NanoSatisfi Inc

ArduSat-2 Orbital Debris Assessment Report (ODAR)

Revision #: 0

Prepared by: Joel Spark
Delivery Date: 7-23-2013

Contents:

Summarized List of Compliance Status to Orbital Debris Requirements

For convenience, below is a summarized list of the compliance status to orbital debris requirements. Detailed explanations for each of these compliance statements are available in ODAR Sections 1 through 8.

4.3-1, Mission-Related Debris Passing Through LEO:	**COMPLIANT**
4.3-2, Mission-Related Debris Passing Near GEO	**COMPLIANT**
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:	**COMPLIANT**
4.4-2, Design for passivation after completion of mission operations while in orbit about Earth or the Moon:	**N/A**
4.4-3, Limiting the long-term risk to other space systems from planned breakups:	**COMPLIANT**
4.4-4, Limiting the short-term risk to other space systems from planned breakups:	**COMPLIANT**
4.5-1, Probability of Collision with Large Objects:	**COMPLIANT**
4.5-2, Probability of Damage from Small Objects:	**COMPLIANT**
4.6-1, Disposal for space structures passing through LEO:	**COMPLIANT**
4.6-2, Disposal for space structures passing through GEO:	**N/A**
4.6-3, Disposal for space structures between LEO and GEO:	**N/A**
4.6-4, Reliability of postmission disposal operations:	**N/A**
4.8-1, Collision Hazards of Space Tethers	**N/A**

ODAR Section 1: Program Management and Mission Overview

Program / Project Manager	Peter Platzer
Mission Description	The primary mission of ArduSat-2 is to provide a platform on which students and private space enthusiasts may design and run their own space-based experiments. ArduSat-2 is a follow-on mission to the ArduSat-1 launched in November 2013, with more onboard capacity for hosting experiments, improved data downlink, and new payload sensors. ArduSat-2 is part of an ongoing market study investigating the use of using low-Earth orbiting nanosatellites for engaging, sustainable STEM education.
Project Milestones:	The ArduSat-2 development of ArduSat-2 began in Spring 2013, following the delivery of ArduSat-1 and ArduSat-X to their launch provider. The detailed design of ArduSat-2 was completed in Summer 2013, and is currently undergoing Phase C/D manufacturing / integration in San Francisco. ArduSat-2 will be delivered to NanoRacks LLC, NanoSatisfi's launch service provider POC, in November 2013. ArduSat-2 is manifested to be launched on the ORB-1 ISS resupply mission in December 2013, and deployed from ISS into its operational orbit in early 2014.
Foreign Government Involvement	None
Proposed Launch Date:	December 5, 2013
Proposed Launch Vehicle:	Antares (Cygnus), ORB-1 ISS resupply mission
Proposed Launch Site:	Wallops
Launch Vehicle Operator:	Orbital Sciences
Mission Duration	9-18 months following deployment from ISS
Launch / Deployment Profile:	The ArduSat-2 mission is divided into three segments: launch & pre-deployment, TX Inhibit, and operations. **Launch & Pre-Deployment** ArduSat-2 is launched in the JSSOD, contained within a Cargo Transfer Bag (CTB), in the soft-stowage portion of the Cygnus spacecraft. During launch, it maintains an unpowered state using three independent inhibits detailed in "Launch Inhibits" below. On-orbit, the JSSOD is removed from the CTB by the ISS crew, which is mounted to the MPEP and transferred through the JEM airlock; there is no required interaction with ArduSat-2 by the ISS crew prior to

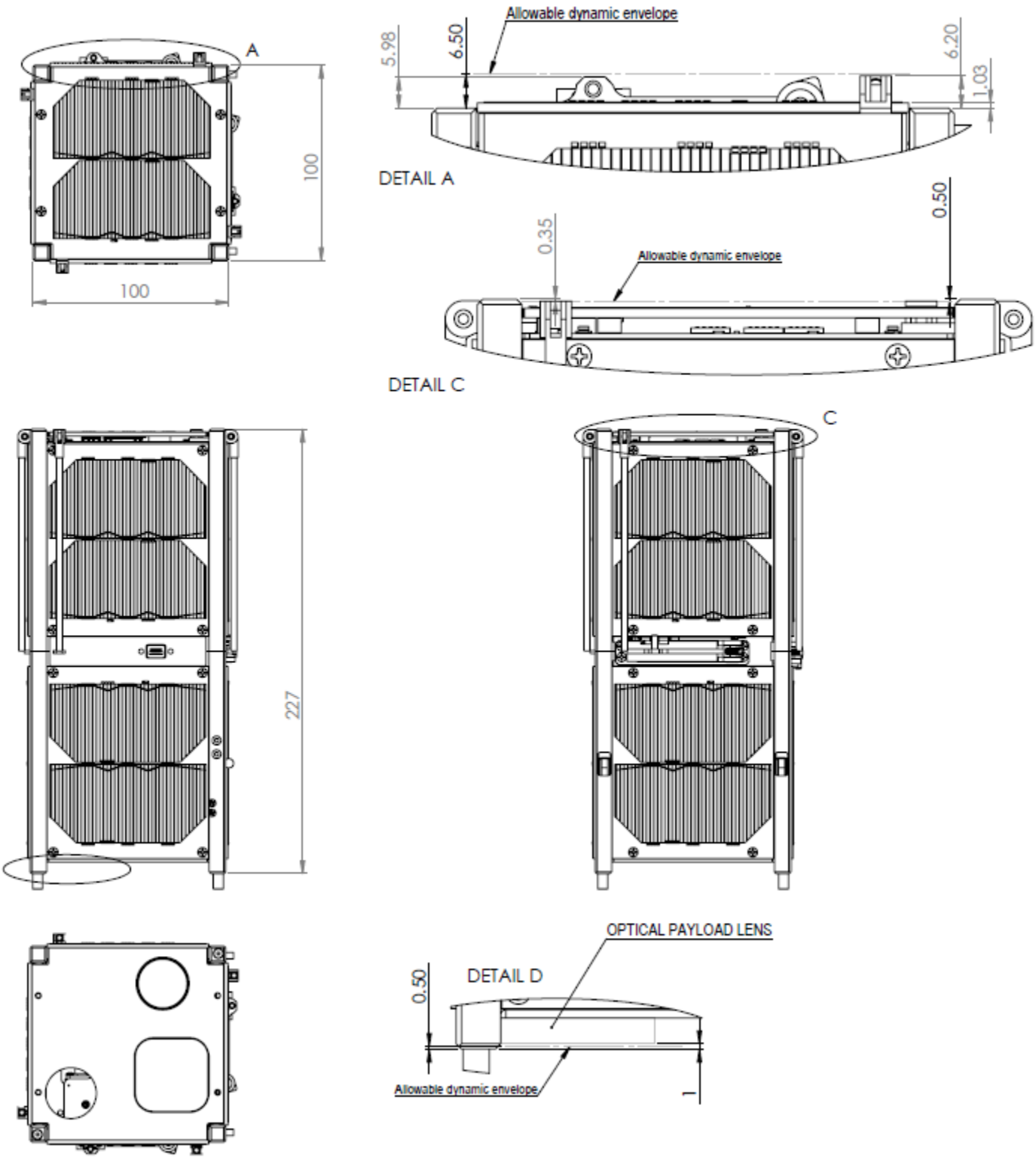
	transferring the MPEP through the airlock. The launch & pre-deployment phase continues from launch until the JSSOD deploys the satellite from the station. **TX Inhibit** The TX inhibit phase of the mission begins upon deployment of ArduSat-2 from the JSSOD, whereupon the three inhibit switches release, powering on the satellite and starting a 45-minute "TX Inhibit" timer. Immediately following complete deployment from JSSOD, the UHF turnstile antenna is deployed. During the 45 minutes following deployment from the JSSOD, ArduSat-2 does not transmit with either its UHF or S-Band transmitter. The post-deployment phase of the mission ends at the completion of the 45-minute TX Inhibit timer. **Operations** The operational phase of the satellite begins following the completion of the TX Inhibit timer, and continues until the satellite passively reenters the atmosphere and disintegrates. During the operational phase, once contact has been established with ArduSat-2 by one of NanoSatisfi's ground stations, an active "AIS Deploy" command is transmitted from the ground, to instruct the satellite to deploy the two orthogonal VHF monopole antennae. Depending on its deployment altitude (between 380km and 410km), it is estimated that ArduSat-2 will reenter the atmosphere 10-18 months following deployment.
Selection of Orbit:	The selection of the ISS orbit was made due to available launch opportunities and a lack of onboard propulsion systems.
Potential Physical Interference with Other Orbiting Object:	As ArduSat-2 has no active propulsion systems, its orbit will naturally decay following deployment from the ISS. Consequently, the only period during which there is potential physical interference with the station is during its deployment, after which normally-scheduled station maintenance maneuvers by the ISS will place it at a higher altitude. As detailed in Section 5, the probability of physical interference between ArduSat-2 and any other orbiting bodies is sufficiently unlikely that the satellite complies requirement 4.5.

ODAR Section 2: Spacecraft Description

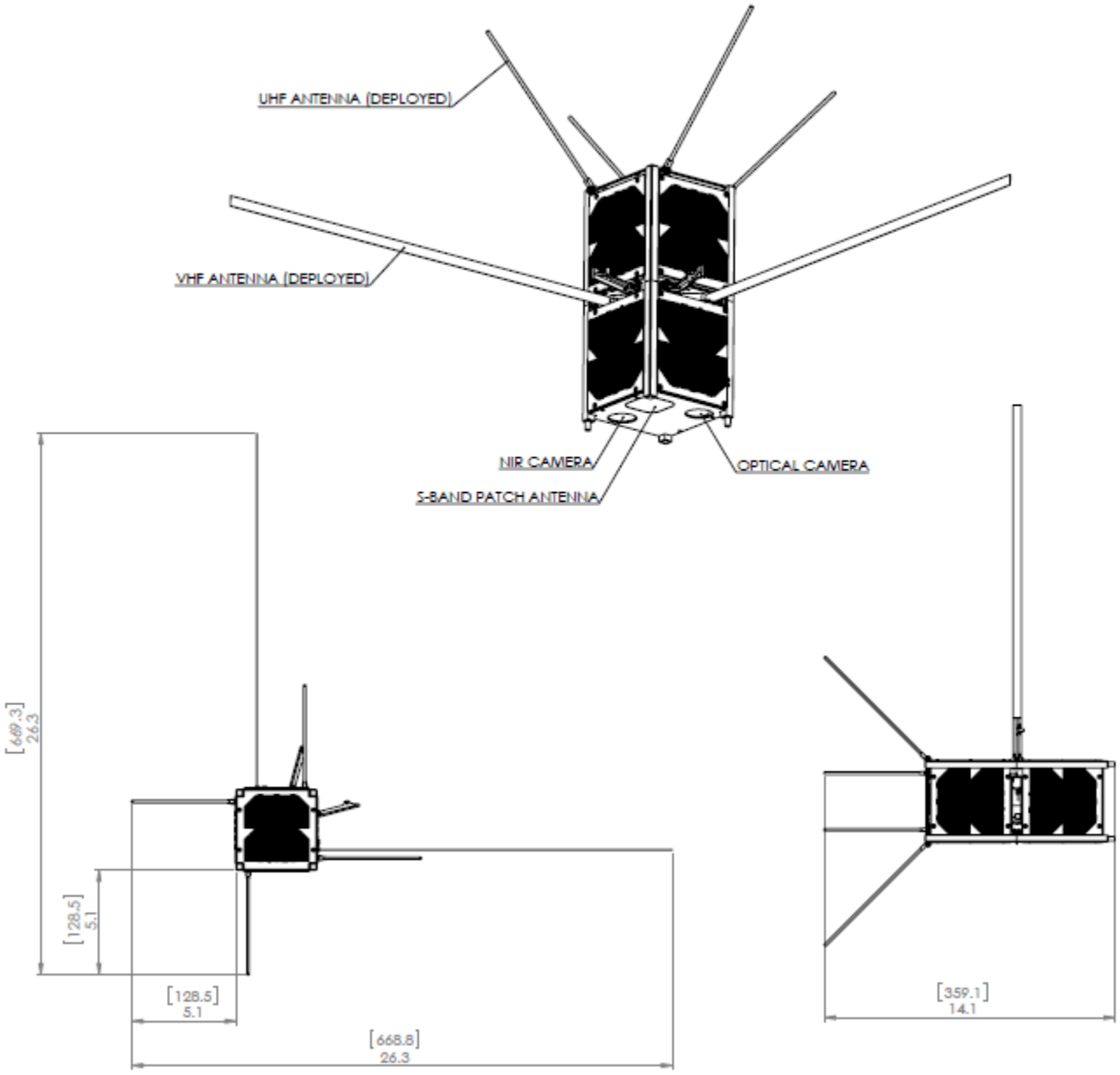
Physical Description:

Property	Value
Total Mass at Launch	2.6kg
Dry Mass at Launch	2.6kg
Form Factor	2U CubeSat
COG	<1cm radius from geometric center
Envelope (stowed)	100mm x 100mm x 227mm (excluding dynamic envelope)
Envelope (deployed)	670mm x 670mm x 360mm
Propulsion Systems	None
Fluid Systems	None
AOCS	Coarse stabilization/pointing (magnetotorquer)
Range Safety / Pyrotechnic Devices	None
Electrical Generation	Body-mounted triple-junction GaAs solar panels
Electrical Storage	Rechargeable lithium-ion battery pack
Radioactive Materials	None

Geometry (Stowed):



Geometry (Deployed):



ODAR Section 3: Assessment of Debris Released During Normal Operations

Objects larger than 1mm expected to be released during orbit:	**None**
Rationale for release of each object:	N/A
Time of release of each object:	N/A
Release velocity of each object:	N/A
Expected orbital parameters of each object:	N/A
Calculated orbital lifetime of each object:	N/A

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2:	
4.3-1, Mission-Related Debris Passing Through LEO:	**COMPLIANT**
4.3-2, Mission-Related Debris Passing Near GEO:	**COMPLIANT**

A DAS 2.0.2 log demonstrating the compliance of ArduSat-2 to the above requirements is available in Appendix A – “ArduSat-2 DAS 2.0.2 Log”.

ODAR Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions

Potential causes for spacecraft breakup:

As there are compressed fluids, energy-storage mechanics, pyrotechnics, moving parts, or propellants on board ArduSat-2, there is no plausible cause for breakup of ArduSat-2.

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

The batteries aboard ArduSat-2 are 2600mAh Lithium-Ion cells, and represent the only credible failure mode during which stored energy is released. The main failure modes associated with Lithium Ion batteries result from overcharging, overdischarging, internal shorts, and external shorts.

The battery pack onboard ArduSat-2 is in compliance with NASA's Crewed Space Vehicle Battery Safety Requirements (JSC-20793), and complies with all controls / process requirements identified in JSC-20793 Section 5.4.3 to mitigate chance of any accidental venting / explosion caused by the above failure modes.

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

There is no designed breakup of ArduSat-2 on-orbit.

List of components passivated at EOM:

There are no components aboard ArduSat-2 that require passivation or could be passivated. Furthermore, ArduSat-2 will naturally reenter Earth's atmosphere 10-18 months following deployment from the ISS.

Rationale for all items required to be passivated that can not be due to design:

N/A

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:	
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	**COMPLIANT**
4.4-2, Design for passivation after completion of mission operations while in orbit about Earth or the Moon	**N/A**
4.4-3, Limiting the long-term risk to other space systems from planned breakups: There are no planned breakups of ArduSat-2.	**COMPLIANT**
4.4-4, Limiting the short-term risk to other space systems from planned breakups There are no planned breakups of ArduSat-2.	**COMPLIANT**

ODAR Section 5: Assessment of Spacecraft Potential for On-Orbit Collisions

Probability for Collision with Objects >10cm:

The probability of a collision of ArduSat-2 with an orbiting object larger than 10cm in diameter was sufficiently small that the simulation performed using DAS 2.0.2 software returned a probability value of 0.

Assessment of spacecraft compliance with Requirement 4.5-1 and 4.5-2:	
4.5-1, Probability of Collision with Large Objects:	**COMPLIANT**
4.5-2, Probability of Damage from Small Objects:	**COMPLIANT**

A DAS 2.0.2 log demonstrating the compliance of ArduSat-2 to the above requirements is available in Appendix A – “ArduSat-2 DAS 2.0.2 Log”.

ODAR Section 6: Assessment of Spacecraft Postmission Disposal Plans and Procedures

Description of Disposal Option Selected:

Following its deployment from the ISS, ArduSat-2's orbit will naturally decay until the satellite reenters the atmosphere after approximately 10-18 months. As detailed in Section 7, ArduSat-2 will completely disintegrate during reentry, with no components surviving reentry to the ground.

Identification of Systems Required for Postmission Disposal: None

Plan for Spacecraft Maneuvers required for Postmission Disposal: N/A

Calculation of final Area-to-Mass Ratio if Atmospheric Reentry Not Selected: N/A

Assessment of Spacecraft Compliance with Requirements 4.6-1 through 4.6-4:	
4.6-1, Disposal for space structures passing through LEO ArduSat-2 will reenter the atmosphere within 25 years of mission completion and 30 years of launch.	**COMPLIANT**
4.6-2, Disposal for space structures passing through GEO:	**N/A**
4.6-3, Disposal for space structures between LEO and GEO:	**N/A**
4.6-4, Reliability of postmission disposal operations:	**N/A**

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Detailed description of spacecraft components by size, mass, material, shape, and original location on the space vehicle:

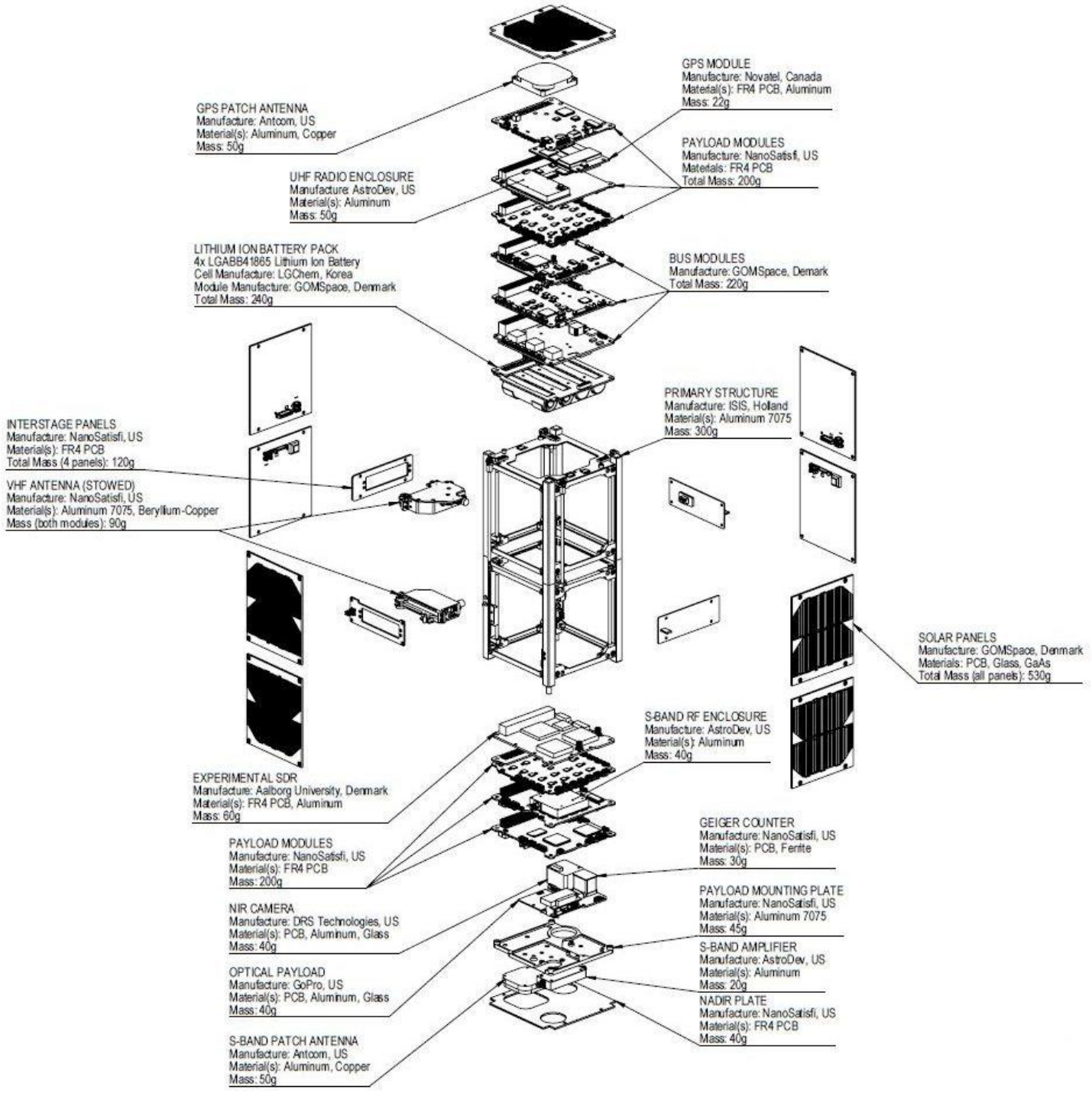
A system-level mass breakdown and primary materials list included in ArduSat-2 is available in the table below:

Subsystem	Materials	Quantity	Mass (g)	Shape	Size (mm)
Solar Panels	Glass, GaAs, FR4 PCB	9	59	Flat Plate	80 x 100
GPS Patch Antenna	Aluminum	1	50	Box	40 x 40 x 20
Subsystem PCBs	FR4 PCB	11	100	Flat Plate	90 x 90
Primary Structure	Aluminum	1	400	Box	100 x 100 x 227
VHF Antenna Deployer	Aluminum, FR4 PCB	2	50	Box	40 x 70 x 10
Payload Mounting Plate	Aluminum	1	100	Plate	90 x 90
S-Band Patch Antenna	Aluminum	1	50	Box	40 x 40 x 20
S-Band Amplifier	Aluminum, FR4 PCB	1	20	Box	40 x 20 x 8
NIR Camera	Aluminum, FR4 PCB, Glass	1	40	Box	40 x 40 x 30
Optical Camera	Aluminum, FR4 PCB, Glass	1	40	Box	50 x 30 x 20
Geiger Counter	Ferrite, FR4 PCB	1	30	Box	30 x 30 x 20

Summary of objects expected to survive an uncontrolled reentry (using DAS 2.0.2 software): None

Calculation of probability of human casualty for expected reentry year and inclination: 0%

ArduSat-2 Subsystems (Expanded View):



Assessment of spacecraft compliance with Requirement 4.7-1:	
4.7-1, Casualty Risk from Reentry Debris:	**COMPLIANT**

A DAS 2.0.2 log demonstrating the compliance of ArduSat-2 to Requirement 4.7-1 is available in Appendix A – “ArduSat-2 DAS 2.0.2 Log”.

ODAR Section 7A: Assessment of Spacecraft Hazardous Materials

Summary of Hazardous Materials Contained on Spacecraft: None

ODAR Section 8: Assessment for Tether Missions

Type of tether: N/A

Description of tether system: N/A

Determination of minimum size of object that will cause the tether to be severed: N/A

Tether mission plan, including duration and postmission disposal: N/A

Probability of tether colliding with large space objects: N/A

Probability of tether being severed during mission or after postmission disposal: N/A

Maximum orbital lifetime of a severed tether fragment: N/A

Assessment of compliance with Requirement 4.8-1:	
4.8-1, Collision Hazards of Space Tethers:	**N/A**

Appendix A: ArduSat-2 DAS 2.0.2 Log

Below is the log of an assessment performed of the ArduSat-2 mission using DAS 2.0.2 software, copied unmodified from the DAS log file:

07 23 2013; 07:21:18AM DAS Application Started
07 23 2013; 07:21:20AM Opened Project C:\Program Files (x86)\NASA\DAS 2.0\project\
07 23 2013; 07:46:03AM New Project Files Created
07 23 2013; 08:43:56AM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 380.000000 (km)
Apogee Altitude = 380.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004300 (m^2/kg)
Start Year = 2013.929000 (yr)
Integration Time = 10.000000 (yr)

OUTPUT

Plot
07 23 2013; 08:44:46AM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 380.000000 (km)
Apogee Altitude = 380.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004300 (m^2/kg)
Start Year = 2013.929000 (yr)
Integration Time = 25.000000 (yr)

OUTPUT

Plot
07 23 2013; 08:45:40AM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 410.000000 (km)
Apogee Altitude = 410.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004300 (m^2/kg)
Start Year = 2013.929000 (yr)
Integration Time = 25.000000 (yr)

OUTPUT

Plot
07 23 2013; 08:54:29AM Mission Editor Changes Applied
07 23 2013; 08:56:31AM Processing Requirement 4.3-1: Return Status : Not Run

==========
No Project Data Available
==========

========== End of Requirement 4.3-1 ==========
07 23 2013; 09:02:35AM Processing Requirement 4.3-1: Return Status : Not Run

==========
No Project Data Available
==========

========== End of Requirement 4.3-1 ==========
07 23 2013; 09:02:44AM Processing Requirement 4.3-2: Return Status : Passed

==========
No Project Data Available
==========

========== End of Requirement 4.3-2 ==========
07 23 2013; 09:02:47AM Requirement 4.4-3: Compliant

========== End of Requirement 4.4-3 ==========
07 23 2013; 09:02:52AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = ArduSat-2
Space Structure Type = Payload
Perigee Altitude = 380.000000 (km)
Apogee Altitude = 380.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass Ratio = 0.004200 (m^2/kg)

Start Year = 2013.000000 (yr)
Initial Mass = 2.600000 (kg)
Final Mass = 2.600000 (kg)
Duration = 1.500000 (yr)
Station-Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)
PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Collision Probability = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range
Status = Pass

==========

========== End of Requirement 4.5-1 ==========
07 23 2013; 09:03:30AM Processing Requirement 4.6 Return Status : Passed

==========
Project Data
==========

INPUT

Space Structure Name = ArduSat-2
Space Structure Type = Payload

Perigee Altitude = 380.000000 (km)
Apogee Altitude = 380.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004200 (m^2/kg)
Start Year = 2013.000000 (yr)
Initial Mass = 2.600000 (kg)
Final Mass = 2.600000 (kg)
Duration = 1.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)

PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 380.000000 (km)
Suggested Apogee Altitude = 380.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2013 (yr)
Requirement = 61
Compliance Status = Pass

==========

========== End of Requirement 4.6 ==========
07 23 2013; 09:11:59AM Project Data Saved To File
07 23 2013; 09:32:54AM Project Data Saved To File
07 23 2013; 09:47:27AM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = ArduSat-2
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 2.600000
Thermal Mass = 2.600000
Diameter/Width = 0.100000
Length = 0.227000
Height = 0.100000

name = Structure
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.100000
Length = 0.200000
Height = 0.100000

name = Batteries
quantity = 4
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.060000
Thermal Mass = 0.060000
Diameter/Width = 0.020000
Length = 0.080000

name = Solar Panels
quantity = 9
parent = 1
materialID = 24
type = Flat Plate
Aero Mass = 0.059000
Thermal Mass = 0.059000
Diameter/Width = 0.100000
Length = 0.100000

name = PCB Stack
quantity = 11
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.100000
Length = 0.100000

name = VHF_Deployer
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.050000
Length = 0.070000
Height = 0.010000

name = Patch Antennae
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.050000

Thermal Mass = 0.050000
Diameter/Width = 0.040000
Length = 0.040000
Height = 0.030000

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

name = ArduSat-2
Demise Altitude = 77.996980
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Structure
Demise Altitude = 75.458480
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Batteries
Demise Altitude = 74.437316
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Solar Panels
Demise Altitude = 77.493699
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = PCB Stack
Demise Altitude = 76.249371
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = VHF_Deployer
Demise Altitude = 75.650746
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Patch Antennae
Demise Altitude = 75.063910
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

========== End of Requirement 4.7-1 ==========
07 23 2013; 09:58:13AM Processing Requirement 4.3-1: Return Status : Not Run

==========
No Project Data Available
==========

========== End of Requirement 4.3-1 ==========
07 23 2013; 09:58:17AM Processing Requirement 4.3-2: Return Status : Passed

==========
No Project Data Available
==========

========== End of Requirement 4.3-2 ==========
07 23 2013; 09:58:19AM Requirement 4.4-3: Compliant

========== End of Requirement 4.4-3 ==========
07 23 2013; 09:58:22AM Processing Requirement 4.5-1: Return Status : Passed

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

INPUT

Space Structure Name = ArduSat-2
Space Structure Type = Payload
Perigee Altitude = 380.000000 (km)
Apogee Altitude = 380.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass Ratio = 0.004200 (m^2/kg)
Start Year = 2013.000000 (yr)
Initial Mass = 2.600000 (kg)
Final Mass = 2.600000 (kg)
Duration = 1.500000 (yr)
Station-Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)
PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Collision Probability = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range
Status = Pass

==========

========== End of Requirement 4.5-1 ==========
07 23 2013; 09:58:31AM Requirement 4.5-2: Compliant
07 23 2013; 09:58:38AM Processing Requirement 4.6 Return Status : Passed

==========
Project Data
==========

INPUT

Space Structure Name = ArduSat-2
Space Structure Type = Payload

Perigee Altitude = 380.000000 (km)
Apogee Altitude = 380.000000 (km)
Inclination = 51.600000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.004200 (m^2/kg)
Start Year = 2013.000000 (yr)
Initial Mass = 2.600000 (kg)
Final Mass = 2.600000 (kg)
Duration = 1.500000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)
PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 380.000000 (km)
Suggested Apogee Altitude = 380.000000 (km)
Returned Error Message = Reentry during mission (no PMD req.).

Released Year = 2013 (yr)
Requirement = 61
Compliance Status = Pass

==========

========== End of Requirement 4.6 ==========
07 23 2013; 09:58:49AM *********Processing Requirement 4.7-1
Return Status : Passed

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

name = ArduSat-2
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 2.600000
Thermal Mass = 2.600000
Diameter/Width = 0.100000
Length = 0.227000
Height = 0.100000

name = Structure
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.400000
Thermal Mass = 0.400000
Diameter/Width = 0.100000
Length = 0.200000
Height = 0.100000

name = Batteries
quantity = 4
parent = 1
materialID = 5
type = Cylinder
Aero Mass = 0.060000
Thermal Mass = 0.060000
Diameter/Width = 0.020000
Length = 0.080000

name = Solar Panels
quantity = 9
parent = 1

materialID = 24
type = Flat Plate
Aero Mass = 0.059000
Thermal Mass = 0.059000
Diameter/Width = 0.100000
Length = 0.100000

name = PCB Stack
quantity = 11
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.100000
Length = 0.100000

name = VHF_Deployer
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.050000
Length = 0.070000
Height = 0.010000

name = Patch Antennae
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.050000
Thermal Mass = 0.050000
Diameter/Width = 0.040000
Length = 0.040000
Height = 0.030000

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

name = ArduSat-2
Demise Altitude = 77.996980
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Structure
Demise Altitude = 75.458480
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Batteries
Demise Altitude = 74.437316
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Solar Panels
Demise Altitude = 77.493699
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = PCB Stack
Demise Altitude = 76.249371
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = VHF_Deployer
Demise Altitude = 75.650746
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Patch Antennae
Demise Altitude = 75.063910
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

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