Acadia 1&2 Orbital Debris Assessment Report (ODAR)

Lucas Riggi*

E-mail: lucas.riggi@capellaspace.com

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

Report Version: 1, 03/01/2023

Document Data is Not Restricted.

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

DAS Software Version Used In Analysis: v3.2.3

VERSION APPROVAL and/or FINAL APPROVAL:

Christian Lenz, CTO

PREPARED BY:

Lucas Riggi, Systems & Mission Design

Table of Contents

Self-assessment of the ODAR

This ODAR follows the format recommended in NASA-STD-8719.14, Appendix A.1, sections 1 through 8 for the Capella satellites. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

Orbital Debris Self-Assessment Report Evaluation: Acadia 1&2 Mission

(based upon ODAR version 1, dated March 1, 2023)

Reqm #	Launch Vehicle				Spacecraft			Comments
	Compliant	Not Compliant	Incomplete	Standard Not Compliant	Compliant or N/A	Not Compliant	Incomplete	
4.3-1.a	☐	☐	☑	☐	☑	☐	☐	
4.3-1.b	☐	☐	☑	☐	☑	☐	☐	
4.3-2	☐	☐	☑	☐	☑	☐	☐	
4.4-1	☐	☐	☑	☐	☑	☐	☐	
4.4-2	☐	☐	☑	☐	☑	☐	☐	
4.4-3	☐	☐	☑	☐	☑	☐	☐	
4.4-4	☐	☐	☑	☐	☑	☐	☐	
4.5-1	☐	☐	☑	☐	☑	☐	☐	
4.5-2	☐	☐	☑	☐	☑	☐	☐	
4.6-1.a	☐	☐	☑	☐	☑	☐	☐	
4.6-1.b	☐	☐	☑	☐	☑	☐	☐	
4.6-1.c	☐	☐	☑	☐	☑	☐	☐	
4.6-2	☐	☐	☑	☐	☑	☐	☐	
4.6-3	☐	☐	☑	☐	☑	☐	☐	
4.6-4	☐	☐	☑	☐	☑	☐	☐	
4.7-1	☐	☐	☑	☐	☑	☐	☐	
4.8-1					☑	☐	☐	

Figure 1: ODAR Review Check sheet

1. Mission Overview

Project Manager: Christian Lenz

Mission Overview: Acadia 1 & 2 will be launched no earlier than June 2023, on a circular inclined orbit with an altitude between 575 km and 625 km. The launch and operational inclination of the spacecrafts will be between 42 and 56 deg. The nominal operational altitude will be 585 km, but the spacecrafts could operate between a maximum altitude of 625 km and a minimum altitude of 400 km. For the purposes of this document, the worst case altitude of 625 km and worst case inclination of 56 deg will be used during the mission duration of 3 years, after which the satellites will reenter the atmosphere through natural orbit decay. During the 3 year mission duration, Capella expects normal operations of Acadia 1 & 2 to be in the range of 550 km to 625 km. As the satellites experience natural orbital decay, Capella anticipates continuing to conduct imaging operations down to approximately 400 km. But this lower operational altitude is not considered to be a nominal operational altitude.

ODAR Summary: All the debris generated in orbit are compliant with Requirements 4.3, there is no credible scenario for breakups, the collision probability with other objects is compliant with NASA standards, the estimated nominal decay lifetime due to atmospheric drag is less than 6 years (as calculated by DAS 3.2.3) and there is a 0 probability of human casualty after orbital reentry.

Launch: Acadia 1 & 2 are currently planned to be launched on a Rocket Lab rocket, no earlier than June, 1 2023.

Mission Duration: Maximum Nominal Operations: 3 years, Maximum On-Orbit lifetime: less than 6 years.

Orbit Profile: Acadia 1 & 2 will deploy from the launch vehicle into a near-circular inclined orbit at an altitude between 575 km and 625 km, at an inclination between 42 degrees and 56 degrees. They will maintain an altitude between 625 and 550 km using a RF xenon propulsion system for a maximum of 3 years of operational mission.

2. Spacecraft Description

Physical Description of the Spacecraft: The Acadia 1 & 2 satellites have a nominal launch mass between 150 kg and 170 kg. Two 1.25 m^2 deployable solar arrays, a 10 m^2 deployable antenna and a 3m long boom deploy from the principal bus structure.

All deployables use a frangibolt and motor based deployment system from which no debris will be generated.

Power storage is provided by Lithium-Ion cells. The batteries will be recharged by solar cells mounted on on the two deployable solar panels.

Capella attitude is estimated with an accuracy of 50 arcsec using filtering of sensor data from 2 star trackers, an IMU, sun sensors and a magnetometer. Acadia 1 & 2's attitudes will be controlled by 3 reaction wheels for nominal operation and a 3-axis magnetorquer during detumbling and for wheel desaturation.

Total satellite mass at launch, including all propellants and fluids: 150 - 170 kg for all launches.

Dry mass of satellites at launch, excluding solid rocket motor propellants: 150 - 170 kg for all launches.

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant,

electric, nuclear): Acadia 1 & 2 will be equipped with a propulsion system for station keeping. The baseline system is a xenon-based RF magnetic thruster from Phase Four. It is an electromagnetic electric propulsion system that accelerates the xenon propellant using magnetic mechanisms. It uses 4.2 kg of xenon for a maximum thrust force of 6 mN.

Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes: On Acadia 1 & 2, the only fluid will be in the propulsion system tank. There will be 4.2 kg of xenon propellant. The fluid system is split between a high-pressure region and a low-pressure region by a dual stage regulator. For pressure system design, Phase Four uses a minimum safety factor of 1.5 and as such, all parts and components on the high-pressure side have been proof tested to a minimum of 1.5 times the maximum expected operating pressure (MEOP). Xenon will be loaded onto the system to a target density which equates 3,000 $psia$ (MEOP) at maximum operating temperature (45 $degC$). The propulsion system can be filled with propellant either as a standalone system of while integrated into the satellite bus via external-facing fluid and electronic interface locations. Phase Four has designed and built ground support equipment to achieve the desired xenon density load.

Fluids in Pressurized Batteries: None. Acadia 1 & 2 use unpressurized standard Lithium-Ion battery cells. Each battery has a height of 65mm, a diameter of 18mm.

Description of attitude control system and indication of the nominal attitude of the spacecraft: Acadia 1 & 2 use 3 magnetic rods to despin the satellites during the initial tumbling phase after deployment from the launch vehicle. 3 reaction wheels oriented in the direction of the principal axes allow 3-axis control during nominal operation. The magnetorquers are also used for desaturation of the wheels during nominal operations. The nominal attitude will be with the solar panels in the radial direction and the SAR antenna pointing in the nadir direction. At the end of operations, the 3-axis controller can be used to rotate the satellite into maximum drag configuration, with the SAR antenna in the opposite direction of the velocity, to accelerate orbital decay, if desired.

3. Spacecraft Debris Released during Normal Operations

Requirement 4.3-1: Debris passing through LEO, released debris with diameters of 1mm or larger

No release of debris will occur during the lifetime of Acadia 1 & 2 satellites. All deployments use a frangibolt and motor based systems that do not generate any debris. Additionally, there is no probable scenario for unintentional debris generation.

Result for Requirement 4.3-1: COMPLIANT

Requirement 4.3-2: Debris passing near GEO

There will be no intentional release of debris during the lifetime of the mission, as Acadia 1 & 2's mission is contained in Low Earth Orbit.

Result for Requirement 4.3-2: COMPLIANT

4. Spacecraft Intentional Breakups and Potential for Explosions

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

The probability of battery or pressurized tank explosion is very low, believed to be much less than 0.001 and, due to the small mass of the satellite and its short orbital lifetime, the long-term effects of an unlikely explosion on the LEO environment are negligible. During the development process, the heat pipes have been space qualified through pressure testing, burst pressure testing, vibration testing and thermal vacuum cycling. At the end of the 3 years of nominal operations, any leftover propellant can be used to accelerate the reentry of the satellite.

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 will prove that no internal short circuit sensitivity exists.
Combined faults required for realized failure: Environmental testing AND functional charge / discharge tests must both be ineffective in discovery of the failure mode.

Failure mode 2: Internal thermal rise due to high load discharge rate.
Mitigation 2: Cells will be tested in lab for high load discharge rates in a variety of flight like configurations to determine if the feasibility of an out of control thermal rise in the cell. Cells will also be tested in a hot environment to test the upper limit of the cells capability.
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 will be 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 must all occur to enable this failure mode.

Failure mode 4: Inoperable vents.
Mitigation 4: Battery vents are not inhibited by the battery holder design or the spacecraft.
Combined faults required for realized failure: The manufacturer 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 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 will be 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 over-current monitoring and control must all fail for this failure mode to occur.

Result for Requirement 4.4-1: COMPLIANT

Requirement 4.4-2: Design for passivation after completion of mission operations while in orbit about Earth or the Moon

Passivation will happen naturally at the end of mission by depletion of any remaining energy contained in the batteries (either through uncontrolled tumbling in case of ADCS failure or attitude control in case of nominal ADCS operations) and natural orbit decay and re-entry within 6 years.

Result for Requirement 4.4-2: COMPLIANT

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

There are no planned breakup during the mission.

Result for Requirement 4.4-3: COMPLIANT

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

There are no planned breakup during the mission.

Result for Requirement 4.4-4: COMPLIANT

5. Spacecraft Potential for On-Orbit Collisions

Since the orientation of the spacecraft during operations will vary, the probability of collision with other objects is computed with the average area to mass ratio of 0.031. DAS v3.2.3 is used for orbit and collision analysis. It is to be noted that Acadia 1 & 2's on-orbit collision avoidance scheme has already been implemented, tested successfully, and has been used on orbit for several years. Capella uses a human-in-the-loop collision avoidance procedure. Conjunction Data Messages are assessed to determined if a maneuver is required. Potential maneuvers are screened for safety and executed only if safe to do so. The results of maneuvers are monitored to determine potential subsequent steps.

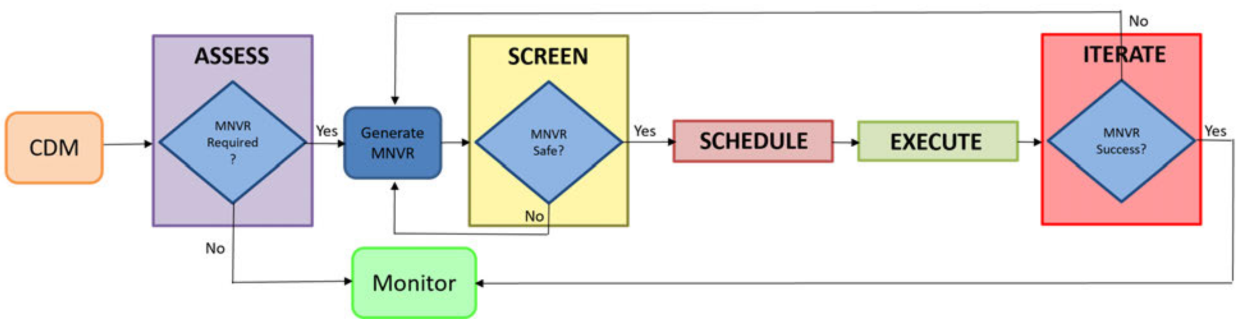

Figure 2: Collision Avoidance Scheme

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

The worst case initial orbit of Acadia 1 & 2 is a circular orbit at an altitude of 625 km and an inclination of 56 deg. The aera/mass ratio of the spacecraft is 0.031 m^2/kg in the average attitude. The computed probability of collision with large objects for the individual satellites is 2.3889e-4. The compounded probability of collision with a large object for the combined Acadia 1 & 2 satellites is 4.777e-4, below the maximum acceptable probability of 0.001. The detailed results including the DAS logs are reported in Appendix A.1.

Result for Requirement 4.5-1: COMPLIANT

Requirement 4.5-2. Limiting the probability of damage from small objects when operating in Earth or lunar orbit

Acadia 1 & 2 do not need active post-mission disposal. The natural orbital decay of the spacecrafts will happen within 6 years from its worst-case initial altitude, without the need for post-mission disposal maneuvers. However, Capella still wants to understand the probability that control subsystems would become disabled before spacecraft reentry, and the likelihood that Acadia 1 & 2 could perform any desired maneuvers during the lifetime of the satellites. The component critical for spacecraft control operations are the systems that will enable the control of the attitude and orbit of the spacecraft. Namely, the Attitude Control System (reaction wheels, torque rods, control avionics, star trackers), Batteries and the Propulsion System. The results for each critical subsystem, for Acadia 1 & 2, are given in the table below. The detailed results from the DAS logs are reported in Appendix A.2. The probability of damage from small objects for the individual spacecrafts is computed to be 3.2194e-3. This is considered conservative, as Acadia 1 & 2 have 2x star trackers and 3x battery pack that give those systems inherent redundancy.

The probability of damage from small objects for the 2 combined Acadia 1 & 2 satellites is 6.4284e-3, below the 0.01 requirement.

Table 1: Small Object Damage Analysis for Acadia 1 & 2

Critical Surface	**Probability of Penetration**
ADCS Avionics	9.8619e-5
RW1	2.2263e-5
RW2	6.7473e-5
RW3	2.2236e-4
ST	7.0928e-4
TR1	1.0247e-5
TR2	1.0247e-5
TR3	8.7120e-7
Prop System	2.0798e-3
Batteries	9.2992e-7
Probability of PMD Failure	**3.2194e-3**

Result for Requirement 4.5-2: COMPLIANT

6. Spacecraft Post-mission Disposal Plans and Procedures

The orbit of the Acadia 1 & 2 satellites will decay because of atmospheric drag and the satellites will eventually naturally de-orbit by atmospheric reentry. At the end of the spacecraft lifetime, Acadia 1 & 2 will begin the deorbit process. Capella will maintain enough fuel in the propulsion system to maintain maneuverability as the spacecraft passes through the ISS and Tiangong-2 orbits. In the case where there is propellant in excess of what is needed to safely traverse the space station orbits, it can be used in a series of propulsive maneuvers to further accelerate orbital decay and reentry. The natural reentry of the Acadia 1 & 2 satellites will happen within 6 years after launch from the worst-case insertion altitude.

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

The DAS software uses a solar activity model that follows the past observations and future predictions made by NOAA. This model is greatly underestimating the solar activity for the current solar cycle. For instance, the actual solar flux for December 2022 was 80% higher than the NOAA prediction for the same month, and already 30% higher than the maximum predicted NOAA value for the entirety of the solar cycle (see Figure 3 below).

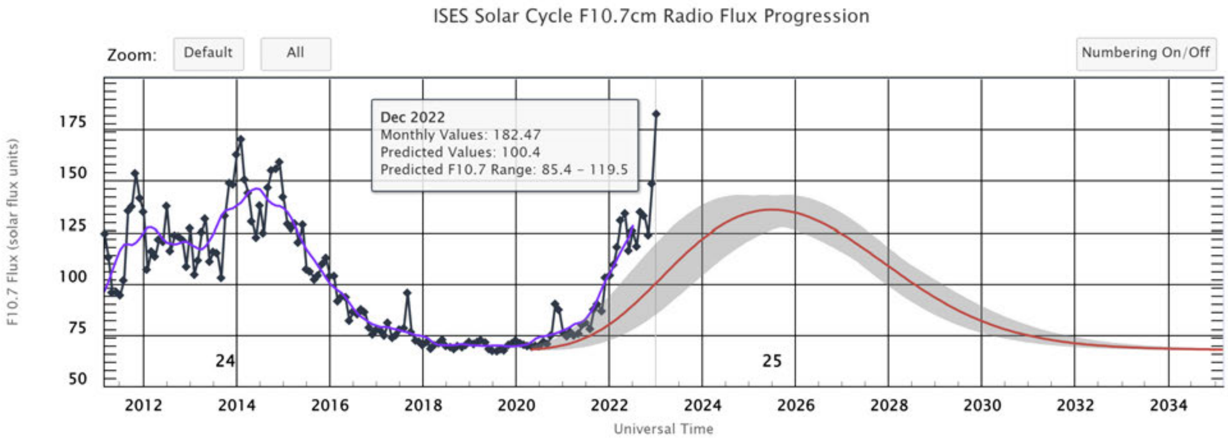

Figure 3: NOAA Solar Cycle Observations and Predictions

Instead, the model developed by Scott McIntosh seems to represent the solar activity for solar cycle 25 more accurately. Capella uses the lower bound of the McIntosh model which predicts a maximum F10.7cm radio flux of 170 sfu for solar cycle 25. This is still considered conservative, as the actual solar flux is already exceeding this value (see Figure 4 below).

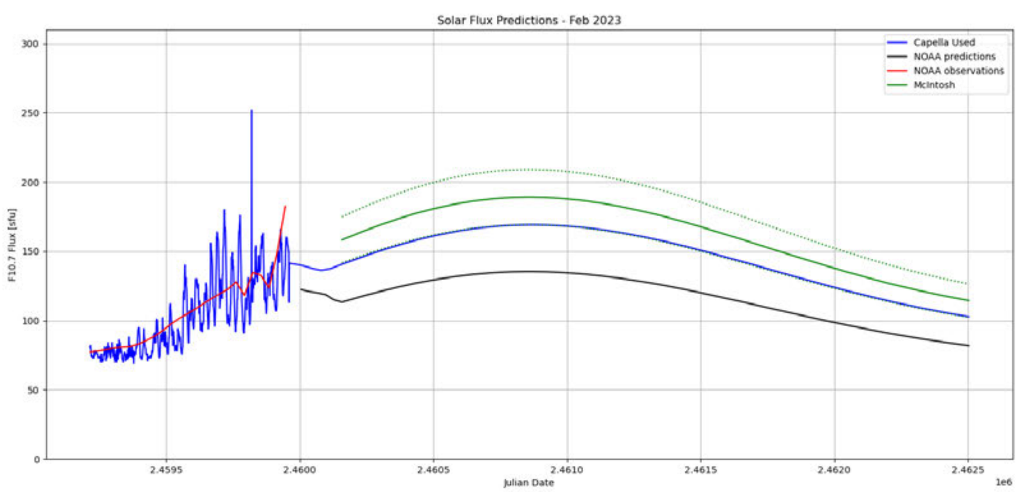

Figure 4: Models of Solar Flux for Solar Cycle 25

The altitudes of Acadia-1 and Acadia-2 are computed from their worst-case initial circular orbits at the altitude of 625 km. The average area to mass ratio for the tumbling spacecraft is used (0.031 m^2/kg). The lifetime of Acadia 1 & 2 with no orbit maintenance from the altitude of 625 km is computed by DAS to be 4.15 years. The nominal operational altitude of Acadia 1 & 2 is 585 km. DAS shows 2.75 years of orbit maintenance at 585 km is possible after which the spacecraft will take 3.05 years to deorbit, for a maximum total on-orbit lifetime of 5.80 years. The detailed DAS logs are reported in Appendix A.3.

Result for Requirement 4.6-1: COMPLIANT

Requirement 4.6-2. Disposal for space structures near GEO

There are no space structures near GEO involved in this mission.

Result for Requirement 4.6-2: COMPLIANT

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

There are no space structures between LEO and GEO involved in this mission.

Result for Requirement 4.6-3: COMPLIANT

Requirement 4.6-4. Reliability of post-mission disposal operations in Earth orbit

Capella has launched 8 spacecrafts on orbit that have a combined lifetime of more than 12 years. Capella has performed thousands of routine collision avoidance maneuvers and orbit raising and maintenance maneuvers for several years on orbit.

Result for Requirement 4.6-4: COMPLIANT

7. Spacecraft Reentry Debris Casualty Risks

Requirement 4.7-1. Limit the risk of human casualty

The risk of human casualty was computed by DAS v3.2.3[1] for an uncontrolled reentry to be 0 for both Acadia-1 and Acadia-2. The detailed results can be found in the logs provided with this report.

[1] There are a number of carbon fiber components in the Acadia 1 & 2 satellites, the demisability of which can be modeled in multiple ways in DAS. Those components are made of graphite epoxy composites, graphite fibers encased in an epoxy resin matrix. Capella performed its analysis using the material properties for carbon fiber listed in the DAS user guide (specifically, "Graphite Epoxy 1"). The epoxy resin will fully demise and carbon fibers lose structural integrity thereafter. DAS also provides alternative material "presets" for carbon fiber components, which Capella did not use. The properties of these preset materials were changed, as of DAS 3.0, to be modeled as pure carbon, in light of new findings that "carbon fiber overwrapped pressure vessels" may be less demisable than previously believed. Benton Greene and Christopher Sanchez, Demisability of GFRP and CFRP Components of Reentring Orbital Debris: Phase I Test Results, 2 (May 15, 2019), [https://ntrs.nasa.gov/api/citations/20190025208/downloads/2019002528.pdf]. The carbon fiber components used in Capella spacecrafts are standalone components that are not wrapped over sub-components to protect them during reentry. They are long, narrow tubes that will lose structural integrity once the epoxy resin has melted off during reentry.

Table 2: Spacecraft Model for Acadia 1 & 2

System	Subsystem	Subcomponent
Bus		
	Reaction Wheels	
	ADCS Avionics	
	IDRS Antenna	
	Bus Panels	
	IDRS Terminal	
	GPS LGA	
		GPS Antenna
		GPS Front End
		Card S-Band
	Star Trackers	
	LGA Comms	
	Propulsion System	
	Voltage Regulator	
	Card Stack	
		Backplane Board
		Mech Board
		Power Distribution Board
		Heater Board
		IRB
		GPS Host
		Masterboard
	Radar	
		Radar Board
		GPU
		Baseband Board
	Batteries	
	Torque Rods	
	Solar Panels	
	Feed	
		Horn
		Bracket
		Amplifier
		TSU
		TRM
SAR Antenna		
	SAR Antenna Battens	
	SAR Antenna Ribs	
	SAR Antenna Hub	
	SAR Antenna Deployer	
	SAR Antenna ClampBand	
	Boom	
Launch Interface Rings		

Result for Requirement 4.7-1: COMPLIANT

8. Collision risk posed by tether systems

Requirement 4.8-1. Mitigate the collision hazards of space tethers in Earth or Lunar orbits

No tethers are to be used in Capella missions.

Result for Requirement 4.8-1: COMPLIANT

END OF ODAR FOR ACADIA 1 & 2

Approved:

03/03/2023

Appendix A.1 – Requirement 4.5-1 – DAS Logs

02 27 2023; 16:35:20PM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = Acadia
Space Structure Type = Payload
Perigee Altitude = 625.000 (km)
Apogee Altitude = 625.000 (km)
Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0310 (m^2/kg)
Start Year = 2023.500 (yr)
Initial Mass = 155.000 (kg)
Final Mass = 150.000 (kg)
Duration = 3.000 (yr)
Station-Kept = True
Abandoned = True
Long-Term Reentry = False

OUTPUT

Collision Probability = 2.3889E-04
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

INPUT

Space Structure Name = Acadia2
Space Structure Type = Payload
Perigee Altitude = 625.000 (km)
Apogee Altitude = 625.000 (km)
Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass Ratio = 0.0310 (m^2/kg)
Start Year = 2023.500 (yr)

Initial Mass = 155.000 (kg)
Final Mass = 150.000 (kg)
Duration = 3.000 (yr)
Station-Kept = True
Abandoned = True
Long-Term Reentry = False

OUTPUT

Collision Probability = 2.3889E-04
Returned Message: Normal Processing
Date Range Message: Normal Date Range
Status = Pass

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

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

Appendix A.2 – Requirement 4.5-2 – DAS Logs

02 27 2023; 17:10:17PM Requirement 4.5-2: Compliant

==
Spacecraft = Acadia
Critical Surface = TR1
==

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 7.500 (g/cm^2)
CS Surface Area = 0.0060 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 0.100 (g/cm^2) Separation: 0.100 (cm)

OUTPUT

Probability of Penetration = 1.0247E-05 (1.0247E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

==
Spacecraft = Acadia
Critical Surface = TR2
==

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 7.500 (g/cm^2)
CS Surface Area = 0.0060 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 0.100 (g/cm^2) Separation: 0.100 (cm)

OUTPUT

Probability of Penetration = 1.0247E-05 (1.0247E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

==
Spacecraft = Acadia
Critical Surface = TR3
==

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 7.500 (g/cm^2)
CS Surface Area = 0.0060 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 3.000 (g/cm^2) Separation: 1.000 (cm)

OUTPUT

Probability of Penetration = 8.7120E-07 (8.7120E-07)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Acadia
Critical Surface = Star Tracker
===

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 1.000 (g/cm^2)
CS Surface Area = 0.0025 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 1.500 (g/cm^2) Separation: 1.500 (cm)

OUTPUT

Probability of Penetration = 7.0928E-04 (7.0953E-04)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Acadia
Critical Surface = Batteries
===

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)

Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 10.500 (g/cm^2)
CS Surface Area = 0.0200 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 3.500 (g/cm^2) Separation: 0.100 (cm)
Outer Wall 2   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)

OUTPUT

Probability of Penetration = 9.2992E-07 (9.2992E-07)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Acadia
Critical Surface = ADCS Avionics
===

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 0.500 (g/cm^2)
CS Surface Area = 0.0100 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 0.800 (g/cm^2) Separation: 2.000 (cm)
Outer Wall 2   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)
Outer Wall 3   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)

OUTPUT

Probability of Penetration = 9.8619E-05 (9.8624E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Acadia
Critical Surface = Prop Tank
===

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 2.500 (g/cm^2)
CS Surface Area = 0.0200 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = Yes
Outer Wall 1 Density: 2.300 (g/cm^2) Separation: 2.000 (cm)
Outer Wall 2 Density: -1.000 (g/cm^2) Separation: -1.000 (cm)

OUTPUT

Probability of Penetration = 2.0798E-03 (2.0820E-03)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Acadia
Critical Surface = RW1
===

INPUT

Apogee Altitude = 625.000 (km)

Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 5.000 (g/cm^2)
CS Surface Area = 0.0200 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 1.000 (g/cm^2) Separation: 0.200 (cm)
Outer Wall 2   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)
Outer Wall 3   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)

OUTPUT

Probability of Penetration = 2.2263E-05 (2.2263E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

==
Spacecraft = Acadia
Critical Surface = RW2
==

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 5.000 (g/cm^2)
CS Surface Area = 0.0200 (m^2)

Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 1.000 (g/cm^2) Separation: 0.200 (cm)
Outer Wall 2   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)
Outer Wall 3   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)

OUTPUT

Probability of Penetration = 6.7473E-05 (6.7476E-05)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

==
Spacecraft = Acadia
Critical Surface = RW3
==

INPUT

Apogee Altitude = 625.000 (km)
Perigee Altitude = 625.000 (km)
Orbital Inclination = 56.000 (deg)
RAAN = 0.000 (deg)
Argument of Perigee = 0.000 (deg)
Mean Anomaly = 0.000 (deg)
Final Area-To-Mass = 0.0310 (m^2/kg)
Initial Mass = 150.000 (kg)
Final Mass = 150.000 (kg)
Station Kept = Yes
Start Year = 2023.500 (yr)
Duration = 3.000 (yr)
Orientation = Random Tumbling
CS Areal Density = 5.000 (g/cm^2)
CS Surface Area = 0.0200 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 1.000 (g/cm^2) Separation: 0.200 (cm)
Outer Wall 2   Density: -1.000 (g/cm^2) Separation: -1.000 (cm)

OUTPUT

Probability of Penetration = 2.2236E-04 (2.2238E-04)
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

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

Appendix A.3 – Requirement 4.6-1 – DAS Logs

02 28 2023; 11:37:05AM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2023.500000 (yr)
Perigee Altitude = 625.000000 (km)
Apogee Altitude = 625.000000 (km)
Inclination = 56.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Area-To-Mass Ratio = 0.031000 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 4.153320 (yr)
Time Spent in LEO during Lifetime = 4.153320 (yr)
Last year of Propagation = 2027 (yr)
Returned Error Message: Object reentered

02 28 2023; 11:09:11AM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2026.250000 (yr)
Perigee Altitude = 585.000000 (km)
Apogee Altitude = 585.000000 (km)
Inclination = 56.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Area-To-Mass Ratio = 0.031000 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 3.055441 (yr)
Time Spent in LEO during Lifetime = 3.055441 (yr)
Last year of Propagation = 2029 (yr)
Returned Error Message: Object reentered

Appendix A.4 – Requirement 4.7-1 – DAS Logs

02 28 2023; 11:25:12AM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 1

name = Acadia
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 150.000000
Thermal Mass = 150.000000
Diameter/Width = 0.700000
Length = 0.800000
Height = 0.400000

name = Reaction Wheels
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 3.300000
Thermal Mass = 3.300000
Diameter/Width = 0.170000
Length = 0.170000
Height = 0.070000

name = ADCS Avionics
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.800000
Thermal Mass = 0.800000
Diameter/Width = 0.120000
Length = 0.120000
Height = 0.050000

name = IDRS Antenna
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.220000
Thermal Mass = 0.220000

Diameter/Width = 0.080000
Length = 0.240000
Height = 0.070000

name = -Y Bus Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 8.000000
Thermal Mass = 8.000000
Diameter/Width = 0.470000
Length = 0.720000

name = +Z Bus Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 4.100000
Thermal Mass = 4.100000
Diameter/Width = 0.340000
Length = 0.530000

name = -Z Bus Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 2.600000
Thermal Mass = 2.600000
Diameter/Width = 0.340000
Length = 0.460000

name = +Y Bus Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 6.100000
Thermal Mass = 6.100000
Diameter/Width = 0.580000
Length = 0.830000

name = Shelf Support Panel
quantity = 1
parent = 1
materialID = 9

type = Flat Plate
Aero Mass = 2.500000
Thermal Mass = 2.500000
Diameter/Width = 0.340000
Length = 0.820000

name = -X Bus Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 3.500000
Thermal Mass = 3.500000
Diameter/Width = 0.440000
Length = 0.690000

name = +X Bus PAnel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 6.000000
Thermal Mass = 6.000000
Diameter/Width = 0.440000
Length = 0.920000

name = Shelf Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.150000
Length = 0.390000

name = Boom Panel
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.080000
Length = 0.130000

name = Stiffening Panel +X
quantity = 1

parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.210000
Length = 0.320000

name = Stiffening Panel -Z
quantity = 1
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 2.600000
Thermal Mass = 2.600000
Diameter/Width = 0.320000
Length = 0.810000

name = Boom Sliding Guide Angle
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.120000
Thermal Mass = 0.120000
Diameter/Width = 0.050000
Length = 0.180000

name = IDRS Terminal
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 1.200000
Thermal Mass = 1.200000
Diameter/Width = 0.110000
Length = 0.120000
Height = 0.070000

name = GPS LGA
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.600000
Thermal Mass = 0.100000
Diameter/Width = 0.190000
Length = 0.360000

Height = 0.010000

name = GPS Antenna
quantity = 1
parent = 18
materialID = 5
type = Flat Plate
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.100000
Length = 0.100000

name = GPS Front End
quantity = 1
parent = 18
materialID = 5
type = Flat Plate
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.100000
Length = 0.100000

name = Card S-Band
quantity = 1
parent = 18
materialID = 5
type = Box
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.060000
Length = 0.060000
Height = 0.020000

name = Star Tracker
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.080000
Length = 0.170000
Height = 0.070000

name = LGA Comms
quantity = 1
parent = 1
materialID = 5

type = Box
Aero Mass = 0.600000
Thermal Mass = 0.600000
Diameter/Width = 0.110000
Length = 0.130000
Height = 0.050000

name = Prop System
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 10.000000
Thermal Mass = 10.000000
Diameter/Width = 0.240000
Length = 0.410000
Height = 0.230000

name = Voltage Regulator
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.800000
Thermal Mass = 0.800000
Diameter/Width = 0.110000
Length = 0.130000
Height = 0.040000

name = Card Stack
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.970000
Thermal Mass = 0.600000
Diameter/Width = 0.180000
Length = 0.190000
Height = 0.150000

name = Backplane Board
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.600000
Thermal Mass = 0.600000
Diameter/Width = 0.150000

Length = 0.170000

name = Mastercard
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.300000
Thermal Mass = 0.300000
Diameter/Width = 0.110000
Length = 0.170000

name = Mech Board
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.220000
Thermal Mass = 0.220000
Diameter/Width = 0.110000
Length = 0.170000

name = PDB
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.250000
Thermal Mass = 0.250000
Diameter/Width = 0.110000
Length = 0.170000

name = SHB
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.250000
Thermal Mass = 0.250000
Diameter/Width = 0.110000
Length = 0.170000

name = IRB
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.250000

Thermal Mass = 0.250000
Diameter/Width = 0.110000
Length = 0.170000

name = GPS Host
quantity = 1
parent = 26
materialID = 5
type = Flat Plate
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.110000
Length = 0.180000

name = Hawk
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 2.050000
Thermal Mass = 1.000000
Diameter/Width = 0.100000
Length = 0.130000
Height = 0.100000

name = Baseband Board
quantity = 1
parent = 34
materialID = 5
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.100000
Length = 0.130000
Height = 0.020000

name = GPU
quantity = 1
parent = 34
materialID = 5
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.100000
Length = 0.130000
Height = 0.040000

name = Radar Board

quantity = 1
parent = 34
materialID = 5
type = Flat Plate
Aero Mass = 0.150000
Thermal Mass = 0.150000
Diameter/Width = 0.100000
Length = 0.130000

name = Batteries
quantity = 64
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.030000
Length = 0.060000

name = Battery Plate
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.080000
Length = 0.160000
Height = 0.050000

name = Torque Rods
quantity = 3
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.030000
Length = 0.200000

name = Solar Panel
quantity = 6
parent = 1
materialID = 5
type = Flat Plate
Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.500000

Length = 0.800000

name = Talon Box
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 5.000000
Thermal Mass = 0.500000
Diameter/Width = 0.310000
Length = 0.310000
Height = 0.230000

name = Feed Horn
quantity = 1
parent = 42
materialID = 8
type = Flat Plate
Aero Mass = 0.150000
Thermal Mass = 0.150000
Diameter/Width = 0.100000
Length = 0.100000

name = Bracket
quantity = 1
parent = 42
materialID = 5
type = Flat Plate
Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.250000
Length = 0.250000

name = Amplifier
quantity = 1
parent = 42
materialID = 5
type = Box
Aero Mass = 2.000000
Thermal Mass = 2.000000
Diameter/Width = 0.170000
Length = 0.170000
Height = 0.150000

name = TSU
quantity = 1
parent = 42
materialID = 8

type = Flat Plate
Aero Mass = 0.750000
Thermal Mass = 0.750000
Diameter/Width = 0.170000
Length = 0.180000

name = TRM
quantity = 1
parent = 42
materialID = 8
type = Box
Aero Mass = 0.600000
Thermal Mass = 0.600000
Diameter/Width = 0.160000
Length = 0.250000
Height = 0.070000

name = Boom Lateral Restraint
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.210000
Thermal Mass = 0.210000
Diameter/Width = 0.040000
Length = 0.060000
Height = 0.040000

name = Boom Section 1
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 1.520000
Thermal Mass = 1.520000
Diameter/Width = 0.080000
Length = 0.650000

name = Boom Section 2
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 1.400000
Thermal Mass = 1.400000
Diameter/Width = 0.080000
Length = 1.240000

name = Boom Section 3
quantity = 1
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 1.160000
Thermal Mass = 1.160000
Diameter/Width = 0.076000
Length = 1.020000

name = Yoke Clamp Assy
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.350000
Thermal Mass = 0.350000
Diameter/Width = 0.100000
Length = 0.110000
Height = 0.060000

name = Frangi Clamp Assy
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.500000
Thermal Mass = 0.500000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.100000

name = Lower Boom Clamp
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.150000
Thermal Mass = 0.150000
Diameter/Width = 0.090000
Length = 0.090000
Height = 0.030000

name = Upper Boom Clamp
quantity = 1
parent = 1
materialID = 9
type = Box

Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.090000
Length = 0.100000
Height = 0.030000

name = Hinge Assy
quantity = 2
parent = 1
materialID = 9
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.200000
Length = 0.500000
Height = 0.100000

name = Outer Boom Clam Shell
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.600000
Thermal Mass = 0.600000
Diameter/Width = 0.100000
Length = 0.300000
Height = 0.090000

name = Boom Flange
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.100000
Length = 0.110000
Height = 0.080000

name = Sway Clamp Arm
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.110000
Length = 0.240000

Height = 0.030000

name = HDR Gimbal Base
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.250000
Thermal Mass = 1.250000
Diameter/Width = 0.150000
Length = 0.230000
Height = 0.120000

name = HDR Gimbal Azimuth
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.800000
Thermal Mass = 1.800000
Diameter/Width = 0.140000
Length = 0.180000
Height = 0.130000

name = HDR Gimbal Elevation
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.200000
Thermal Mass = 1.200000
Diameter/Width = 0.120000
Length = 0.140000
Height = 0.110000

name = HDR Gimbal Bracket
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.300000
Thermal Mass = 0.300000
Diameter/Width = 0.140000
Length = 0.250000

name = HDR Antenna
quantity = 1
parent = 1

materialID = 5
type = Box
Aero Mass = 0.800000
Thermal Mass = 0.800000
Diameter/Width = 0.110000
Length = 0.210000
Height = 0.020000

name = HDR Radiator
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.300000
Thermal Mass = 0.300000
Diameter/Width = 0.160000
Length = 0.300000

name = -Y Interface Ring
quantity = 1
parent = 1
materialID = 9
type = Box
Aero Mass = 1.400000
Thermal Mass = 1.400000
Diameter/Width = 0.400000
Length = 0.400000
Height = 0.040000

name = ALB15
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 3.500000
Thermal Mass = 3.500000
Diameter/Width = 0.480000
Length = 0.480000
Height = 0.080000

name = +Z Interface Ring
quantity = 1
parent = 1
materialID = 9
type = Cylinder
Aero Mass = 6.000000
Thermal Mass = 6.000000
Diameter/Width = 0.410000

Length = 0.130000

name = Brace
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.450000
Thermal Mass = 0.450000
Diameter/Width = 0.120000
Length = 0.150000
Height = 0.070000

name = SAR Antenna Ribs
quantity = 12
parent = 1
materialID = -1
type = Flat Plate
Aero Mass = 0.090000
Thermal Mass = 0.090000
Diameter/Width = 0.050000
Length = 1.500000

name = SAR Antenna Hub
quantity = 1
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 10.000000
Thermal Mass = 10.000000
Diameter/Width = 0.200000
Length = 0.600000

name = SAR Antenna Battens
quantity = 12
parent = 1
materialID = -1
type = Cylinder
Aero Mass = 0.122000
Thermal Mass = 0.122000
Diameter/Width = 0.020000
Length = 0.600000

name = SAR Antenna Clampband
quantity = 1
parent = 1
materialID = 54
type = Box

Aero Mass = 10.000000
Thermal Mass = 10.000000
Diameter/Width = 0.200000
Length = 0.600000
Height = 0.200000

name = SAR Antenna Root Deployer
quantity = 1
parent = 1
materialID = 54
type = Box
Aero Mass = 10.804000
Thermal Mass = 10.000000
Diameter/Width = 0.200000
Length = 0.600000
Height = 0.200000

name = Box Plates
quantity = 6
parent = 74
materialID = -1
type = Flat Plate
Aero Mass = 0.134000
Thermal Mass = 0.134000
Diameter/Width = 0.250000
Length = 0.250000

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

name = Acadia
Demise Altitude = 77.996400
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Reaction Wheels
Demise Altitude = 74.513882
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ADCS Avionics
Demise Altitude = 76.511072
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = IDRS Antenna
Demise Altitude = 77.767685
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = -Y Bus Panel
Demise Altitude = 72.509347
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = +Z Bus Panel
Demise Altitude = 73.758640
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = -Z Bus Panel
Demise Altitude = 74.939465
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = +Y Bus Panel
Demise Altitude = 74.664053
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Shelf Support Panel
Demise Altitude = 76.200271
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = -X Bus Panel
Demise Altitude = 75.490342
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = +X Bus PAnel
Demise Altitude = 74.534542
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Shelf Panel
Demise Altitude = 75.794958
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Panel
Demise Altitude = 76.299599
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Stiffening Panel +X
Demise Altitude = 75.923897
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Stiffening Panel -Z
Demise Altitude = 76.031115
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Sliding Guide Angle
Demise Altitude = 77.531980
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = IDRS Terminal
Demise Altitude = 76.025604
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = GPS LGA
Demise Altitude = 77.925164
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = GPS Antenna
Demise Altitude = 75.773645
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = GPS Front End
Demise Altitude = 75.773645
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Card S-Band
Demise Altitude = 76.264085
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Star Tracker
Demise Altitude = 76.230308
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = LGA Comms
Demise Altitude = 75.172522
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Prop System
Demise Altitude = 70.840813
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Voltage Regulator
Demise Altitude = 73.964146
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Card Stack
Demise Altitude = 76.964905
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Backplane Board
Demise Altitude = 73.837873
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Mastercard
Demise Altitude = 75.145516
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Mech Board
Demise Altitude = 75.635455
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PDB
Demise Altitude = 75.452563
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = SHB
Demise Altitude = 75.452563
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = IRB
Demise Altitude = 75.452563
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = GPS Host
Demise Altitude = 74.073268
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Hawk
Demise Altitude = 74.771651
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Baseband Board
Demise Altitude = 72.198771
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = GPU
Demise Altitude = 72.125318
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Radar Board
Demise Altitude = 73.543865
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Batteries
Demise Altitude = 76.556103
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Battery Plate
Demise Altitude = 75.831048
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Torque Rods
Demise Altitude = 74.667661
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Solar Panel
Demise Altitude = 77.367467
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Talon Box
Demise Altitude = 77.586120
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Feed Horn
Demise Altitude = 76.991191
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Bracket
Demise Altitude = 74.790009
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Amplifier
Demise Altitude = 73.366735
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = TSU
Demise Altitude = 76.348181
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = TRM
Demise Altitude = 77.113367
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Lateral Restraint
Demise Altitude = 75.412843
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Section 1
Demise Altitude = 77.116626
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Section 2
Demise Altitude = 77.557400
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Section 3
Demise Altitude = 77.541827
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Yoke Clamp Assy
Demise Altitude = 76.321293
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Frangi Clamp Assy
Demise Altitude = 75.807526
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Lower Boom Clamp
Demise Altitude = 76.829509
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Upper Boom Clamp
Demise Altitude = 76.588595
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Hinge Assy
Demise Altitude = 76.368613
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Outer Boom Clam Shell
Demise Altitude = 76.951002
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Boom Flange
Demise Altitude = 76.123447
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Sway Clamp Arm
Demise Altitude = 76.797438
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = HDR Gimbal Base
Demise Altitude = 75.755078
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = HDR Gimbal Azimuth
Demise Altitude = 74.172786
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = HDR Gimbal Elevation
Demise Altitude = 74.440572
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = HDR Gimbal Bracket
Demise Altitude = 77.594760
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = HDR Antenna
Demise Altitude = 74.821289
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = HDR Radiator
Demise Altitude = 77.682382
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = -Y Interface Ring
Demise Altitude = 76.479049
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ALB15
Demise Altitude = 74.900184
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = +Z Interface Ring
Demise Altitude = 71.629695
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Brace
Demise Altitude = 77.390942
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = SAR Antenna Ribs
Demise Altitude = 77.971137
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = SAR Antenna Hub
Demise Altitude = 66.674050
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = SAR Antenna Battens
Demise Altitude = 77.813822
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = SAR Antenna Clampband
Demise Altitude = 68.991200
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = SAR Antenna Root Deployer
Demise Altitude = 69.227092
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Box Plates
Demise Altitude = 69.086605
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
============== End of Requirement 4.7-1 ==============