

EXHIBIT 2

Orbital Debris Assessment Report

Vigoride-5 Spacecraft

Orbital Debris Assessment Report (ODAR)

Rev 2

5/2/2022

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Revision History

Revision Number	Updates	Page #	Author	Date
1	Initial Release	All	Sam Avery	03/10/22
2	Updated launch parameters, revised manifest, and other changes	All	Sam Avery	05/02/22

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Orbital Debris Self-Assessment Evaluation

Reqm't #	Launch Vehicle				Spacecraft			Comments <i>For all incompletes, include risk assessment (low, medium, or high risk) of non-compliance & Project Risk Tracking #</i>
	Compliant or N/A	Not Compliant	Std. Non-Compliant	Incomplete	Compliant or N/A	Not Compliant	Incomplete	
4.3-1.a <i>MRD 25-year limit</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1. No debris released.
4.3-1.b <i>MRD<100 object x-year limit</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1. No debris released.
4.3-2 <i>GEO MRD</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1. No debris released.
4.4-1 <i><0.001 Explosion Risk</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.4-2 <i>Passivate Energy Sources</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.4-3 <i>Limit Intentional BU</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1. No intentional breakups.
4.4-4 <i>Limit Intentional BU</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1. No intentional breakups.
4.5-1 <i><0.001 10cm Impact Risk</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.5-2 <i><0.01 Small MMOD Impacts</i>	☐	☐	☐	☐	☒	☐	☐	See comment 1.
4.6-1a-c <i>LEO Disposal</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.6-2 <i>Storage or Earth-escape</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.6-3 <i>Long-term Reentry</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.6-4 <i>Disposal Reliability</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.7-1 <i>Reentry Risk</i>	☒	☐	☐	☐	☒	☐	☐	See comment 1.
4.8-1 <i>Special Classes</i>	☐	☐	☐	☐	☒	☐	☐	No special classes.

Comment 1. This ODAR analyzes only the Vigoride-5 ("VR-5") and provides representative information regarding the customer payloads. The launch vehicle and other launch vehicle payloads are not considered in this ODAR.

Assessment Report Format

ODAR Technical Sections Format Requirements: This ODAR follows the format recommended in NASA-STD-8719.14, Appendix A.1 and includes the content indicated at a minimum in sections 2 through 8 for the VR-5 spacecraft. Sections 9 through 14 of the NASA standard apply to the launch vehicle ODAR and are not covered here.

I. Program Management and Mission Overview

Project Manager:

- Scott Wenger

Foreign Government or space agency participation:

- None

Schedule of Upcoming Mission Milestones:

- Launch - October 2022

Mission Overview:

This ODAR evaluates the Momentus VR-5 demonstration mission, which is targeted to launch on a SpaceX Falcon 9 rocket in October 2022. For the demonstration mission, VR-5 will exhibit the capacity to transport and deploy multiple payloads. Each deployed payload is a commercial smallsat individually licensed and authorized to operate by its respective national jurisdiction.¹ The necessary de-orbit and debris analysis for each deployed payload will be addressed through the licensing process for the relevant payload. Additionally, VR-5 will include a hosted payload, which will be authorized as part of Momentus' license application.

Launch Vehicle:

- Falcon 9

Expected Launch Site:

- Cape Canaveral, Florida

Operational Mission Duration:

- Planned for 250 days.

The VR-5 concept of operations is as follows:

¹ General information regarding the payloads is provided in Exhibit 5 to the application narrative. If there are any changes to the customer manifest, Momentus may replace a customer payload with a mass dummy, which would not be deployed on orbit. Any such mass dummies to replace Momentus customer payloads would simulate the mechanical interfaces and mass of the customer spacecraft and allow Momentus to conduct a demonstration of the planned deployment without any deployment in fact occurring.

1. Launch vehicle arrives at initial orbit (maximum 550 km altitude circular sun-synchronous orbit (“SSO”).
2. VR-5 separates from launch vehicle.
3. VR-5 undergoes commissioning and preliminary testing.
4. VR-5 deploys all but one deployable payload.
5. If insertion orbit is higher than 538 km, then VR-5 conducts orbit reduction maneuvers to second orbit (538 km circular SSO). If insertion orbit is lower than 538 km, then VR-5 conducts orbit raise maneuvers to second orbit (538 km circular SSO).
6. VR-5 deploys Qosmosys ZEUS-1.
7. VR-5 conducts orbit raise maneuvers to 541 km circular SSO.
8. VR-5 commences operations of hosted payload.
9. VR-5 conducts orbit and inclination adjustment maneuvers to the final end-of-life orbit (maximum 541 km x 350 km elliptical with a ~98° inclination). Momentus will ensure that its maneuvers through the orbits of inhabitable spacecraft will not create risk to such spacecraft, as discussed below.

VR-5 is planned to operate with an approximately 20% margin of propellant, in addition to the propellant necessary to achieve the operational concept. Momentus calculates that this reserve will be sufficient to support all contingencies during the VR-5 mission, including orbital debris and object avoidance maneuvers throughout the mission life. Additionally, our calculations suggest we would have sufficient propellant remaining at the conclusion of the mission to conduct further perigee reduction maneuvers, which could reduce to months the demise of the VR-5.

Table 1: Orbital Parameters	VR-5 Insertion Orbit ⁶	Second Orbit	Third Orbit	VR-5 Final Orbit
Apogee Altitude	550 km (max)	538 km	541 km	541 km
Perigee Altitude	550 km (max)	538 km	541 km	350 km
Inclination	~97.5 +/- 0.1° (SSO)	~97.5° (SSO)	~97.5° (SSO)	~98° (Elliptical)
Period	96 mins	95 mins	95 mins	94 mins

Argument of Perigee	N/A	N/A	N/A	N/A
Local Time of the Ascending Node (LTAN)	~09:30 + 60 min	~09:30	~09:30	N/A
Maximum De-Orbit Life	VR-5 ² ~ 12 years	VR-5 ³ ~ 8 years	VR-5 ⁴ ~ 8 years	VR-5 ~ 1 year

² This is the deorbit duration, if VR-5 fails after deployment.

³ This is the deorbit duration, if VR-5 achieves the second orbit and then the propulsion system fails.

⁴ This is the deorbit duration, if VR-5 achieves the third orbit and then the propulsion system fails.

II. Spacecraft Description

Physical Description:

VR-5 has the following subsystems: Propulsion System, Structures, Mechanisms, Electric Power System, and Avionics.

VR-5 includes a primary and a secondary structural assembly with: Propellant Tanks, MET, Reaction Control System thrusters, Solar Array Assemblies, a launch vehicle separation ring, two ISIS 12U cubesat deployers, and a Caltech hosted payload.

VR-5 includes two 3-panel 600W deployable solar arrays which are deployed using a frangibolt Hold Down and Release Mechanism (HDRM). The solar array deployment is controlled by a software timer via the flight computer.

The Payloads are fully stowed in their deployers and their power is inhibited prior to on-orbit deployment. The Payloads will follow the form and mass characteristics of a standard cubesat of the relative U-size of the payload. The VR-5 spacecraft platform components all have their power inhibited until launch vehicle separation occurs.



Figure 1. Artist rendering of Vigoride deploying a customer spacecraft.

Table 2. General Spacecraft Description

Criteria	Description	Notes
Spacecraft Total Launch Mass	363 kg	Includes 51 kg of propellant.
Spacecraft Launch Dry Mass	326 kg	Includes 24 kg of deployable payloads and a single 43 kg hosted payload.
Propulsion System	Redundant MET and reaction control thrusters. <i>See Propulsion System Description.</i>	Propulsion system operates using non-toxic and low-pressure liquid water propellant.
Body Dimensions	1.60x1.23x0.84 m ³ , stowed solar arrays body configuration 1.60x1.23x1.39 m ³ , with hosted payload	Body Dims with Stowed Solar Array Body Dims with SSPD
Deployed Solar Array Dimensions	1.4x2.23x0.03 m ³	Dimensions per solar array wing.
Identification of all Fluids	• Liquid/vapor water mixture (propellant) • Nitrogen Gas (tank pressurant) • Dynalene HC-50 (Potassium Formate/H₂O Solution – for cooling) <i>See Fluids Description.</i>	
Fluids in Pressurized Batteries	None. VR-5 uses unpressurized lithium-ion cells.	
Attitude Determination and Control	Attitude Determination • Star Trackers • Sun Sensors • Gyroscopes Attitude Control	

	• Reaction Control Thrusters See <i>Attitude Determination and Control System Description</i>.	
Range Safety or Pyrotechnic Devices	None	
Electrical Generation and Storage System	Two 600W solar array wings for power generation. Four 500 Wh batteries are included and charged prior to launch vehicle integration.	
Other Stored Energy	• Solar array spring energy stored in hinges. • Clampband separation system spring energy. • Payload deployer hinged door spring energy.	
Radioactive Materials	Not applicable.	

Propulsion System Description

The Vigoride-5 fully redundant propulsion system energizes distilled water into plasma using RF microwave energy. The plasma is expelled out of the thruster using a nozzle to produce thrust at a specific impulse (Isp) exceeding traditional chemical propulsion systems. The expected thrust and Isp will vary with input power levels but will not exceed 150 mN per thruster. The VR-5 mission will nominally include 51 kg of liquid water propellant at launch. The maximum expected total impulse is approximately 150 kNs.

In addition, there are eight reaction control thrusters each with estimated maximum thrust of 30 mN and specific impulse of 120 seconds. These reaction control thrusters are also redundant and use the same stored liquid water as a propellant.

Fluids Description

The propulsion system includes a single primary tank with liquid water propellant pressurized using inert gaseous Nitrogen. At spacecraft integration the propellant tank is pressurized to 18 psig. The tank is expected to remain within 20% of this pressure during transportation to the launch site, during launch, and post launch until thruster operations.

Attitude Determination and Control System Description

The VR-5 spacecraft includes 3-axis control with reaction control thrusters. For attitude determination, the spacecraft includes redundant star trackers, sun sensors, and gyroscopes, providing nominally $>1^\circ$ pointing knowledge.

- A sun tracking mode that is optimized for solar power generation from the spacecraft. The spacecraft's body will be oriented in two axes, and on-board Solar Array Drive Assemblies (SADAs) will rotate the panels along the third axis.
- A targeted tracking mode will allow the thrust axis to be pointed in any direction in inertial space.

III. Spacecraft Debris Released during Normal Operations

Payload Re-Contact Mitigation

Momentum will plan to support at least three re-contact mitigation strategies for deployments from VR-5:

- Each deployment group will be spaced apart by at least 90 minutes, or 1 full orbit.
- Momentum will optimize deployment orientation and sequence to minimize re-contact.
- On-board propulsion may also be used for maneuvers to minimize the risk of re-contact.

Persistent Liquids and Propellant-Related Debris

During primary mission operations, any water released into space through the MET or the reaction control thrusters will be vaporized at sufficiently high temperature (>500K) to prevent the formation of debris. In the off-nominal case of a leak or flow of liquid water, there is potential for the creation of small water ice crystals. Any generated water ice crystals are expected to sublime within minutes of exposure to sunlight.

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v3.1.2)

- 4.3-1, Mission Related Debris Passing Through LEO: COMPLIANT
- 4.3-2, Mission Related Debris Passing Near GEO: COMPLIANT

IV. Intentional Breakups and Potential for Explosions

Potential causes of spacecraft breakup during deployment and mission operations:

There are two potential scenarios that could potentially lead to a breakup of the spacecraft:

- 1) Rupture of the propellant tank or pressurant tank (H₂O, N₂)
- 2) Lithium-ion battery cell failure

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 failure modes and effects analysis (“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 an explosion.

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

- There are no planned breakups.

List of components which shall be passivated at End of Mission including method of passivation and amount which cannot be passivated:

- 200 Lithium-ion battery cells. At the End of Mission, the battery cell maximum charge voltage may be reduced.

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

- None.

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).

Supporting Rationale and FMEA details:

- **Pressure Tank Explosion:**

- **Effect:** A rupture of one propellant or pressurant tank would release water and Nitrogen gas. Due to the low pressure of the propellant (18 psi), the penetrating energy of any debris would be relatively low. In addition, a Nitrogen pressurant tank (250 psi) rupture would be insufficient to penetrate the surrounding solid aluminum structural walls of the spacecraft. These aluminum walls would contain any released debris within the body of the spacecraft.
- **Probability:** Very low. A structural failure of the tank would need to occur, and the mechanisms by which these failures occur are very well understood. The factor of safety for the propellant tanks is at least 2, for the pressurant tanks is 40, and for the surrounding structure is greater than 2.
- **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, although 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 and multiple enclosures surrounding the batteries.
 - **Probability:** Extremely Low. Estimated 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).
 - **Failure Mode 1:** Internal short circuit.
 - *Mitigation 1:* All of the following testing has or will be performed prior to flight: qualification level sine burst, sine, and random vibration testing in all three axes, thermal vacuum cycling and extensive functional testing, system rate-limited charge and discharge cycles, and subsystem and component level functional testing. The testing helps prove that no internal short circuit sensitivity exists.
 - *Combined Faults Required for Realized Failure:* Environmental testing AND functional charge / discharge tests must both be ineffective in discovery of the failure mode.
 - **Failure Mode 2:** Internal thermal rise due to high load discharge rate.
 - *Mitigation 2:* Battery cells were tested in lab for high load discharge rates in a variety of flight-like configurations to determine the feasibility of an out-of-control thermal rise in the cell. Cells are also tested in a hot, thermal vacuum environment to test the upper limit of the cells' capability. No failures were observed or identified via spacecraft telemetry or via external monitoring circuitry.

- *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 devices failure of terminal contact with conductors not at battery voltage levels (due to abrasion or inadequate proximity separation).
 - *Mitigation 3:* Qualification testing of 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 observation of such other mechanical failures by protoflight level environmental tests (sine burst, random 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 must all occur to enable this failure mode.
- **Failure Mode 4:** Inoperable vents.
 - *Mitigation 4:* 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 OR the spacecraft integrator fails to install proper venting.
- **Failure Mode 5:** Crushing.
 - *Mitigation 5:* This mode is negated by spacecraft design with 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 spacecraft 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 or short-circuit through battery pack case or due to moisture-based degradation of insulators.
 - *Mitigation 6:* The battery interface includes a printed circuit board and standoffs from any conductive materials, and operation in vacuum ensures 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 failures 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 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.
 - *Combined Faults Required for Realized Failure:* Thermal analysis AND thermal design AND mission simulations in thermal-vacuum chamber testing AND over-current monitoring and control must all fail for this failure mode to occur.

Requirement 4.4-2: Design for passivation after completion of mission operations while in orbit about 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:
 - At End-of-Life, VR-5 can reduce stored energy in the battery and limit power generation capability of the solar arrays. In case of a battery failure, the cells are, at a minimum, doubly contained within aluminum structural walls to prevent debris generation.
 - All liquid water propellant has low stored energy (at 18 psi) and is chemically stable. The Nitrogen pressurant tanks, which have a maximum pressure of 250 psi and a factor of safety of 40, do not contain enough stored energy to penetrate or break apart the spacecraft structure.

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

- Compliance statement:
 - 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:
 - Not applicable. There are no planned breakups.

V. Spacecraft Potential for On-Orbit Collisions

While the calculated risk of on-orbit collision with large debris or other operational space stations is low, Momentus shall monitor the VR-5 throughout the operational life of the spacecraft to ensure near real-time collision avoidance, as ground station available allows, and orbital maintenance maneuvers are executed as needed. The VR-5 mission will launch with a substantial propellant reserve which is intended to provide sufficient propellant to perform contingency operations (e.g., as needed collision avoidance maneuvers) during the mission while also retaining ample propellant to execute de-orbit maneuvers necessary to achieve end-of-mission timeline targets. Additionally, this monitoring shall assess, on an ongoing basis, the accuracy with which the targeted orbital parameters are to be maintained.⁵ Furthermore, the proposed operation of the VR-5 does not rely on or otherwise necessitate coordination with any other operational space stations and no assessment of successful coordination with such an operator has been performed to date.

Collision Avoidance Maneuver Process

In order to determine whether the risk of a close approach is high enough to warrant avoiding a potential collision by performing a maneuver, or some other trajectory modification, if Momentus receives a CDM message with a probability of collision (“PoC”) greater than $1E-5$, then the company will forecast VR-5 ephemeris at least 48 hours into the future to better assess the PoC and determine whether the risk of a close approach is high enough to warrant further actions. In this scenario, the conjunction will be reanalyzed using higher fidelity ephemeris from the Momentus asset and, if available, high-fidelity ephemeris from the other asset’s owner/operator or a third-party source. Momentus is working with Kayhan Space to provide more detailed conjunction analysis, including higher fidelity ephemeris, and advanced warning services.

If the PoC is greater than $1E-4$, Momentus will coordinate with the other owner operator on next steps. If the PoC is greater than $1E-3$ and the conjunction has not been resolved by coordination (e.g., the owner/operator cannot be contacted), Momentus will work with the 18SPCS and perform an avoidance maneuver to decrease the PoC below $1E-5$.

⁵ The Momentus assessment of the VR-5’s accuracy for orbital parameter maintenance indicates performance will be within the following ranges: Apogee, $\pm 1\text{km}$; Perigee, $\pm 200\text{m}$; Inclination, $<1\%$; and the Right Ascension of the Ascending Node(s), $<1\%$.

Table 3: Planned Actions in Response to CDM Messages

Probability of Collision (PoC)	Planned Actions ⁶
> 1E-5	Refine PoC through detailed analysis. Begin maneuver planning.
> 1E-4	Coordinate with the other owner/operator.
> 1E-3	Perform avoidance maneuver described in Table 4 below to decrease the PoC below 1E-5.

Momentum will share planned maneuvers and as-measured ephemeris via on-board GPS with the 18SPCS via Space-Track.org and with operators with whom Momentum is conducting physical coordination. Data shared with 18SPCS will be uploaded as OPM files in accordance with the current protocols laid out in the Combined Force Space Component Command satellite operator safety handbook.⁷

The anticipated maximum duration to commence a collision avoidance maneuver is captured below. Once a CDM has been received, Momentum will use the most accurate available ephemeris data to generate a maneuver plan within 3 hours. Following this, Momentum will update the proposed maneuver plan to Space-Track.org and coordinate with the 18SPCS, which is expected to occur within 6 hours. After the 18SPCS confirms that the proposed maneuver resolves the CDM, Momentum anticipates updating its command scheduler within 3 hours. Momentum has analyzed the worst-case gap between Earth station passes to be 10 hours. Lastly, once the maneuver has been scheduled during a pass, it is anticipated that the time from start to finish of the maneuver will be within 2 hours.

Momentum expects that VR-5 will be able to generate a 1 km change in orbital altitude within 2 hours. Literature surveys, support the conclusion by Momentum that its ability to implement a 1 km orbit altitude maneuver⁸ within 24 hours of the time of closest approach (“TCA”) should reduce the PoC to much less than 1E-5 and by at least one and one-half orders of magnitude.⁹

⁶ The planned actions are cumulative. For example, for a PoC > 1E-3, Momentum would first refine PoC through detailed analysis, begin maneuver planning, and coordinate with the other owner/operator before performing avoidance maneuvers.

⁷ See Spaceflight Safety Handbook for Satellite Operators: 18 SPCS Processes for On-Orbit Conjunction Assessment & Collision Avoidance, Version 1.5, August 2020. 18th Space Control Squadron, Combined Force Space Component Command, Vandenberg AFB.

⁸ Momentum notes that radial distance is materially different from in-track or cross-track distances for collision avoidance purposes.

⁹ See 18th Space Control Squadron, Combined Force Space Component Command, Vandenberg AFB, *Spaceflight Safety Handbook for Satellite Operators: 18 SPCS Processes for On-Orbit Conjunction Assessment & Collision Avoidance*, Version 1.5 at 9 (Table 3) (August 2020), available at

Additionally, as necessary for collision avoidance, Momentus could conduct up to a 2-km orbital altitude maneuver (such as an orbit raise) within 48 hours, during which VR-5 would produce more than 1 m/s of delta V.¹⁰

Table 4: Estimated Maneuver Duration

Task	Estimated Duration
Generate maneuver plan	3 hrs
Update proposed maneuver plan to Space-Track.org and receive confirmation from 18SPCS that maneuver resolves CDM	6 hrs
Update command scheduler to include proposed plan	3 hrs
Worst case delay for Earth station availability	10 hrs
Estimated total time until maneuver completion	2 hrs
Total Time	24 hrs

Protection of International Space Station

VR-5 will not be placed in or otherwise operate within a 10 km sphere centered around the ISS. However, in the scenario where a conjunction occurs, Momentus will implement the collision avoidance maneuver process discussed above. Momentus will implement the collision avoidance maneuver process discussed above. Additionally, when VR-5's perigee drops below the orbit of the ISS, Momentus will contact the NASA JSC Flight Operations Director (FOD) Human Space Flight Conjunction Assessment Operations to ensure that the ISS has a point of contract for the VR-5 spacecraft.

https://www.space-track.org/documents/Spaceflight_Safety_Handbook_for_Operators.pdf (NASA will conduct conjunction screening for satellites in low-Earth orbit only for events within a 400 m radial miss distance at TCA minus 5 days); *id.* at 10 (Table 5) (NASA will report CDMs only where overall miss distance is less than or equal to 1 km at TCA minus 3 days); NASA, *NASA Conjunction Assessment Risk Analysis Update Requirements Architecture*, at 14 (August 2019), *available at* <https://ntrs.nasa.gov/api/citations/20190029214/downloads/20190029214.pdf> (providing examples of overall miss distances of ~800 m and ~1000 m suggesting $P_c=0$, where the radial miss distance is between 125 m and 163 m). *See also* Hedron Space Inc. Response to FCC Questions, Ref No. 67622, ELS File No. 0024-EX-CN-2022, at 3 (Mar. 3, 2022) (providing example avoidance maneuvers resulting in miss distances of slightly greater than 1 km resulting in $P_c < 1E-05$); HE360 Response to FCC Questions, IBFS File No. SAT-MOD-20210114-00010, at 2 (Mar. 31, 2021) (providing examples where the miss distance is increased from 105 m to 523 m and 438 m, respectively, resulting in the P_c reducing from $2.1E-05$ to $1.34E-07$ and $4.6E-10$, respectively).

¹⁰ Because the delta V would be achieved by two propulsive maneuvers (separated by ~24 hours), the in-track spacing would be changed by more than 70 km as a result of the orbit altitude change from the first maneuver.

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).
- **Large Object Impact and Debris Generation Probability:**
 - 8.3632E-5; COMPLIANT.

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

- For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable postmission disposal requirements is less than 0.01 (Requirement 56507).
- **Small Object Impact and Debris Generation Probability:**
 - 7.1589E-6; COMPLIANT

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

- None are specifically required, but the propulsion system is expected to be used for a postmission de-orbit maneuver to decrease the time until atmospheric reentry. The flight computer, radio hardware, battery system, and control boards will be used to reduce stored energy.

VI. Spacecraft Postmission Disposal Plans and Procedures

Description of spacecraft disposal option selected:

- VR-5 will de-orbit naturally by atmospheric reentry without any intervention. However, VR-5 will attempt a de-orbit maneuver (discussed below) to reduce the time to atmospheric reentry.

Plan for any spacecraft maneuvers required to accomplish postmission disposal:

- No maneuvers are required for postmission disposal. However, VR-5 will attempt a de-orbit maneuver as a proof of concept for future missions. The maneuver will be performed using the on-board propulsion system to lower the orbital perigee below 350 km altitude. Note that there is no planned controlled reentry.

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

- Spacecraft Final Mass: 299 kg
- Cross-sectional Area: 3.3 m² (estimated average area in tumbling)
- Area to mass ratio: 0.011 m²/kg

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

A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods: (Requirement 56557)

1. Atmospheric reentry option:
 - a. Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or
 - b. Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.
2. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.
3. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

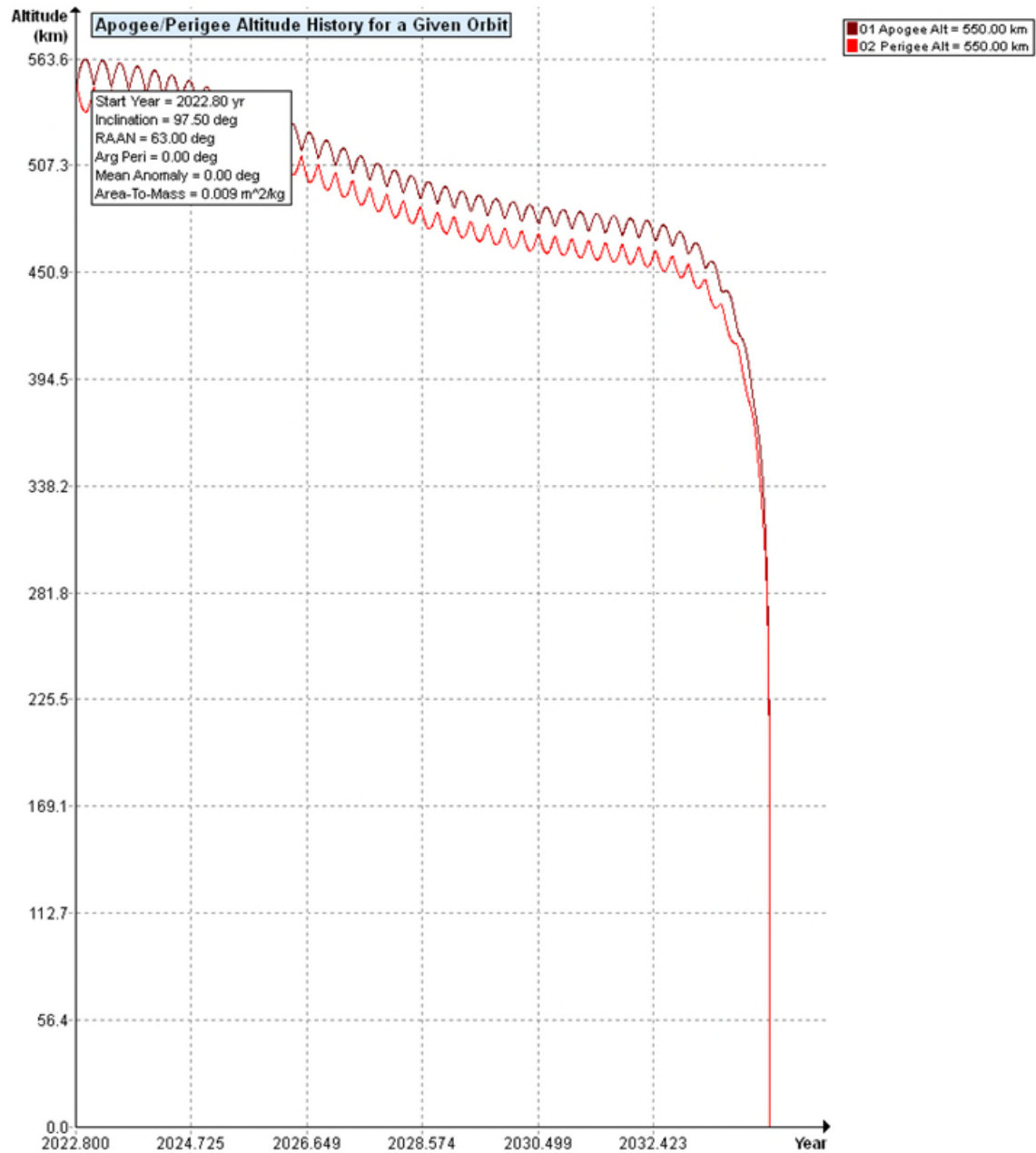
Analysis:

VR-5 will follow a concept of operations to ensure a safe disposal within 25 years of the end of the mission under all scenarios.

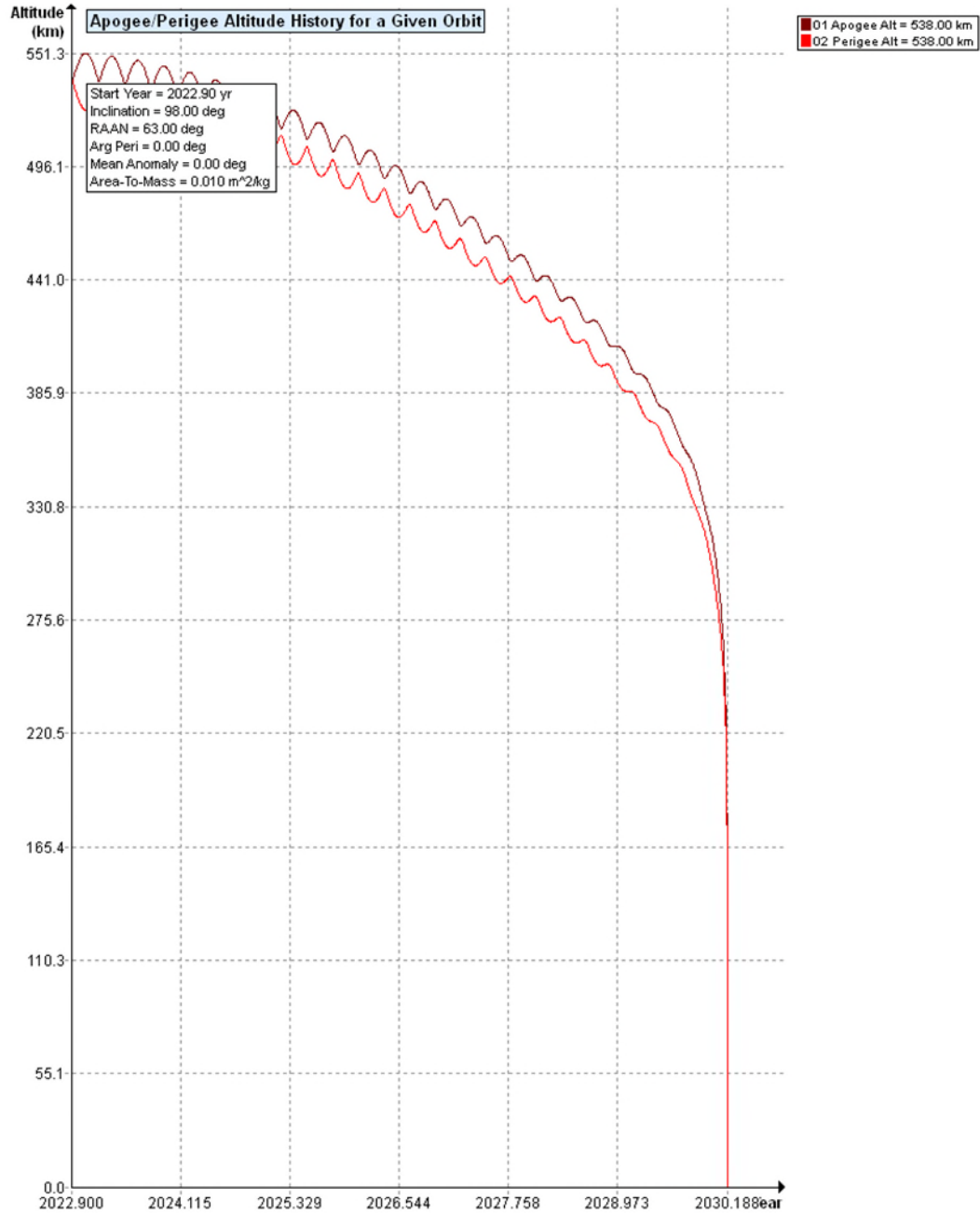
In the event of a propulsion system failure on launch, VR-5 is expected to undergo atmospheric reentry within 12 years. In the event of a propulsion system failure after achieving the target second orbit (538 x 538 km), VR-5 is expected to undergo atmospheric reentry also within 8 years. In the event of a propulsion system failure after achieving the target third orbit (541 x 541 km), VR-5 is expected to undergo atmospheric reentry also within 8 years. In the final orbit (538 x 350 km), VR-5 is expected to undergo atmospheric re-entry within 1 year. At the conclusion of the mission, Momentus intends to conduct further perigee reduction maneuvers, which could reduce to months the demise of VR-5.

VR-5 Failure at Launch Insertion Orbital Decay (550x550 km)¹¹

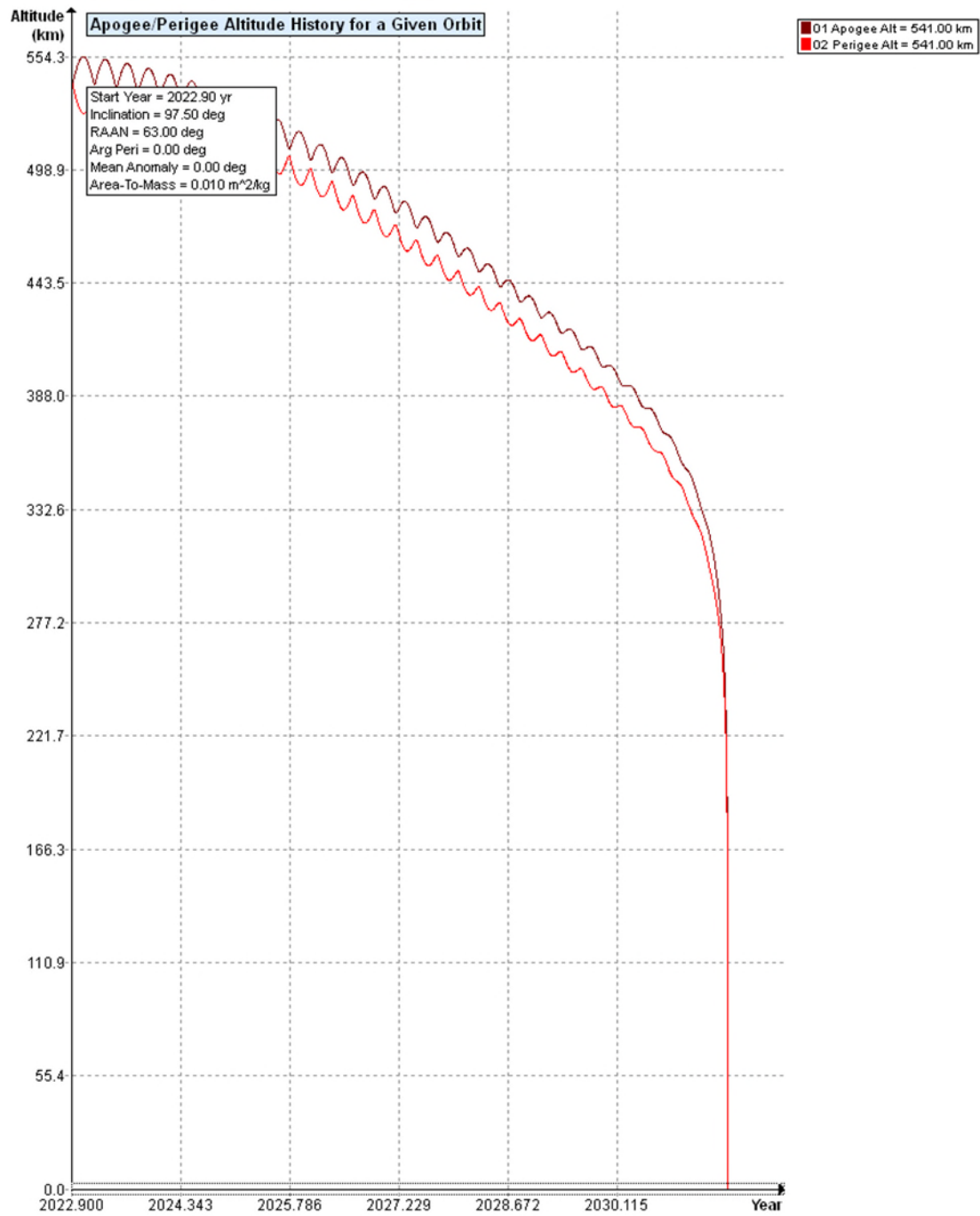
¹¹ VR-5 has an initial Area-to-Mass ratio of 0.009 m²/kg including deployment of solar arrays.



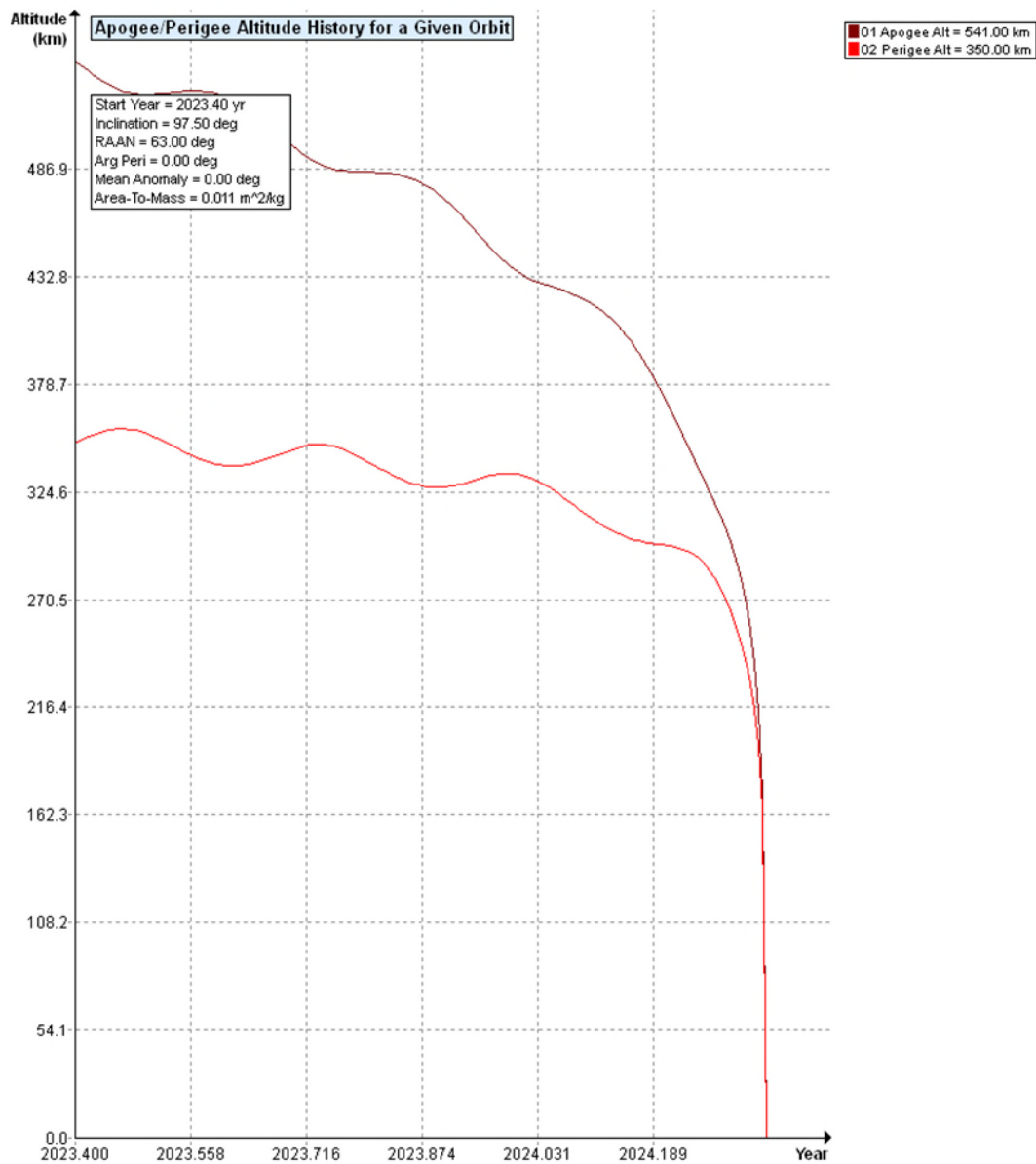
VR-5 Failure at Second Orbit - Orbital Decay (538x538 km)



VR-5 Failure at Third Orbit - Orbital Decay (541x541 km)



VR-5 Final Orbit Orbital Decay (541x350 km)



Requirement 4.6-2. Disposal for space structures near GEO.

- Not applicable.

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

- Not applicable.

Requirement 4.6-4. Reliability of Postmission Disposal Operations

- Not applicable. The spacecraft will reenter passively without post mission disposal operations within allowable timeframe.

VII. Spacecraft Reentry Hazards

Requirement 4.7-1. Limit the risk of human casualty:

The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules:

1. For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

Summary Analysis Results: DAS v3.1.2 reports that VR-5 is compliant with the requirement with a 1:100000000 risk of human casualty. As shown below, six VR-5 components may survive reentry. In each case, the impacting kinetic energy is less than 15 joules.

Analysis using DAS v3.1.2:

04 29 2022; 15:06:31PM Processing Requirement 4.3-1: Return Status : Not Run

=====

No Project Data Available

=====

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

04 29 2022; 15:06:32PM Processing Requirement 4.3-2: Return Status : Passed

=====

No Project Data Available

=====

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

04 29 2022; 15:19:58PM Processing Requirement 4.5-1: Return Status : Passed

=====

Run Data

=====

INPUT

Space Structure Name = Vigoride-5
Space Structure Type = Payload
Perigee Altitude = 550.000 (km)
Apogee Altitude = 550.000 (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 = 0.0090 (m²/kg)
Start Year = 2022.800 (yr)
Initial Mass = 363.000 (kg)
Final Mass = 363.000 (kg)
Duration = 0.700 (yr)
Station-Kept = False
Abandoned = True

OUTPUT

Collision Probability = 8.3632E-05
Returned Message: Normal Processing
Date Range Message: Normal Date Range

Status = Pass

=====

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

04 29 2022; 15:20:41PM	Project Data Saved To File
04 29 2022; 15:20:41PM	Project Data Saved To File
04 29 2022; 15:23:13PM	Requirement 4.5-2: Compliant

=====

Spacecraft = Vigoride-5

Critical Surface = Avionics

=====

****INPUT****

Apogee Altitude = 550.000 (km)
Perigee Altitude = 550.000 (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 = 0.0090 (m²/kg)
Initial Mass = 363.000 (kg)
Final Mass = 363.000 (kg)

Station Kept = No

Start Year = 2022.800 (yr)

Duration = 0.700 (yr)

Orientation = Random Tumbling

CS Areal Density = 5.000 (g/cm²)

CS Surface Area = 1.0000 (m²)

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

CS Pressurized = No

Outer Wall 1 Density: 10.000 (g/cm²) Separation: 50.000 (cm)

****OUTPUT****

Probability of Penetration = 7.1589E-06 (7.1590E-06)

Returned Error Message: Normal Processing

Date Range Error Message: Normal Date Range

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

04 29 2022; 15:24:42PM Processing Requirement 4.6 Return Status : Passed

=====

Project Data

=====

****INPUT****

Space Structure Name = Vigoride-5

Space Structure Type = Payload

Perigee Altitude = 550.000000 (km)

Apogee Altitude = 550.000000 (km)

Inclination = 97.500000 (deg)

RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)

Mean Anomaly = 0.000000 (deg)

Area-To-Mass Ratio = 0.009000 (m^2/kg)

Start Year = 2022.800000 (yr)

Initial Mass = 363.000000 (kg)

Final Mass = 363.000000 (kg)

Duration = 0.700000 (yr)

Station Kept = False

Abandoned = True

PMD Perigee Altitude = 533.722880 (km)

PMD Apogee Altitude = 560.858706 (km)

PMD Inclination = 97.473433 (deg)

PMD RAAN = 247.707422 (deg)

PMD Argument of Perigee = 102.934295 (deg)

PMD Mean Anomaly = 0.000000 (deg)

****OUTPUT****

Suggested Perigee Altitude = 533.722880 (km)

Suggested Apogee Altitude = 560.858706 (km)

Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2034 (yr)

Requirement = 61

Compliance Status = Pass

=====

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

04 29 2022; 15:25:43PM *****Processing Requirement 4.7-1

Return Status : Passed

*****INPUT*****

Item Number = 1

name = Vigoride-5

quantity = 1

parent = 0

materialID = 8

type = Box

Aero Mass = 363.000000

Thermal Mass = 363.000000

Diameter/Width = 1.230000

Length = 1.560000

Height = 0.970000

name = Primary Radiator Segment

quantity = 4

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 3.500000

Thermal Mass = 3.500000

Diameter/Width = 0.400000

Length = 0.400000

name = Secondary Radiator

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 3.400000

Thermal Mass = 3.400000

Diameter/Width = 0.500000

Length = 0.500000

name = Side Radiator Plate

quantity = 2

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 6.000000

Thermal Mass = 6.000000

Diameter/Width = 0.350000

Length = 1.200000

name = Corner Brackets

quantity = 4

parent = 1

materialID = 8

type = Box

Aero Mass = 1.100000

Thermal Mass = 1.100000

Diameter/Width = 0.100000

Length = 0.350000

Height = 0.100000

name = Comms Panel

quantity = 2

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 1.100000

Thermal Mass = 1.100000

Diameter/Width = 0.150000

Length = 0.350000

name = Lower Payload Deck Segment

quantity = 4

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 4.500000

Thermal Mass = 4.500000

Diameter/Width = 0.500000

Length = 0.500000

name = Structure

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 20.000000

Thermal Mass = 20.000000

Diameter/Width = 0.600000

Length = 0.600000

Height = 0.350000

name = Propellant Tank

quantity = 1

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 66.000000

Thermal Mass = 15.000000

Diameter/Width = 0.400000

Length = 0.400000

name = Water Propellant

quantity = 1

parent = 9

materialID = 75

type = Cylinder

Aero Mass = 51.000000

Thermal Mass = 51.000000

Diameter/Width = 0.400000

Length = 0.400000

name = Launch Vehicle Adapter

quantity = 1

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 4.000000

Thermal Mass = 4.000000

Diameter/Width = 0.600000

Length = 0.600000

name = Solar Array Panel

quantity = 6

parent = 1

materialID = 8

type = Box

Aero Mass = 3.400000

Thermal Mass = 3.400000

Diameter/Width = 0.350000

Length = 1.400000

Height = 0.020000

name = Battery Assembly

quantity = 4

parent = 1

materialID = 8

type = Box

Aero Mass = 4.000000

Thermal Mass = 4.000000

Diameter/Width = 0.150000

Length = 0.150000

Height = 0.100000

name = Power Supply Unit

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 1.200000

Thermal Mass = 1.200000

Diameter/Width = 0.100000

Length = 0.250000

Height = 0.050000

name = Microwave Source Box

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 4.000000

Thermal Mass = 4.000000

Diameter/Width = 0.200000

Length = 0.200000

Height = 0.200000

name = Feed System Box

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 0.500000

Thermal Mass = 0.500000

Diameter/Width = 0.100000

Length = 0.200000

Height = 0.030000

name = Power Distribution Unit

quantity = 2

parent = 1

materialID = 8

type = Box

Aero Mass = 1.600000

Thermal Mass = 1.600000

Diameter/Width = 0.100000

Length = 0.250000

Height = 0.050000

name = Diaphragm Tank Middle

quantity = 2

parent = 1

materialID = 27

type = Cylinder

Aero Mass = 0.250000

Thermal Mass = 0.250000

Diameter/Width = 0.150000

Length = 0.300000

name = Diaphragm Tank End 1

quantity = 2

parent = 1

materialID = 27

type = Sphere

Aero Mass = 0.100000

Thermal Mass = 0.100000

Diameter/Width = 0.150000

name = Diaphragm Tank End 2

quantity = 2

parent = 1

materialID = 27

type = Sphere

Aero Mass = 0.100000

Thermal Mass = 0.100000

Diameter/Width = 0.150000

name = Diaphragm Tank Liner

quantity = 2

parent = 1

materialID = 8

type = Cylinder

Aero Mass = 1.200000

Thermal Mass = 1.200000

Diameter/Width = 0.200000

Length = 0.200000

name = Plumbing Lines

quantity = 20

parent = 1

materialID = 59

type = Cylinder

Aero Mass = 0.030000

Thermal Mass = 0.030000

Diameter/Width = 0.005000

Length = 0.500000

name = Plumbing Fittings

quantity = 20

parent = 1

materialID = 59

type = Cylinder

Aero Mass = 0.050000

Thermal Mass = 0.050000

Diameter/Width = 0.020000

Length = 0.020000

name = Thruster

quantity = 1

parent = 1

materialID = 58

type = Cylinder

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.100000

Length = 0.070000

name = Window

quantity = 1

parent = 1

materialID = 1

type = Cylinder

Aero Mass = 0.010000

Thermal Mass = 0.010000

Diameter/Width = 0.050000

Length = 0.015000

name = Reaction Control Thruster

quantity = 4

parent = 1

materialID = 59

type = Box

Aero Mass = 0.160000

Thermal Mass = 0.160000

Diameter/Width = 0.050000

Length = 0.050000

Height = 0.040000

name = RCS Fasteners

quantity = 4

parent = 1

materialID = 66

type = Flat Plate

Aero Mass = 0.025000

Thermal Mass = 0.025000

Diameter/Width = 0.060000

Length = 0.060000

name = 12U Cubesat Deployer 1

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 22.500000

Thermal Mass = 22.500000

Diameter/Width = 0.400000

Length = 0.600000

Height = 0.400000

name = 12U Cubesat Deployer 2

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 22.500000

Thermal Mass = 22.500000

Diameter/Width = 0.400000

Length = 0.600000

Height = 0.400000

name = Deployer Mass Dummy

quantity = 4

parent = 1

materialID = 8

type = Box

Aero Mass = 8.000000

Thermal Mass = 8.000000

Diameter/Width = 0.400000

Length = 0.600000

Height = 0.400000

name = SSPD1 DOLCE

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 32.770000

Thermal Mass = 32.770000

Diameter/Width = 0.250000

Length = 0.760000

Height = 0.250000

name = SSPD1 Controller

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 1.260000

Thermal Mass = 1.260000

Diameter/Width = 0.200000

Length = 0.200000

Height = 0.110000

name = SSPD1 Avionics

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 3.000000

Thermal Mass = 3.000000

Diameter/Width = 0.144000

Length = 0.204000

Height = 0.121000

name = SSPD1 MAPLE

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 2.750000

Thermal Mass = 2.750000

Diameter/Width = 0.265000

Length = 0.369000

Height = 0.125000

name = SSPD1 ALBA

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 3.550000

Thermal Mass = 3.550000

Diameter/Width = 0.110000

Length = 0.494000

Height = 0.100000

name = Payload Interface Adapter

quantity = 6

parent = 1

materialID = 8

type = Flat Plate

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.200000

Length = 0.300000

name = Structural Fasteners

quantity = 150

parent = 1

materialID = 57

type = Cylinder

Aero Mass = 0.010000

Thermal Mass = 0.010000

Diameter/Width = 0.010000

Length = 0.020000

name = Microwave Filament

quantity = 2

parent = 1

materialID = 43

type = Cylinder

Aero Mass = 0.005000

Thermal Mass = 0.005000

Diameter/Width = 0.010000

Length = 0.010000

name = CHIRP

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 1.000000

Thermal Mass = 1.000000

Diameter/Width = 0.100000

Length = 0.200000

Height = 0.100000

*****OUTPUT*****

Item Number = 1

name = Vigoride-5

Demise Altitude = 77.999969

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Primary Radiator Segment

Demise Altitude = 68.339340

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Secondary Radiator

Demise Altitude = 70.507484

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Side Radiator Plate

Demise Altitude = 70.150421

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Corner Brackets

Demise Altitude = 75.058891

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Comms Panel

Demise Altitude = 73.081581

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Lower Payload Deck Segment

Demise Altitude = 67.931320

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Structure

Demise Altitude = 58.394646

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Propellant Tank

Demise Altitude = 69.065308

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Water Propellant

Demise Altitude = 62.448414

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Launch Vehicle Adapter

Demise Altitude = 70.353996

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Solar Array Panel

Demise Altitude = 74.224129

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Battery Assembly

Demise Altitude = 61.337185

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Power Supply Unit

Demise Altitude = 72.532799

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Microwave Source Box

Demise Altitude = 68.165077

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Feed System Box

Demise Altitude = 74.695160

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Power Distribution Unit

Demise Altitude = 70.876625

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Diaphragm Tank Middle

Demise Altitude = 0.000000

Debris Casualty Area = 1.319117

Impact Kinetic Energy = 13.946575

name = Diaphragm Tank End 1

Demise Altitude = 0.000000

Debris Casualty Area = 1.074385

Impact Kinetic Energy = 10.209861

name = Diaphragm Tank End 2

Demise Altitude = 0.000000

Debris Casualty Area = 1.074385

Impact Kinetic Energy = 10.209861

name = Diaphragm Tank Liner

Demise Altitude = 74.294724

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Plumbing Lines

Demise Altitude = 77.295326

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Plumbing Fittings

Demise Altitude = 71.364571

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Thruster

Demise Altitude = 64.667725

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Window

Demise Altitude = 0.000000

Debris Casualty Area = 0.393613

Impact Kinetic Energy = 0.854896

name = Reaction Control Thruster

Demise Altitude = 69.837067

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = RCS Fasteners

Demise Altitude = 0.000000

Debris Casualty Area = 1.742400

Impact Kinetic Energy = 2.833660

name = 12U Cubesat Deployer 1

Demise Altitude = 63.330349

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = 12U Cubesat Deployer 2

Demise Altitude = 63.330349

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Deployer Mass Dummy

Demise Altitude = 72.479500

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = SSPD1 DOLCE

Demise Altitude = 56.654633

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = SSPD1 Controller

Demise Altitude = 73.469284

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = SSPD1 Avionics

Demise Altitude = 68.697594

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = SSPD1 MAPLE

Demise Altitude = 72.831642

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = SSPD1 ALBA

Demise Altitude = 70.678658

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Payload Interface Adapter

Demise Altitude = 73.726173

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Structural Fasteners

Demise Altitude = 75.218445

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

name = Microwave Filament

Demise Altitude = 0.000000

Debris Casualty Area = 0.744200

Impact Kinetic Energy = 2.287773

name = CHIRP

Demise Altitude = 74.080803

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

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

VIII. Special Classes

Not applicable.