ASTRANIS

Orbital Debris Assessment

Astranis DemoSat-2

Overview

The Astranis DemoSat-2 test satellite is being launched to a 500 km circular, sun-synchronous orbit, and will be deployed by a standard QuadPack satellite dispenser. The satellite does not have propulsion, pressure vessels, detachable components, or any other similar potential sources of debris. The spacecraft conforms to the form factor of a 3U cubesat (35 cm X 10 cm X 10 cm in size), and spacecraft mass of 5 kg was used. All calculations were done using NASA's DAS (Debris Assessment Software) program, see the following pages for screenshots of the program outputs.

An orbital lifetime calculation for this orbit estimates that the satellite will remain on obit for approximately 6.4 years in the nominal case. In this case, the satellite is assumed to be tumbling and the calculation was done with an average cross-sectional area with 20% factor applied for conservatism, per the ISO/ANSI draft standard 27852:2010(E). In the worst case, in which the satellite is somehow able to present its smallest cross-section to its direction of travel for its entire life on orbit, analysis shows the satellite would remain on orbit for 17.3 years. The satellite has four small deployable monopole antennas, which were not considered in this analysis. These antennas would be expected to have a measurable effect, reducing the lifetime further.

Collision risk analysis was performed using the DAS software, which showed a collision probability of 0.0000 in both the nominal and worst case lifetime scenarios. An atmospheric demise analysis was completed as well, showing a de minimis risk of human casualties.

To support collision avoidance, Astranis will be in communication with JSpOC directly to provide orbital parameters and any other assistance necessary for the cataloging of the satellite. An Astranis employee will be assigned as the point of contact for communications with JSpOC regarding conjunction warnings.

Orbital Lifetime Calculation

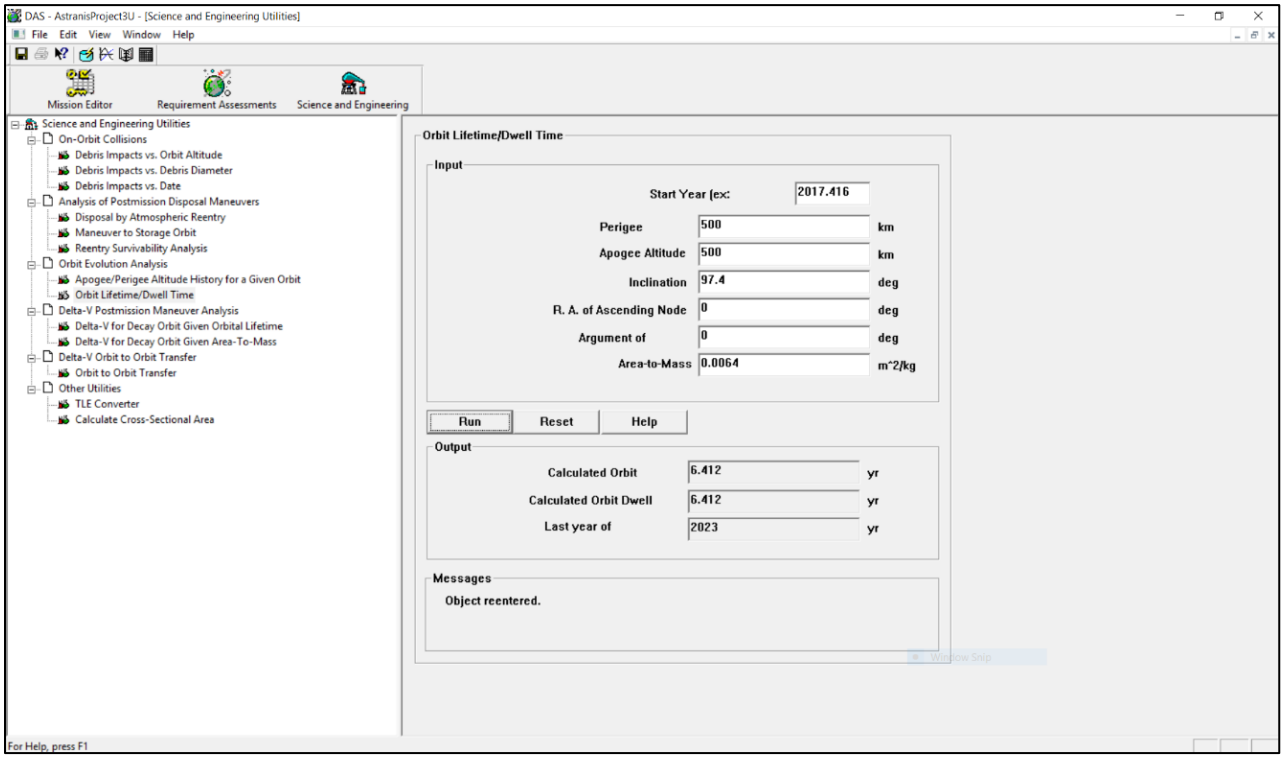
NASA DAS software was used to conduct an orbital lifetime analysis. Two scenarios were contemplated, a nominal case and a worst case.

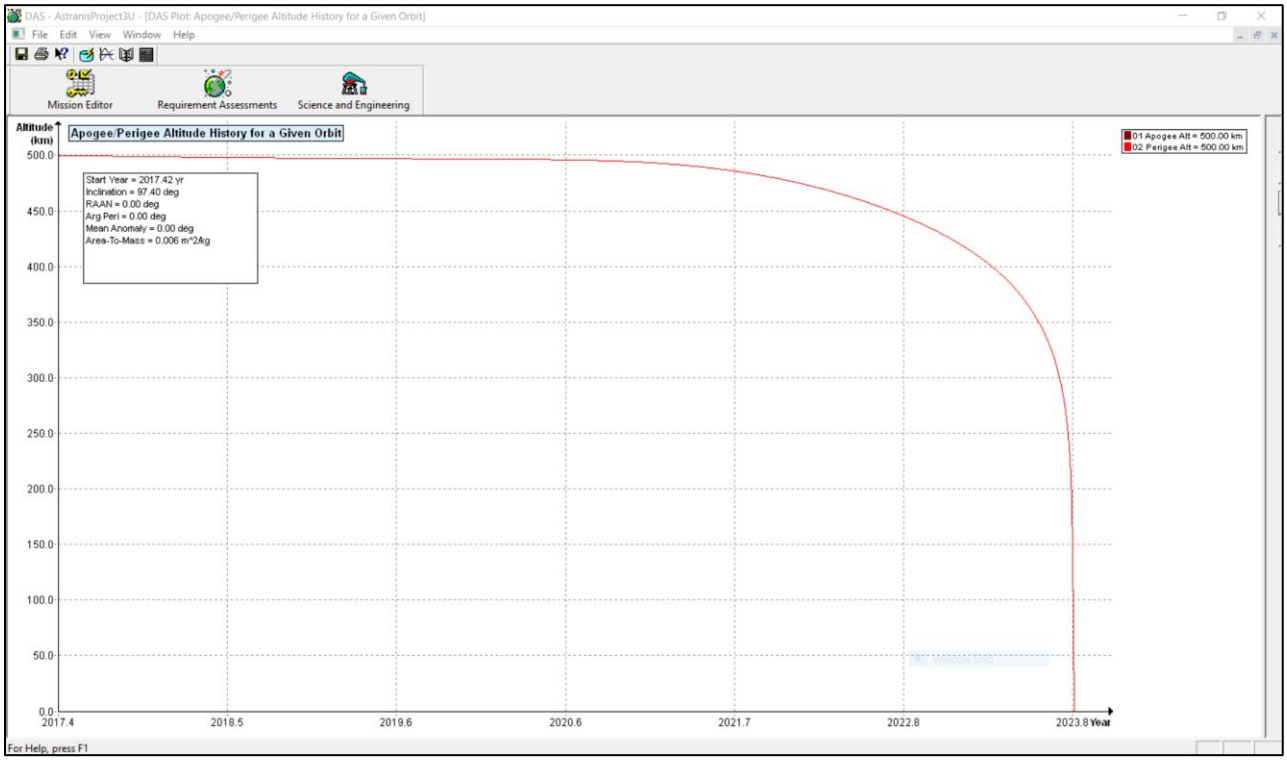
For the nominal case, the spacecraft was assumed to be tumbling and an average cross-sectional area was used. To determine the mean cross-sectional area of a tumbling rectangular parallelepiped, the approach in ISO/ANSI draft standard 27852:2010(E) was taken. The formula for the average cross-sectional area in that case is (S1+S2+S3)/2, with an additional factor of 20% applied for conservatism. This gave an area-to-mass ratio of 0.0064 m^2/kg.

For the worst case, it was assumed that the spacecraft was somehow able to present its minimal cross-sectional area of 10 cm X 10 cm for the duration of its orbital lifetime. This gave an area-to-mass ratio of 0.0020 m^2/kg.

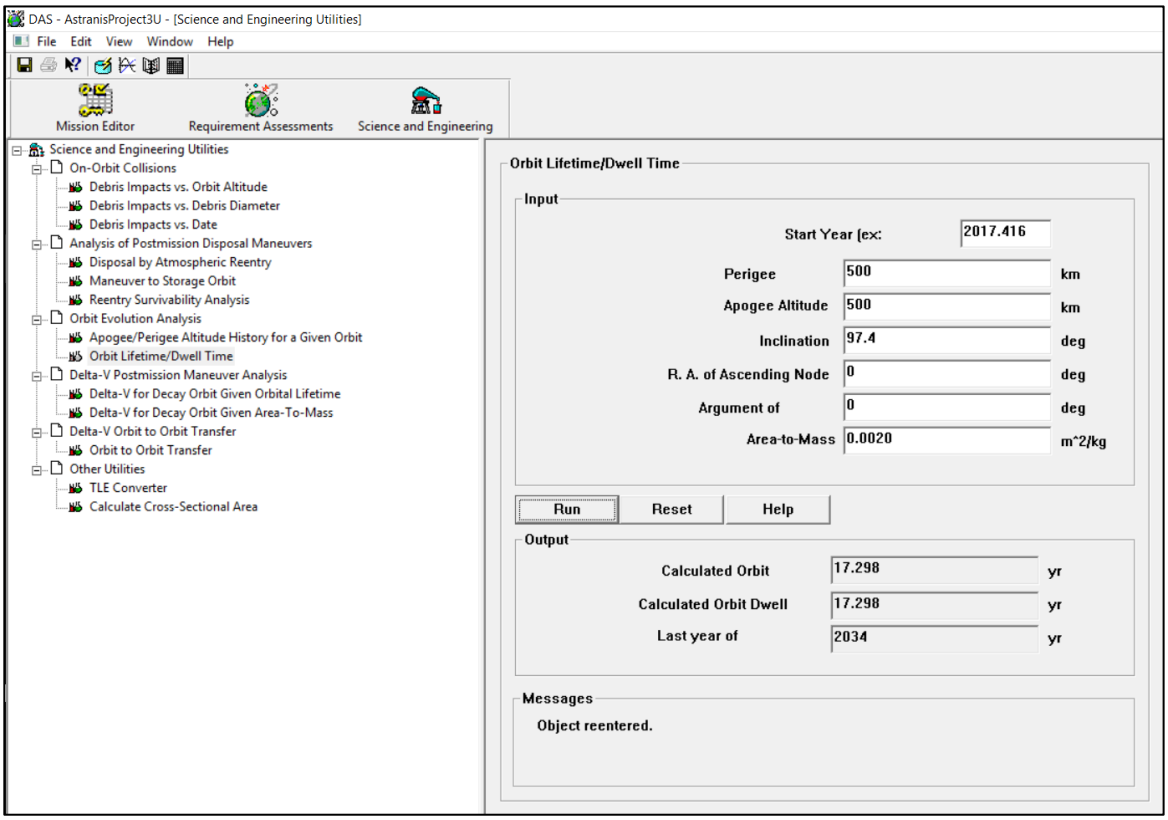
Spacecraft Dimensions and Mass	
Length	35 cm
Width	10 cm
Height	10 cm
Mass	5 kg
Calculated Parameters	
Nominal Area-to-Mass Ratio	0.0064 m^2/kg
Worst case Area-to-Mass Ratio	0.0020 m^2/kg
Orbit Overview	
Altitude	500 km
Inclination	97.4 deg
Orbit Lifetime	
Nominal	6.4 years
Worst case	17.3 years

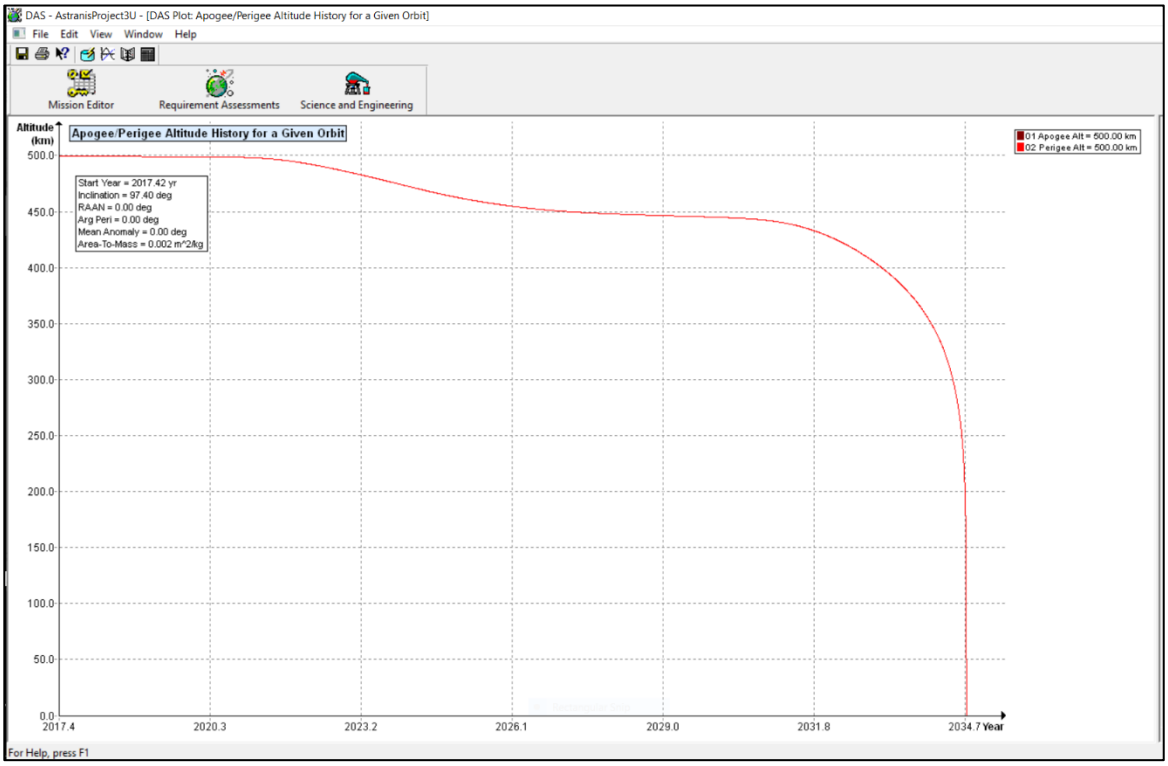
Nominal scenario (average cross-sectional area is used)





Worst case scenario (minimal cross-sectional area is used)

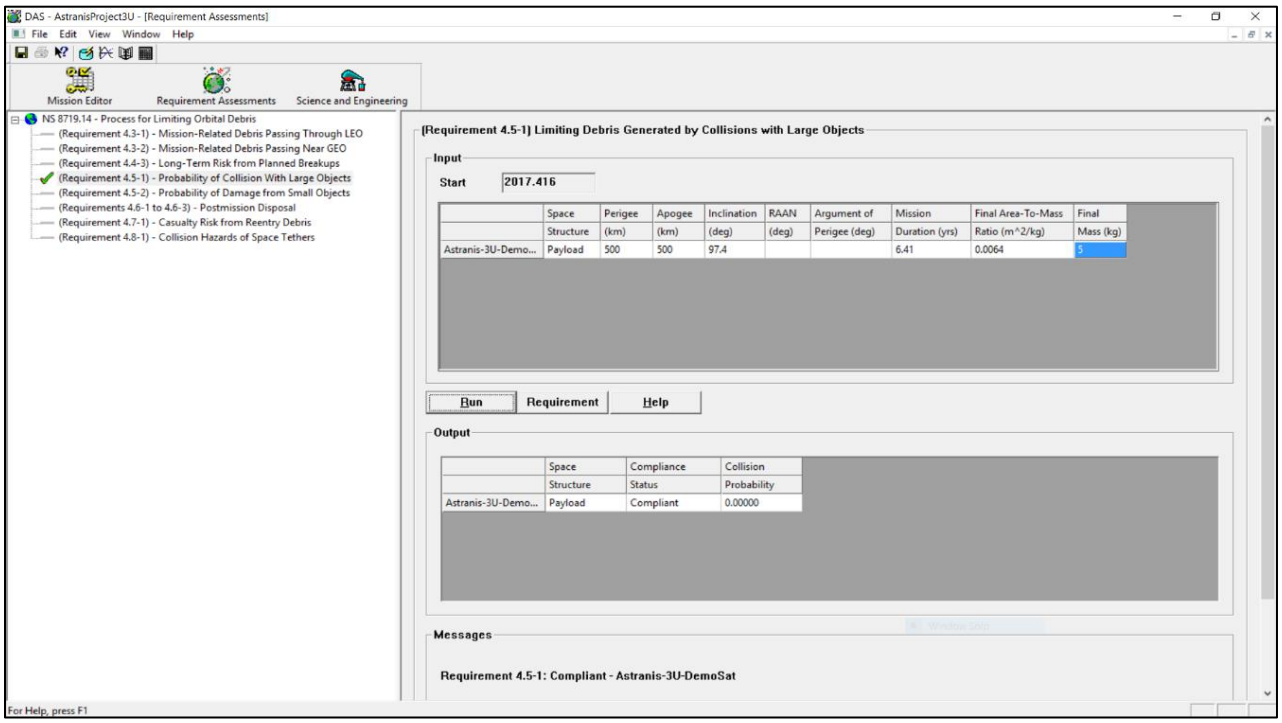




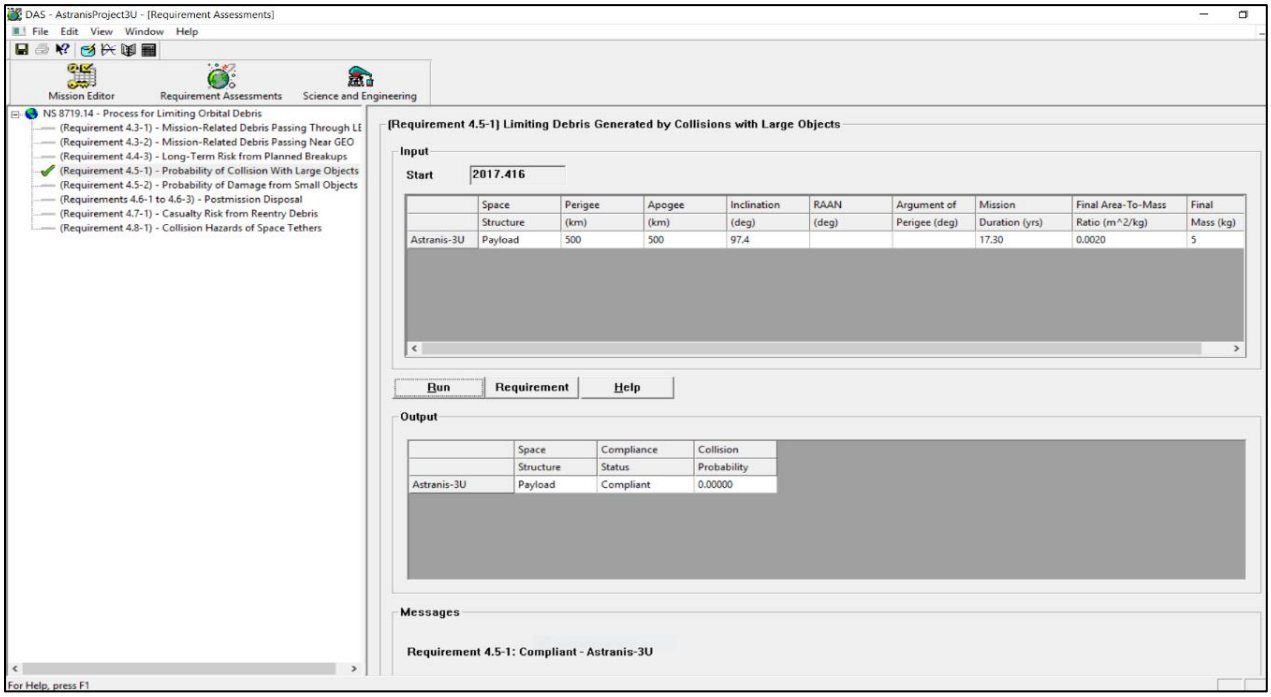
Collision Risk Calculation

The DAS Software was used to calculate the probability of spacecraft collision with large objects. As before two cases were analyzed—a nominal case assuming the spacecraft is tumbling, and therefore has a shorter life, and a worst-case scenario in which the spacecraft has a longer life. In both cases, the DAS Software found the probability of a collision to be 0.0000.

Nominal scenario (average cross-sectional area is used).



Worst case scenario (minimal cross-sectional area is used).



Ground Impact Risk Assessment

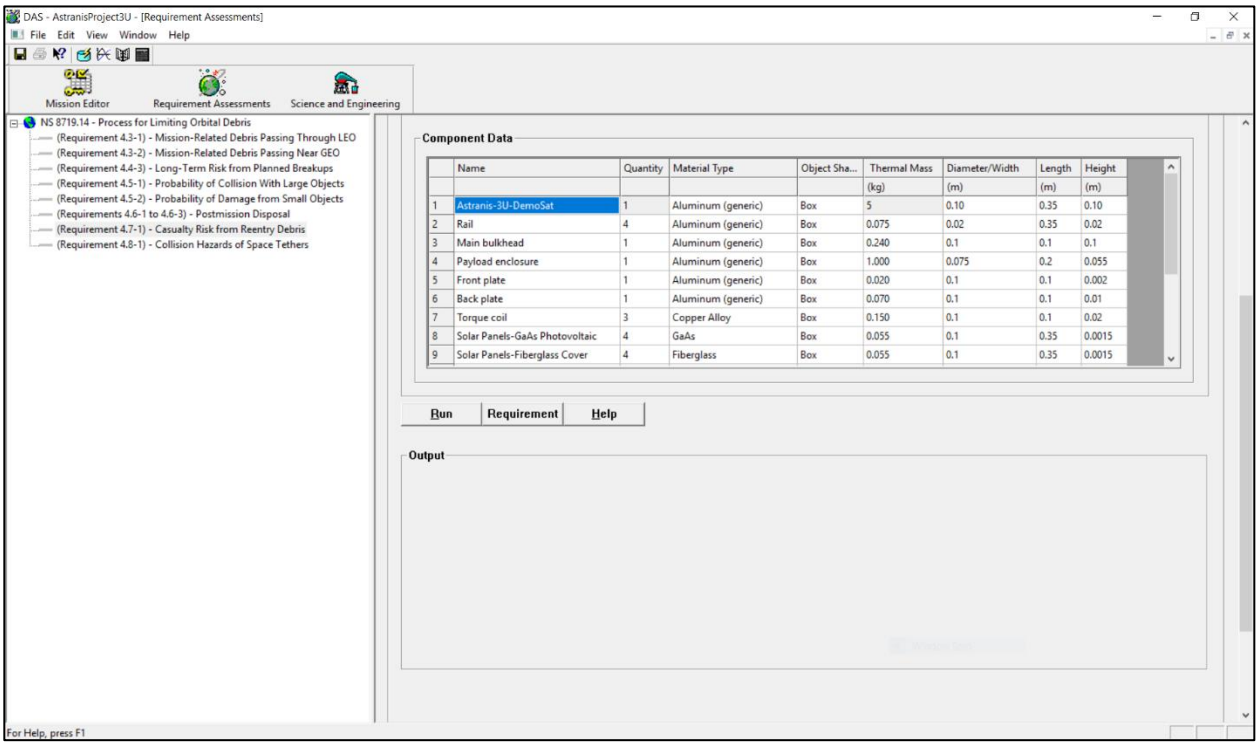
Given the spacecraft's small mass (5 kg) and the makeup of its constituent components (see table below), the spacecraft is expected to break up upon re-entry and for very little, if any, components to make it to the ground.

The DAS analysis found the risk of human casualty to be de minimis and in compliance with Requirement 4.7-1, with only one component found to make it to ground level with a kinetic energy of 2 Joules.

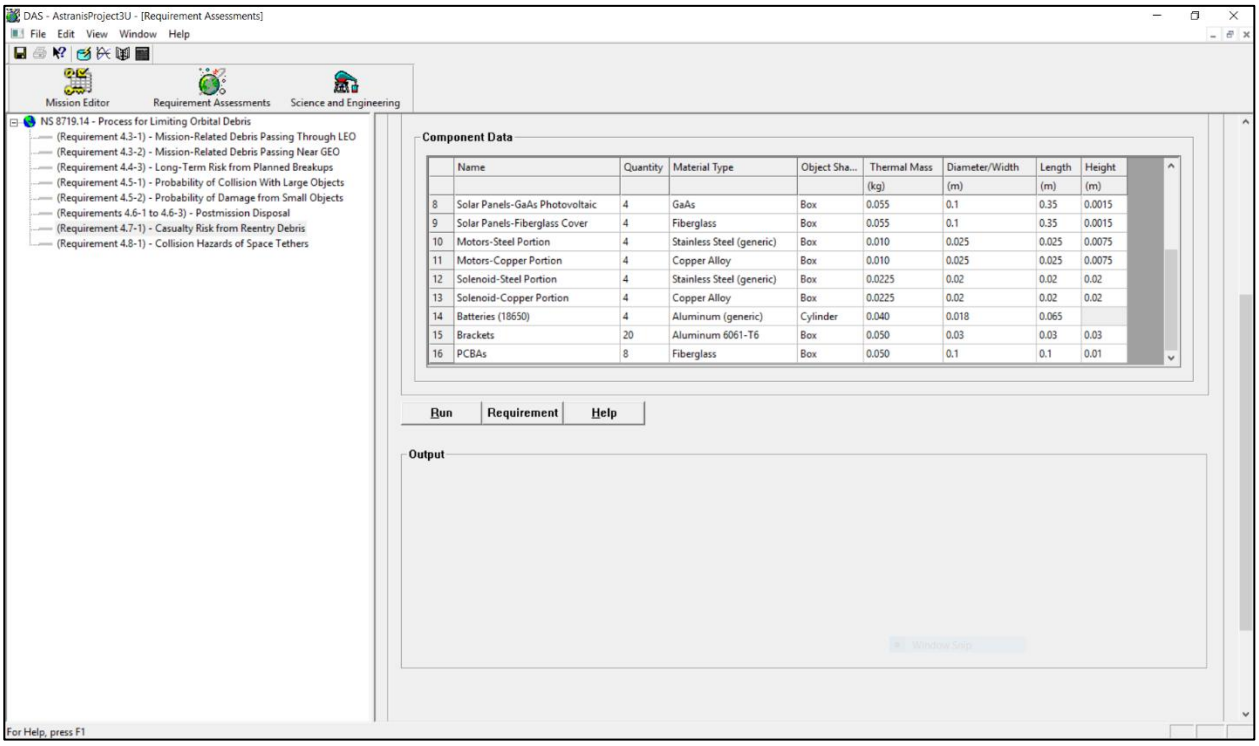
The Astranis DemoSat-2 spacecraft components include:

Name	Qty	Material	Dimensions (m)	Mass per	Mass total
Main bulkhead	1	Al	0.10 x 0.10 x 0.10	0.240	0.240
Payload enclosure	1	Al	0.20 x 0.075 x 0.055	1.000	1.000
Front plate	1	Al	0.10 x 0.10 x 0.002	0.020	0.020
Back plate	1	Al	0.10 x 0.10 x 0.01	0.070	0.070
Torque Coil	3	Copper	0.10 x 0.10 x 0.02	0.150	0.450
Solar Panels-GaAs Photovoltaic	4	GaAs	0.35 x 0.10 x 0.0015	0.055	0.220
Solar Panels-Fiberglass Cover	4	Fiberglass	0.35 x 0.10 x 0.0015	0.055	0.220
Motors-Steel Portion	4	Steel	0.025 x 0.025 x 0.0075	0.010	0.040
Motors-Copper Portion	4	Copper	0.025 x 0.025 x 0.0075	0.010	0.040
Solenoid-Steel Portion	4	Steel	0.02 x 0.02 x 0.02	0.0225	0.090
Solenoid-Copper Portion	4	Copper	0.02 x 0.02 x 0.02	0.0225	0.090
Batteries (18650)	4	Al	(18650 cell) Cylinder, Dia=0.018, Ht=0.065	0.040	0.160
Brackets	20	Al 6061	Default based on density: 0.03x0.03x0.03	0.050	1.000
PCBAs	8	Fiberglass	0.10 x 0.10 x 0.01	0.050	0.400
Total mass					**4.34 kg**

DAS Screenshots Page 1 (inputs to ground impact risk assessment program)



	Name	Quantity	Material Type	Object Sha...	Thermal Mass (kg)	Diameter/Width (m)	Length (m)	Height (m)
1	Astranis-3U-DemoSat	1	Aluminum (generic)	Box	5	0.10	0.35	0.10
2	Rail	4	Aluminum (generic)	Box	0.075	0.02	0.35	0.02
3	Main bulkhead	1	Aluminum (generic)	Box	0.240	0.1	0.1	0.1
4	Payload enclosure	1	Aluminum (generic)	Box	1.000	0.075	0.2	0.055
5	Front plate	1	Aluminum (generic)	Box	0.020	0.1	0.1	0.002
6	Back plate	1	Aluminum (generic)	Box	0.070	0.1	0.1	0.01
7	Torque coil	3	Copper Alloy	Box	0.150	0.1	0.1	0.02
8	Solar Panels-GaAs Photovoltaic	4	GaAs	Box	0.055	0.1	0.35	0.0015
9	Solar Panels-Fiberglass Cover	4	Fiberglass	Box	0.055	0.1	0.35	0.0015



	Name	Quantity	Material Type	Object Sha...	Thermal Mass (kg)	Diameter/Width (m)	Length (m)	Height (m)
8	Solar Panels-GaAs Photovoltaic	4	GaAs	Box	0.055	0.1	0.35	0.0015
9	Solar Panels-Fiberglass Cover	4	Fiberglass	Box	0.055	0.1	0.35	0.0015
10	Motors-Steel Portion	4	Stainless Steel (generic)	Box	0.010	0.025	0.025	0.0075
11	Motors-Copper Portion	4	Copper Alloy	Box	0.010	0.025	0.025	0.0075
12	Solenoid-Steel Portion	4	Stainless Steel (generic)	Box	0.0225	0.02	0.02	0.02
13	Solenoid-Copper Portion	4	Copper Alloy	Box	0.0225	0.02	0.02	0.02
14	Batteries (18650)	4	Aluminum (generic)	Cylinder	0.040	0.018	0.065	
15	Brackets	20	Aluminum 6061-T6	Box	0.050	0.03	0.03	0.03
16	PCBAs	8	Fiberglass	Box	0.050	0.1	0.1	0.01

DAS Screenshots Page 2 (outputs of ground impact risk assessment program)