

Cosmogia Dove-1 Orbital Debris Assessment Report (ODAR)

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

Report Version: 1.3, 01/06/2012



Cosmogia Inc. | 955 Benecia Avenue | Sunnyvale, CA 94085

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DAS Software Version Used In Analysis: v2.0.1

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VERSION APPROVAL and/or FINAL APPROVAL*:

Robbie Schingler
Co-founder, Cosmogia

PREPARED BY:

James Mason
Mission Analyst

Michael Safyan
Communications Engineer

*Approval signatures indicate acceptance of the ODAR-defined risk.

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Record of Revisions				
REV	DATE	AFFECTED PAGES	DESCRIPTION OF CHANGE	AUTHOR (S)
A	11/23/2011	All	Initial release	James Mason
B	11/28/2011	14-18	Addition of DAS analysis	James Mason
1.3	1/5/2012	ALL	Minor Amendments	Michael Safyan

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Self-assessment and OSMA assessment of the ODAR using the format in Appendix A.2 of NASA-STD-8719.14:

A self assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14. In the final ODAR document, this assessment will reflect any inputs received from OSMA as well.

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Orbital Debris Self-Assessment Report Evaluation: Dove-1 Mission

Requirement #	Launch Vehicle				Spacecraft			Comments
	Compliant	Not Compliant	Incomplete	Standard Non Compliant	Compliant	Not Compliant	Incomplete	
4.3-1.a	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No Debris Released in LEO. See note 1.
4.3-1.b	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No Debris Released in LEO. See note 1.
4.3-2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No Debris Released in GEO. See note 1.
4.4-1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.4-2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.4-3	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No planned breakups. See note 1.
4.4-4	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No planned breakups. See note 1.
4.5-1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.5-2					<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No critical subsystems needed for EOM disposal
4.6-1(a)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.6-1(b)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.6-1(c)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.6-2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.6-3	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.6-4	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.6-5	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.7-1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	See note 1.
4.8-1					<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	No tethers used.

Notes:

- The primary payload belongs to Orbital. This is not a Cosmogia Inc. primary mission. All of the other portions of the launch stack are non-Cosmogia and Dove-1 is not the lead.

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Assessment Report Format:

ODAR Technical Sections Format Requirements:

Cosmogia Inc. is a US company; this ODAR follows the format in NASA-STD-8719.14, Appendix A.1 and includes the content indicated at a minimum in each section 2 through 8 below for the Dove-1 satellite. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

Dove-1

ODAR Section 1: Program Management and Mission Overview

Program/project manager: Robbie Schingler

Senior Management: Robbie Schingler

Foreign government or space agency participation: None.

Summary of NASA’s responsibility under the governing agreement(s): N/A.

Schedule of upcoming mission milestones:

FRR:	January 2012
Launch:	NET February 28, 2012

Mission Overview:

Dove-1 is a technology development Earth imagery experiment to be launched to low Earth orbit inside an ISIPOD 3U cubesat deployer on board the first Taurus II /Antares test launch, planned for NET February 28, 2012.

Launch vehicle and launch site: Taurus II / Antares, Wallops Flight Facility, VA.

Proposed launch date: NET February 28, 2011

Mission duration: 7-14 days in LEO operations until reentry via atmospheric orbital decay.

Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination:

The Taurus II will launch into a circular orbit. Once the final stage has burned out, the secondary payloads will be dispensed. After the secondary payloads are clear, the primary payload will separate. All payloads including the primary will burn up and reenter within 1 month of launch due to the low orbit.

The Dove-1 satellite will deploy to, and decay naturally from, an operational circular orbit defined as follows:

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Apogee: 270 km

Perigee: 270 km

Inclination: 51.65 degrees.

Dove-1 has no propulsion and therefore does not actively change orbits. There is no parking or transfer orbit.

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:

Dove-1 is based on the 3U cubesat form factor. Basic physical dimensions are 100mm x 100mm x 340mm with a mass of approximately 6.0 kg.

The Dove-1 superstructure (see Fig. 2) is comprised of three 100mm x 100mm skeleton plates, with L rails along each 300mm corner edge. There is one plate at each end of the structure to carry the telescope and camera mass. Additionally, there is a skeleton support structure behind the telescope to hold the required electronics. The optical path is down the central axis of the satellite.

The design includes a spring-loaded lens flap to protect the optics during launch and to mount the S-band patch antenna.

Total satellite mass at launch, including all propellants and fluids: ~6.0 kg.

Dry mass of satellites at launch, excluding solid rocket motor propellants: ~6.0 kg.

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear): None.

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: None .

Fluids in Pressurized Batteries: None. Dove-1 uses unpressurized standard COTS Lithium-Ion battery cells.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector: Dove-1's attitude will be controlled by a B-dot controller, comprised of 3 air-core coil magnetorquers, which will allow the satellite to be aligned relative to the Earth's magnetic field. These will allow the satellite to despin and 'lock' to the magnetic field. It's operational attitude will be with the satellite locked to the Earth's magnetic field along the optical axis (making full rotations per orbit).

Description of any range safety or other pyrotechnic devices: None.

Description of the electrical generation and storage system: Standard COTS Lithium-Ion battery cells are charged before payload integration and provide electrical energy during the

mission until depleted. The cells are recharged by solar arrays, mounted on the satellite body. The charging cycle is managed by the battery cell protection circuit.

Identification of any other sources of stored energy not noted above: None.

Identification of any radioactive materials on board: None.

ODAR Section 3: Assessment of Spacecraft Debris Released during Normal Operations

Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material: None.

Rationale/necessity for release of each object: N/A.

Time of release of each object, relative to launch time: N/A.

Release velocity of each object with respect to spacecraft: N/A.

Expected orbital parameters (apogee, perigee, and inclination) of each object after release: N/A.

Calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO): N/A.

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v2.0.1)

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

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

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

Potential causes of spacecraft breakup during deployment and mission operations:

There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.

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

In-mission failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell explosion. The battery safety systems discussed in the FMEA (see requirement 4.4-1 below) describe the combined faults that must occur for any of seven (7) independent, mutually exclusive failure modes to lead to explosion.

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

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There are no planned breakups.

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

None.

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

Due to the extremely short duration of the mission before passive reentry and burn up, it was deemed unnecessary to passivate the 8 lithium-ion batteries (total mass of 208 grams) for EOM.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:

Requirement 4.4-1: Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon:

For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).

Compliance statement:

Required Probability: 0.001.

Expected probability: 0.000.

Supporting Rationale and FMEA details:

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, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

Probability: Extremely Low. It is believed 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). Additionally, the expected maximum satellite lifetime is less than 3 weeks - in the unlikely event of debris generation these objects will rapidly reenter.

Failure mode 1: Internal short circuit.

Mitigation 1: Qualification and acceptance shock, vibration, thermal cycling, and vacuum tests followed by maximum system rate-limited charge and discharge to prove that no internal short circuit sensitivity exists.

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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 were 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 were also tested in a hot environment to test the upper limit of the cells capability. No failures were seen.

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. The 8 cells are divided into 4 parallel sets of 2.

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 4: This failure mode is negated by a) qualification tested short circuit protection on each external circuit, b) design of battery packs and insulators such that no contact with nearby board traces is possible without being caused by some other mechanical failure, c) obviation of such other mechanical failures by proto-qualification and acceptance environmental tests (shock, vibration, thermal cycling, and thermal-vacuum tests).

Combined faults required for realized failure: An external load must fail/short-circuit **AND** external over-current detection and disconnect function must all occur to enable this failure mode.

Failure Mode 4: Inoperable vents.

Mitigation 5: Battery vents are not inhibited by the battery holder design or the spacecraft.

Combined effects required for realized failure: The manufacturer fails to install proper venting.

Failure Mode 5: Crushing.

Mitigation 6: 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 7: 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.

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Mitigation 8: The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that batteries do not exceed normal allowable operating temperatures which are well below temperatures of concern for explosions.

Combined faults required for realized failure: Thermal analysis **AND** thermal design **AND** mission simulations in thermal-vacuum chamber testing **AND** 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 postmission disposal or control to a level which can not cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).

Compliance statement:

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

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

Compliance statement:

This requirement is not applicable. There are no planned breakups.

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

Compliance statement:

This requirement is not applicable. There are no planned breakups.

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

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v2.0.1, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):

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).

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Large Object Impact and Debris Generation Probability: 0.00000; 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:** 0.00000; COMPLIANT
- **Identification of all systems or components required to accomplish any postmission disposal operation, including passivation and maneuvering:**

None.

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

6.1 Description of spacecraft disposal option selected: The satellite will de-orbit naturally by atmospheric re-entry. There is no propulsion system.

6.2 Plan for any spacecraft maneuvers required to accomplish postmission disposal: None.

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

Spacecraft Mass: ~6.0kg

Cross-sectional Area: 0.039 m² (Calculated by DAS 2.0.1).

Area to mass ratio: $0.039/6 = 0.0065 \text{ m}^2/\text{kg}$

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v 2.0.1 and NASA-STD-8719.14 section):

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)

a. Atmospheric reentry option:

- 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
- Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.

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- b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.
- c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

Analysis: The Dove-1 satellite's reentry is COMPLIANT using method “a.”. The Dove-1 satellite will be left in a 270 km near-circular orbit, reentering in ~13 days after launch with orbit history as shown in Figure 3 (analysis assumes an approximate random tumbling behavior).

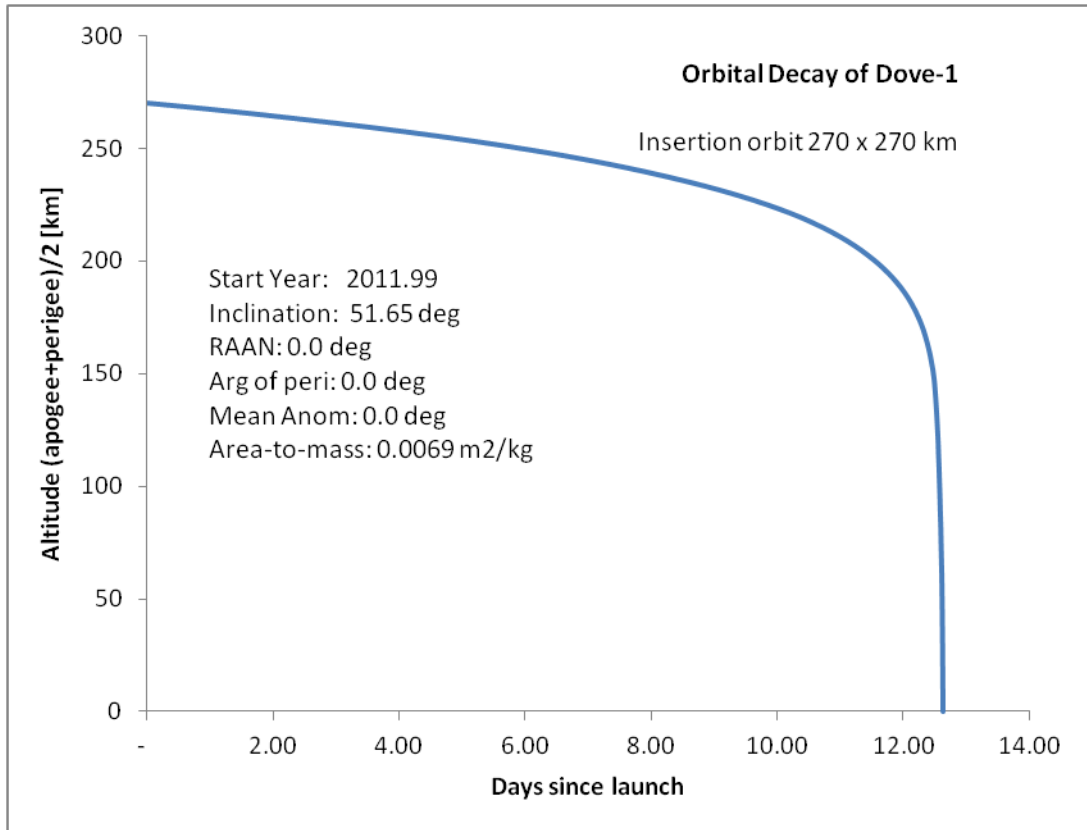


Figure 3: Dove-1 Orbit History

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

Analysis: Not applicable.

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

Analysis: Not applicable.

Requirement 4.6-4. Reliability of Postmission Disposal Operations

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Analysis: Not applicable. The satellite will reenter passively without post mission disposal operations within allowable timeframe.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Assessment of spacecraft compliance with Requirement 4.7-1:

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:

- a) 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 v2.0.1 reports that Dove-1 is COMPLIANT with the requirement. There is a low probability of the Invar telescope tube reaching the ground (see DAS input data below for input parameters). Total human casualty probability is reported by the DAS software as 1:136200. This is expected to represent the absolute maximum casualty risk, as calculated with DAS's limited modeling capability.

Analysis (per DAS v2.0.1):

11 28 2011; 10:47:49AM DAS Application Started
11 28 2011; 10:48:30AM Processing Requirement 4.6 Return Status : Passed

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

INPUT

Space Structure Name = Dove-1
Space Structure Type = Payload

Perigee Altitude = 270.000000 (km)
Apogee Altitude = 270.000000 (km)
Inclination = 51.650000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.006500 (m²/kg)
Start Year = 2012.100000 (yr)
Initial Mass = 6.000000 (kg)
Final Mass = 6.000000 (kg)
Duration = 0.034000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 224.537083 (km)
PMD Apogee Altitude = 231.788150 (km)
PMD Inclination = 51.644873 (deg)
PMD RAAN = 292.979688 (deg)
PMD Argument of Perigee = 27.186775 (deg)

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PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 224.537083 (km)
Suggested Apogee Altitude = 231.788150 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2012 (yr)
Requirement = 61
Compliance Status = Pass

=====

===== End of Requirement 4.6 =====
11 28 2011; 10:48:33AM Processing Requirement 4.3-1: Return Status : Not Run

=====

No Project Data Available

=====

===== End of Requirement 4.3-1 =====
11 28 2011; 10:48:38AM Processing Requirement 4.3-2: Return Status : Passed

=====

No Project Data Available

=====

===== End of Requirement 4.3-2 =====
11 28 2011; 10:48:40AM Requirement 4.4-3: Compliant

===== End of Requirement 4.4-3 =====
11 28 2011; 10:48:43AM Processing Requirement 4.5-1: Return Status : Passed

=====

Run Data

=====

INPUT

Space Structure Name = Dove-1
Space Structure Type = Payload
Perigee Altitude = 270.000000 (km)
Apogee Altitude = 270.000000 (km)
Inclination = 51.650000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass Ratio = 0.006500 (m²/kg)
Start Year = 2012.100000 (yr)
Initial Mass = 6.000000 (kg)
Final Mass = 6.000000 (kg)
Duration = 0.034000 (yr)
Station-Kept = False

Once this document has been printed it will be considered an uncontrolled document.

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 =====
11 28 2011; 10:48:47AM Requirement 4.5-2: Compliant
11 28 2011; 10:48:58AM *****Processing Requirement 4.7-1
Return Status : Passed

*****INPUT****

Item Number = 1

name = Dove-1
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 6.000000
Thermal Mass = 6.000000
Diameter/Width = 0.100000
Length = 0.310000
Height = 0.100000

name = Batteries
quantity = 8
parent = 1
materialID = 58
type = Cylinder
Aero Mass = 0.046000
Thermal Mass = 0.046000
Diameter/Width = 0.018000
Length = 0.065000

name = Structure
quantity = 4
parent = 1
materialID = 5
type = Flat Plate
Aero Mass = 0.780000
Thermal Mass = 0.680000
Diameter/Width = 0.100000

Once this document has been printed it will be considered an uncontrolled document.

Length = 0.300000

name = Solar Cells
quantity = 4
parent = 3
materialID = 24
type = Flat Plate
Aero Mass = 0.100000
Thermal Mass = 0.100000
Diameter/Width = 0.090000
Length = 0.280000

name = Telescope
quantity = 1
parent = 1
materialID = 72
type = Sphere
Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.090000

name = Camera
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 1.512000
Thermal Mass = 1.512000
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.070000

*****OUTPUT****

Item Number = 1

name = Dove-1
Demise Altitude = 77.997074
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

name = Batteries
Demise Altitude = 71.399285
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

name = Structure
Demise Altitude = 72.658918
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

name = Solar Cells

Once this document has been printed it will be considered an uncontrolled document.

Demise Altitude = 72.225785
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

name = Telescope
Demise Altitude = 0.000000
Debris Casualty Area = 0.462074
Impact Kinetic Energy = 2906.069336

name = Camera
Demise Altitude = 64.022409
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because Dove-1 does not use controlled reentry.

4.7-1, b) **NOT APPLICABLE.** For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627).

4.7-1 c) **NOT APPLICABLE.** For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628).

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers in the Dove-1 mission.

END of ODAR for Dove-1

Appendix A: Acronyms

Arg	Argument of Perigee
peri	
CDR	Critical Design Review
cm	centimeter
COTS	Commercial Off-The-Shelf (items)
DAS	Debris Assessment Software
EOM	End Of Mission
FRR	Flight Readiness Review
GEO	Geosynchronous Earth Orbit
ITAR	International Traffic In Arms Regulations
kg	kilogram
km	kilometer
LEO	Low Earth Orbit
Li-Ion	Lithium Ion
m ²	Meters squared
ml	milliliter
mm	millimeter
N/A	Not Applicable.
NET	Not Earlier Than
ODAR	Orbital Debris Assessment Report
OSMA	Office of Safety and Mission Assurance
PDR	Preliminary Design Review
PL	Payload
ISIPOD	ISIS CubeSat Deployer
PSIa	Pounds Per Square Inch, absolute
RAAN	Right Ascension of the Ascending Node
SMA	Safety and Mission Assurance
Ti	Titanium
yr	year

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