Scout 1 & 2 Orbital Debris Assessment Report (ODAR)

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

Report Version: 1, 10/31/2013

Document Data is Not Restricted.

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

DAS Software Version Used In Analysis: v2.0.2

VERSION APPROVAL and/or FINAL APPROVAL*:

Jason Andrews/ Curt Blake

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

Table Contents

Self-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.

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

Requirement #	Launch Vehicle				Spacecraft			Comments
	Compliant	Not Compliant	Incomplete	Standard Non Compliant	Compliant or N/A	Not Compliant	Incomplete	
4.3-1.a	☐	☐	☐	☐	☒	☐	☐	No Debris Released in LEO. See note 1.
4.3-1.b	☐	☐	☐	☐	☒	☐	☐	No Debris Released in LEO. See note 1.
4.3-2	☐	☐	☐	☐	☒	☐	☐	No Debris Released in GEO. See note 1.
4.4-1	☐	☐	☐	☐	☐	☐	☐	See note 1.
4.4-2	☐	☐	☐	☐	☐	☐	☐	See note 1.
4.4-3	☐	☐	☐	☐	☒	☐	☐	No planned breakups.
4.4-4	☐	☐	☐	☐	☒	☐	☐	No planned breakups.
4.5-1	☐	☐	☐	☐	☒	☐	☐	See note 1.
4.5-2	☐	☐	☐	☐	☒	☐	☐	No critical subsystems needed for EOM disposal
4.6-1(a)	☐	☐	☐	☐	☒	☐	☐	See note 1.
4.6-1(b)	☐	☐	☐	☐	☒	☐	☐	See note 1.
4.6-1(c)	☐	☐	☐	☐	☒	☐	☐	See note 1.
4.6-2	☐	☐	☐	☐	☒	☐	☐	Spacecraft does not go to GEO.
4.6-3	☐	☐	☐	☐	☒	☐	☐	Spacecraft does not go beyond LEO.
4.6-4	☐	☐	☐	☐	☒	☐	☐	See note 1.
4.6-5	☐	☐	☐	☐	☒	☐	☐	See note 1.
4.7-1	☐	☐	☐	☐	☒	☐	☐	DAS reports human casualty probability < 1:10,000
4.8-1					☒	☐	☐	No tethers used.

Notes:

1. This launch has several spacecraft manifested and the SCOUT spacecraft are not the primary mission.

Assessment Report Format:

ODAR Technical Sections Format Requirements:

As BlackSky Global, LLC is a US company; this ODAR follows the format recommended 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 SCOUT satellite. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered here.

ODAR Section 1: Program Management and Mission Overview

Project Manager: Adam Wuerl

Foreign government or space agency participation: Roscosmos is the Russian Federal Space Agency which operates the Soyuz space launch vehicle.

Schedule of upcoming mission milestones:

FRR:	September 2014
Launch:	No Earlier Than December 2014

Mission Overview:
SCOUT will be deployed as a secondary payload into a planned circular orbit of 600 x 600 km at 97.8 degrees inclination. Once deployed, SCOUT will immediately begin transfer to a 500x500 km mission orbit (expected to take 2 to 4 weeks). After 36 months of operation in the mission orbit, SCOUT will lower its perigee altitude with any remaining propellant. The perigee altitude following this maneuver is not expected to be <470 km. (For the purposes of orbital decay analysis, we will assume 500x500 km altitude as the End-of-Life orbit). SCOUT will then safe its systems and await atmospheric drag to fully de-orbit the satellite.

ODAR Summary: No debris released in normal operations; no credible scenario for breakups; the collision probability with other objects is compliant with NASA standards; and the estimated nominal decay lifetime due to atmospheric drag is under 25 years following operations (7.4 years after 3 years of nominal operations, as calculated by DAS 2.0.2).

Launch vehicle and launch site: Soyuz, Baikonur, The Republic of Kazakhstan

Proposed launch date: No Earlier Than December 2014

Mission duration: Maximum Nominal Operations: 36 months, Post-Operations Orbit lifetime: 7.37 years until reentry via atmospheric orbital decay (~10.4 years in total).

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

	Apogee Altitude	Perigee Altitude	Inclination	Max. Dwell
Deployment (Parking)	600 km	600 km	97.8 deg	<5 days
Transfer Orbit	600 km	500 km	97.8 deg	< 1 month
Operational Orbit	500 km	500 km	97.8 deg	36 months
End-of-Life Orbit	500 km	470 to 500 km	97.8 deg	<20 years

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:

Each SCOUT spacecraft has a launch mass of ~47 kg. Basic physical dimensions are 410mm x 475mm x 850mm.

The SCOUT load bearing structure aluminum and comprised of four 400mm x 400mm skeleton plates, with 820 mm long corner rails connecting the four corners of each plate. Two-thirds of the solar arrays are body-mounted, while the remainder are mounted to a spring-loaded, non-pyrotechnically released door.

SCOUT maintains 3-axis attitude control. Attitude knowledge is provided by two orthogonally mounted star trackers. Attitude control is affected by three orthogonally arranged reaction wheels. Momentum is dissipated via magnetorquers.

Total satellite mass at launch, including all propellants and fluids: ~47 kg.

Dry mass of satellites at launch, excluding solid rocket motor propellants: ~43 kg **Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear):**

The SCOUT spacecraft contains a single propulsion system with a single valve and a single thruster. This system uses electrically warmed butane as the working fluid. Butane is stored at saturation conditions (normally 1 to 100 psi) within two interconnected tanks. The butane is warmed to several hundred degrees Celsius via an electrically heated aluminum block just before exiting the nozzle.

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: 3.8 kg of butane at saturation conditions not to exceed 100 psia.

Fluids in Pressurized Batteries: None. SCOUT uses two unpressurized standard COTS Lithium-Ion battery cells. Each cell has a height of 28mm, a width of 76mm, a length of 140mm, and a mass of 890 grams. The cells are mounted inside an aluminum housing / containment device.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector:

The long axis of the SCOUT spacecraft can be oriented parallel to the nadir vector during some operating modes, but the SCOUT spacecraft will typically be oriented in a sun-fixed attitude. This implies that the spacecraft orientation with respect to the velocity vector will appear random (tumbling) for the purposes of determining aerodynamic drag, MMOD impacts, etc.

Description of any range safety or other pyrotechnic devices: No pyrotechnic devices are used.

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. The cells are recharged by solar cells mounted on the solar arrays. The battery cell protection circuit manages the charging cycle.

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: There are no intentional releases.

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 v2.0.2)

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.

In addition to the battery protection mentioned about, the SCOUT battery unit features two thermal switches that completely isolate the battery electrically if the temperature gets too high.

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

There are no planned breakups.

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

The butane propulsion system shall be passivated at the end of mission by operating the system to propellant depletion in a deorbit / perigee lowering maneuver.

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

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

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 theoretically 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 the selected COTS batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the battery housing / containment device due to the lack of penetration energy.
Probability: Extremely Low. It is believed to be a much less than 0.1% probability that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

Failure mode 1: Internal short circuit.
Mitigation 1: 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.
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 like likelihood and impact 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: S*pacecraft 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 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 failure 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 final assembler 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 failure modes 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 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:
SCOUT 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 v2.0.2, 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).

Large Object Impact and Debris Generation Probability:

Collision 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:
Collision Probability: 0.0005; COMPLIANT.

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

All spacecraft bus systems are required to transfer the spacecraft to the operational orbit from the drop-off orbit. During this orbit transfer phase, certain MMOD collisions can cause the satellite to fail to reach an orbital altitude that ensures timely (25 yr) re-entry. The collision probability of failing to reach the operational orbit is estimated to be <1/2000 (due to the short duration of the orbit transfer phase and the MMOD protection of vital components). However, once SCOUT reaches the operational orbit (500x500 km), it is no longer at risk of failing the postmission disposal requirements because the expected orbital lifetime is about 7.4 years, according to DAS.

ODAR Section 6: Assessment of Spacecraft Post-mission Disposal Plans and Procedures

6.1 Description of spacecraft disposal option selected: The satellite will de-orbit naturally by atmospheric re-entry. At the end of SCOUT's operational life (i.e. at EOM) the attitude control system will stop counteracting the aerodynamic disturbance torques and will rotate the satellite into the maximum drag configuration. SCOUT will gradually assume a dynamically stable configuration. For atmospheric drag / re-entry calculations in DAS, a minimum cross-section drag area of 40x40 cm was assumed. This is conservative because it represents the minimum cross section possible with the satellite in any orientation, ignores protuberances, and ignores gravity gradient, ignores solar pressure torques, and ignores the high-drag orientation set at EOM.

6.2 Plan for any spacecraft maneuvers required to accomplish postmission disposal:

The stable drag/gravity gradient configuration enables aerodynamic reentry. To accelerate the orbital decay we plan to orient the satellite in this maximum drag configuration at the end of operations.

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

Spacecraft Mass: ~47kg

Cross-sectional Area: 0.16 m^2 (dynamically stable)

Area to mass ratio: 0.003721 m^2/kg (dynamically stable)

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v 2.0.2 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.*

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.

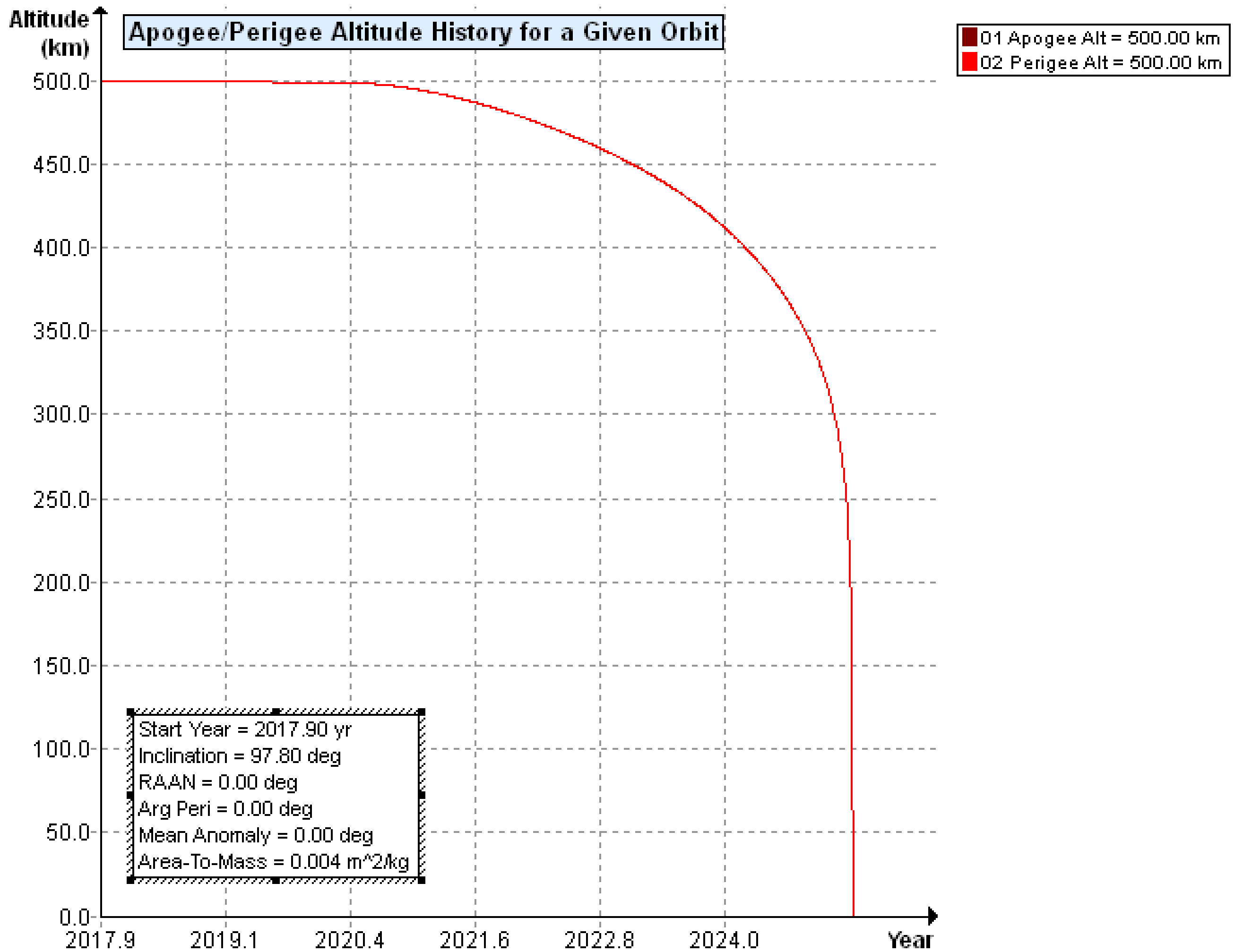

Figure 2 SCOUT orbit history with apogee (brown) & perigee (red)

Analysis: The SCOUT satellite reentry is COMPLIANT using method “a”.

Satellite Name	SCOUT
BOL Orbit (Drop off)	600 x 600 km
Operational Orbit	500 x 500 km
EOM Orbit*	500 x 500 km
Total Lifetime	10.4 years
Post-ops Life	7.4 years

* assumes no de-orbit propulsion maneuver, which would be done with any remaining propellant and reduce the post-ops on-orbit lifetime to 6.2 years

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

Analysis: The minimum drag configuration is the aerodynamically stable state, meaning that even under massive subsystem failure we would eventually assume this orientation. This minimum drag configuration was assumed for atmospheric re-entry analysis.

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 v2.0.2 reports that SCOUTs 1 & 2 are compliant with the requirement. According to DAS calculations, there is a low probability that some[1] spacecraft components (primary mirror, a machined disk of Invar, and machined blocks of aluminum) may reach the ground (see DAS input data below for input parameters). However, the DAS software does not currently allow explicit modeling of a the specific geometries for these components, so these numbers are expected to be larger than anticipated due to conservatism in the inputs provided to DAS. Total human casualty probability is reported by the DAS software as **1:17,000** for each SCOUT spacecraft. This is expected to represent the absolute maximum casualty risk, as calculated with DAS's limited modeling capability.

Analysis (per DAS v2.0.2):

```
10 30 2013; 13:59:50PM       DAS Application Started
10 30 2013; 14:02:06PM       Opened Project C:\SCOUTv1\
10 30 2013; 14:02:24PM       Processing Requirement 4.3-1:      Return Status :  Not Run

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

=============== End of Requirement 4.3-1 ===============
10 30 2013; 14:02:26PM       Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
10 30 2013; 14:02:28PM       Requirement 4.4-3:  Compliant

=============== End of Requirement 4.4-3 ===============
10 30 2013; 14:02:32PM       Processing Requirement 4.5-1:      Return Status :  Passed

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

**INPUT**

       Space Structure Name = SCOUTv1.001
       Space Structure Type = Payload
```

[1] Other components that were modeled (i.e. wire harnesses, PM struts, shim, etc.) are not likely to survive reentry due to the inability to accurately model these with sufficient fidelity within the limitations imposed by DAS. Even with these components accounted for, SCOUT is still compliant with this requirement.

```
       Perigee Altitude = 500.000000 (km)
       Apogee Altitude = 500.000000 (km)
       Inclination = 97.800000 (deg)
       RAAN = 0.000000 (deg)
       Argument of Perigee = 0.000000 (deg)
       Mean Anomaly = 0.000000 (deg)
       Final Area-To-Mass Ratio = 0.003721 (m^2/kg)
       Start Year = 2014.900000 (yr)
       Initial Mass = 46.860000 (kg)
       Final Mass = 43.060000 (kg)
       Duration = 3.000000 (yr)
       Station-Kept = True
       Abandoned = False
       PMD Perigee Altitude = 470.000000 (km)
       PMD Apogee Altitude = 500.000000 (km)
       PMD Inclination = 97.800000 (deg)
       PMD RAAN = 0.000000 (deg)
       PMD Argument of Perigee = 0.000000 (deg)
       PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

       Collision Probability = 0.000002
       Returned Error Message: Normal Processing
       Date Range Error Message: Normal Date Range
       Status = Pass

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

=============== End of Requirement 4.5-1 ===============
10 30 2013; 14:02:34PM       Processing Requirement 4.6   Return Status :  Passed

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

**INPUT**

       Space Structure Name = SCOUTv1.001
       Space Structure Type = Payload

       Perigee Altitude = 500.000000 (km)
       Apogee Altitude = 500.000000 (km)
       Inclination = 97.800000 (deg)
       RAAN = 0.000000 (deg)
       Argument of Perigee = 0.000000 (deg)
       Mean Anomaly = 0.000000 (deg)
       Area-To-Mass Ratio = 0.003721 (m^2/kg)
       Start Year = 2014.900000 (yr)
       Initial Mass = 46.860000 (kg)
       Final Mass = 43.060000 (kg)
       Duration = 3.000000 (yr)
       Station Kept = True
       Abandoned = False
       PMD Perigee Altitude = 470.000000 (km)
       PMD Apogee Altitude = 500.000000 (km)
       PMD Inclination = 97.800000 (deg)
       PMD RAAN = 0.000000 (deg)
       PMD Argument of Perigee = 0.000000 (deg)
       PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

       Suggested Perigee Altitude = 470.000000 (km)
       Suggested Apogee Altitude = 500.000000 (km)
       Returned Error Message = Passes LEO reentry orbit criteria.

       Released Year = 2024 (yr)
       Requirement = 61
```

```
       Compliance Status = Pass

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

=============== End of Requirement 4.6 ===============
10 30 2013; 14:02:40PM       *********Processing Requirement 4.7-1
       Return Status :  Passed

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

name = SCOUTv1.001
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 43.060001
Thermal Mass = 43.060001
Diameter/Width = 0.400000
Length = 0.850000
Height = 0.400000

name = Shell
quantity = 1
parent = 1
materialID = 27
type = Cylinder
Aero Mass = 0.415491
Thermal Mass = 0.415491
Diameter/Width = 0.280000
Length = 0.390000

name = SM baffle
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.054885
Thermal Mass = 0.054885
Diameter/Width = 0.074000
Length = 0.046000

name = SM cover
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.060781
Thermal Mass = 0.060781
Diameter/Width = 0.070000
Length = 0.023000

name = PM
quantity = 1
parent = 1
materialID = -1
type = Flat Plate
Aero Mass = 0.897660
Thermal Mass = 0.897660
Diameter/Width = 0.223330
Length = 0.223330

name = PM baffle
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.221353
Thermal Mass = 0.221353
```

```
Diameter/Width = 0.116000
Length = 0.186500

name = SM spider
quantity = 1
parent = 1
materialID = 72
type = Flat Plate
Aero Mass = 0.497591
Thermal Mass = 0.497591
Diameter/Width = 0.100000
Length = 0.100000

name = Shutter Housing
quantity = 1
parent = 1
materialID = 72
type = Box
Aero Mass = 0.664967
Thermal Mass = 0.664967
Diameter/Width = 0.100000
Length = 0.100000
Height = 0.024200

name = AMS upper plate
quantity = 1
parent = 1
materialID = 27
type = Flat Plate
Aero Mass = 0.097069
Thermal Mass = 0.097069
Diameter/Width = 0.270000
Length = 0.270000

name = AMS core structure
quantity = 1
parent = 1
materialID = 7
type = Flat Plate
Aero Mass = 0.085275
Thermal Mass = 0.085275
Diameter/Width = 0.270000
Length = 0.270000

name = AMS lower plate
quantity = 1
parent = 1
materialID = 27
type = Flat Plate
Aero Mass = 0.097069
Thermal Mass = 0.097069
Diameter/Width = 0.270000
Length = 0.270000

name = Lens Tube Shim
quantity = 1
parent = 1
materialID = 54
type = Flat Plate
Aero Mass = 0.021772
Thermal Mass = 0.021772
Diameter/Width = 0.020000
Length = 0.200000

name = PM Baffle AMS Lock Ring
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
```

```
Aero Mass = 0.014515
Thermal Mass = 0.014515
Diameter/Width = 0.020000
Length = 0.200000

name = Main PM Mount Flexure
quantity = 3
parent = 1
materialID = 9
type = Flat Plate
Aero Mass = 0.083915
Thermal Mass = 0.083915
Diameter/Width = 0.101000
Length = 0.138000

name = PM struts
quantity = 3
parent = 1
materialID = 72
type = Box
Aero Mass = 0.032205
Thermal Mass = 0.032205
Diameter/Width = 0.030000
Length = 0.030000
Height = 0.010000

name = Camera
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.160000
Thermal Mass = 0.160000
Diameter/Width = 0.046000
Length = 0.046000
Height = 0.040000

name = MLI
quantity = 1
parent = 1
materialID = 44
type = Cylinder
Aero Mass = 0.267624
Thermal Mass = 0.267624
Diameter/Width = 0.300000
Length = 0.450000

name = Propulsion Deck Base Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 3.111296
Thermal Mass = 3.111296
Diameter/Width = 0.400000
Length = 0.400000

name = Avionics Deck Base Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 2.481786
Thermal Mass = 2.481786
Diameter/Width = 0.400000
Length = 0.400000

name = Optical Bench Base Plate
quantity = 1
```

```
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.421474
Thermal Mass = 1.421474
Diameter/Width = 0.400000
Length = 0.400000

name = Antenna Deck Base Plate
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.870080
Thermal Mass = 0.870080
Diameter/Width = 0.400000
Length = 0.400000

name = Antenna Deck Extension
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.079654
Thermal Mass = 0.079654
Diameter/Width = 0.029000
Length = 0.400000

name = Corner Rail 1
quantity = 4
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.366623
Thermal Mass = 0.366623
Diameter/Width = 0.045000
Length = 0.820000

name = Side Cross Brace
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.141457
Thermal Mass = 0.141457
Diameter/Width = 0.035000
Length = 0.450000

name = Center Cross Brace
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.141457
Thermal Mass = 0.141457
Diameter/Width = 0.035000
Length = 0.450000

name = Optical Bench Corner Bracket Assembly
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.046632
Thermal Mass = 0.046632
Diameter/Width = 0.037000
Length = 0.037000
Height = 0.037000
```

```
name = Propulsion Deck Corner Bracket Assembly
quantity = 4
parent = 1
materialID = 8
type = Box
Aero Mass = 0.046632
Thermal Mass = 0.046632
Diameter/Width = 0.037000
Length = 0.037000
Height = 0.037000

name = Front Close-out Panel
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 1.451520
Thermal Mass = 1.451520
Diameter/Width = 0.350000
Length = 0.355000

name = Side Close-out Panel
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.576359
Thermal Mass = 0.576359
Diameter/Width = 0.350000
Length = 0.355000

name = Rear Close-out Panel
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.316017
Thermal Mass = 0.316017
Diameter/Width = 0.194000
Length = 0.350000

name = OTA Cover - deployed
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.714204
Thermal Mass = 0.714204
Diameter/Width = 0.358000
Length = 0.382000

name = Lid Hinge
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 0.034991
Thermal Mass = 0.034991
Diameter/Width = 0.025000
Length = 0.032000
Height = 0.025000

name = Pin Puller
quantity = 1
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.032400
Thermal Mass = 0.032400
```

```
Diameter/Width = 0.024000
Length = 0.032000

name = Pin Piller Bracket
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.058259
Thermal Mass = 0.058259
Diameter/Width = 0.022500
Length = 0.100000
Height = 0.015000

name = Fasteners
quantity = 150
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.004370
Thermal Mass = 0.004370
Diameter/Width = 0.006000
Length = 0.020000

name = Light Band Fasteners and Support
quantity = 10
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.003391
Thermal Mass = 0.003391
Diameter/Width = 0.005500
Length = 0.020000

name = Cortex
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 2.866799
Thermal Mass = 2.866799
Diameter/Width = 0.151000
Length = 0.161000
Height = 0.106000

name = Antenna Deck Bracket
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.009350
Thermal Mass = 0.009350
Diameter/Width = 0.098000
Length = 0.188000

name = Reaction Wheel 1
quantity = 3
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.228400
Thermal Mass = 0.228400
Diameter/Width = 0.063000
Length = 0.025400

name = Reaction Wheel Bracket
quantity = 1
parent = 1
materialID = 8
```

```
type = Box
Aero Mass = 0.194522
Thermal Mass = 0.194522
Diameter/Width = 0.075000
Length = 0.090000
Height = 0.014000

name = Torque Rod 1
quantity = 3
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.737000
Thermal Mass = 0.737000
Diameter/Width = 0.034000
Length = 0.120000

name = TQ-15 Bracket
quantity = 6
parent = 1
materialID = 8
type = Box
Aero Mass = 0.019523
Thermal Mass = 0.019523
Diameter/Width = 0.020500
Length = 0.056000
Height = 0.010500

name = Rate Sensor / Bracket Assembly
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.762000
Thermal Mass = 0.762000
Diameter/Width = 0.060000
Length = 0.080000
Height = 0.060000

name = Star Tracker / Bracket Assembly
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 1.254323
Thermal Mass = 1.254323
Diameter/Width = 0.118000
Length = 0.268000
Height = 0.108000

name = GPS Card / Enclosure Assembly
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.259156
Thermal Mass = 0.259156
Diameter/Width = 0.071000
Length = 0.136000
Height = 0.023000

name = GPS Antenna Assembly
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.057198
Thermal Mass = 0.057198
Diameter/Width = 0.030000
```

```
Length = 0.030000
Height = 0.025400

name = Solar Panel 1
quantity = 6
parent = 1
materialID = 50
type = Flat Plate
Aero Mass = 0.482790
Thermal Mass = 0.482790
Diameter/Width = 0.180000
Length = 0.340000

name = Battery
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 2.823436
Thermal Mass = 2.823436
Diameter/Width = 0.108000
Length = 0.178000
Height = 0.065000

name = Harnesses
quantity = 1
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 3.000000
Thermal Mass = 3.000000
Diameter/Width = 0.300000
Length = 2.000000

name = Tank
quantity = 2
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 2.060604
Thermal Mass = 2.060604
Diameter/Width = 0.156000
Length = 0.238000

name = HEX / Insulation / Bracket Assembly
quantity = 1
parent = 1
materialID = 66
type = Box
Aero Mass = 0.360508
Thermal Mass = 0.360508
Diameter/Width = 0.054000
Length = 0.114000
Height = 0.023000

name = Propulsion Heat Sink Block Assembly
quantity = 1
parent = 1
materialID = 66
type = Box
Aero Mass = 0.017214
Thermal Mass = 0.017214
Diameter/Width = 0.022000
Length = 0.022000
Height = 0.012500

name = Propulsion Manifold Assembly
quantity = 1
parent = 1
```

```
materialID = 8
type = Box
Aero Mass = 0.389909
Thermal Mass = 0.389909
Diameter/Width = 0.065000
Length = 0.075000
Height = 0.030000

name = Tubing Run 1
quantity = 2
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.011045
Thermal Mass = 0.011045
Diameter/Width = 0.002000
Length = 0.800000

name = Tube Fitting
quantity = 8
parent = 1
materialID = 54
type = Sphere
Aero Mass = 0.007923
Thermal Mass = 0.007923
Diameter/Width = 0.010000

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

name = SCOUTv1.001
Demise Altitude = 77.993543
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Shell
Demise Altitude = 77.799082
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = SM baffle
Demise Altitude = 76.774886
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = SM cover
Demise Altitude = 76.031699
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = PM
Demise Altitude = 0.000000
Debris Casualty Area = 0.677872
Impact Kinetic Energy = 264.039337

*************************************
name = PM baffle
Demise Altitude = 76.686261
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = SM spider
Demise Altitude = 0.000000
Debris Casualty Area = 0.490000
```

```
Impact Kinetic Energy = 406.204224

*************************************
name = Shutter Housing
Demise Altitude = 0.000000
Debris Casualty Area = 0.460774
Impact Kinetic Energy = 676.811646

*************************************
name = AMS upper plate
Demise Altitude = 77.900019
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = AMS core structure
Demise Altitude = 77.586183
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = AMS lower plate
Demise Altitude = 77.900019
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Lens Tube Shim
Demise Altitude = 0.000000
Debris Casualty Area = 0.439895
Impact Kinetic Energy = 1.934004

*************************************
name = PM Baffle AMS Lock Ring
Demise Altitude = 77.485449
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Main PM Mount Flexure
Demise Altitude = 76.868886
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = PM struts
Demise Altitude = 0.000000
Debris Casualty Area = 1.169982
Impact Kinetic Energy = 15.643453

*************************************
name = Camera
Demise Altitude = 73.228355
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = MLI
Demise Altitude = 77.899847
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Propulsion Deck Base Plate
Demise Altitude = 68.173003
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
```

```
name = Avionics Deck Base Plate
Demise Altitude = 70.182121
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Optical Bench Base Plate
Demise Altitude = 73.581074
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Antenna Deck Base Plate
Demise Altitude = 75.356519
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Antenna Deck Extension
Demise Altitude = 76.885769
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Corner Rail 1
Demise Altitude = 76.072777
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Side Cross Brace
Demise Altitude = 76.426426
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Center Cross Brace
Demise Altitude = 76.426426
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Optical Bench Corner Bracket Assembly
Demise Altitude = 76.010894
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Propulsion Deck Corner Bracket Assembly
Demise Altitude = 76.010894
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Front Close-out Panel
Demise Altitude = 72.826207
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Side Close-out Panel
Demise Altitude = 76.004840
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Rear Close-out Panel
Demise Altitude = 76.617574
Debris Casualty Area = 0.000000
```

```
Impact Kinetic Energy = 0.000000

*************************************
name = OTA Cover - deployed
Demise Altitude = 75.693379
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Lid Hinge
Demise Altitude = 75.709699
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Pin Puller
Demise Altitude = 75.422800
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Pin Piller Bracket
Demise Altitude = 75.982918
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Fasteners
Demise Altitude = 75.393800
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Light Band Fasteners and Support
Demise Altitude = 75.796043
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Cortex
Demise Altitude = 65.029812
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Antenna Deck Bracket
Demise Altitude = 77.902629
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Reaction Wheel 1
Demise Altitude = 67.450081
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Reaction Wheel Bracket
Demise Altitude = 74.019785
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Torque Rod 1
Demise Altitude = 61.045261
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
```

```
name = TQ-15 Bracket
Demise Altitude = 76.706433
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Rate Sensor / Bracket Assembly
Demise Altitude = 68.575738
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Star Tracker / Bracket Assembly
Demise Altitude = 73.815722
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = GPS Card / Enclosure Assembly
Demise Altitude = 74.665964
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = GPS Antenna Assembly
Demise Altitude = 74.349824
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Solar Panel 1
Demise Altitude = 77.348558
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Battery
Demise Altitude = 63.627046
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = Harnesses
Demise Altitude = 0.000000
Debris Casualty Area = 1.889516
Impact Kinetic Energy = 161.982788

*************************************
name = Tank
Demise Altitude = 70.833917
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

*************************************
name = HEX / Insulation / Bracket Assembly
Demise Altitude = 0.000000
Debris Casualty Area = 0.443888
Impact Kinetic Energy = 349.493317

*************************************
name = Propulsion Heat Sink Block Assembly
Demise Altitude = 0.000000
Debris Casualty Area = 0.383756
Impact Kinetic Energy = 6.476353

*************************************
name = Propulsion Manifold Assembly
Demise Altitude = 70.573394
Debris Casualty Area = 0.000000
```

```
Impact Kinetic Energy = 0.000000

************************************
name = Tubing Run 1
Demise Altitude = 77.534371
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
name = Tube Fitting
Demise Altitude = 68.230480
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************

=============== End of Requirement 4.7-1 ===============
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Requirements 4.7-1b, and 4.7-1c below are non-applicable requirements because SCOUT 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 Scout 1 & 2 mission.

END of ODAR for SCOUT 1 & 2