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = Thermal Strap

Demise Altitude = 73.781797

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = VNIR - Baffle Tube

Demise Altitude = 74.499314

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = VNIR - Primary Cell

Demise Altitude = 71.014232

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = VNIR - Spider

Demise Altitude = 72.753076

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = VNIR - Interface Ring to Bench

Demise Altitude = 74.029782

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SWIR - Baffle Tube

Demise Altitude = 74.262809

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SWIR - Optical Barrel Tube

Demise Altitude = 73.755072

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = SWIR - Mount Extension

Demise Altitude = 73.316287

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TIR - Baffle

Demise Altitude = 73.746274

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TIR - Baffle Interface

Demise Altitude = 73.641012

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TIR - OTA Barrel

Demise Altitude = 73.291624

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = TIR - Telescope Interface Ring

Demise Altitude = 73.867580

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****

name = PayloadElectronics

Demise Altitude = 67.848518

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

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

07 03 2026; 11:35:40AM   Project Data Saved To File

END OF ODAR