AST&Science LLC
File No. 1059-EX-CN-2020
SUBMITTED UNDER REQUEST FOR CONFIDENTIAL TREATMENT

Response to Questions of October 20, 2021

QUESTION 1: Why was the LVA modeled as 6 total flat plates (4 for the sides, 2 for the base plate?) The base plate appears to be a cylindrical object, while the sides each appear to be 2 semi-cylindrical objects that could approximately be modeled as boxes.

RESPONSE: AST did model your suggested approach in order to evaluate the 6 flat plate configuration that it used. This was to ensure consistency in the modeling. The casualty risk assessment is unchanged between these two approaches, and the LVA is expected to demise upon re-entry under both approaches. In support of this response, the activity log derived from using your suggested approach is attached to this response.

QUESTION 2: The table on page 5 lists the surviving kinetic energy of the control sat as 147,993 J, while the description on page 4 and the DAS results on page 23 indicate 154,547 J of kinetic energy. Please indicate the correct surviving kinetic energy of the control sat.

RESPONSE: The number in the table on page 5 was a typographical error that occurred when we developed our response using the table that was in the September filing to maintain consistent formatting. The initial modeling approach resulted in a kinetic energy of 147,993 J (as seen in the September filing). After adjusting the materials to more conservatively model the elements in the ControlSat, the resulting kinetic energy was 154,547 J. This amount was correctly included in the description on page 4 of the October 15 filing and is seen in the DAS activity log that accompanied it, but was not properly updated in the table on page 5. The current and correct evaluation for the ControlSat kinetic energy is 154,547 J.

QUESTION 3: In the previous submission posted at the start of September, the mass of the spacecraft was given as ▮▮ kg. In the October 15 update, the combined masses of the control sat and the phased array are ▮▮ kg. What is the cause of the greater than ▮▮ kg difference between these two documents?

RESPONSE: In the September filing, there was a typographical error related to the description of the mass, which did not note that the number included the VLA. The mass statement read as follows:

"The spacecraft consists of an array of Microns and a ControlSat, with a total allocated mass of ▮▮ kg."

This statement *should have read* instead:

"The payload consists of an array of Microns, a ControlSat, ***and a Launch Vehicle Adapter (LVA)*** with a total allocated mass of ▮▮ kg." (emphasis added)

The BW3 modeled mass breakdown is as follows:

Object	Mass (kg)
ControlSat	███
Phased Array	███
Launch Vehicle Adapter	███
TOTAL	███

As seen in this table, the total payload mass is ███ kg.

One important note is that in the activity log submitted on October 15, the LVA mass was not updated to reflect changes that AST made to the design to improve the probability of demise and to increase structural stability to successfully withstand launch loads. The ███ kg stated above is the mass of the current LVA design, which is nearly finished and so AST does not anticipate any more changes. Notwithstanding the mass increase of the LVA, it does not result in a change to the casualty risk assessment and does not impact the probability of demise. This is shown in the attached activity log and incorporates the support for the response to Question 1.

QUESTION 4: Why are the control sat and phased array being treated as two separate space objects for all DAS calculations (collision risk, small object penetration risk, demisability of components and lifetime of the spacecraft?)

RESPONSE: Given the unique configuration for the BlueWalker 3 satellite, AST did not believe that it would be correct to model the ControlSat and Phased Array as a single entity. This is because the inputs to the casualty risk assessment would assume a shared parent object for each of these objects (the ControlSat and the Phased Array). Since the exterior surface materials and dimensions of these two objects are *different*, AST modeled them as separate objects to allow for a more refined modeling approach, including the ability to select different external materials and to accommodate different parent object dimensions. In any instance where risks were assessed as a probability for the objects separately, AST reported the combined probability, as the two systems are mechanically linked. For example, the activity log (both the current one and the one submitted on October 15) shows the following results for the probability of collision with large objects:

Object	Mass (kg)
ControlSat	4.60E-06
Phased Array	6.36E-05

In the October 15 filing, AST reported this number for the total probability of collision with large objects (as $6.82(10^{-5})$), which is the combined probability of the objects listed in the table and detailed in the activity log. Each other assessment was reported in this manner so that the total satellite probabilities and risks were properly assessed, regardless of how modeling was approached in the DAS.

QUESTION 5: All DAS calculations are done using an altitude of 400 km, instead of the previously stated operational altitude of 415 km. Has the operational or disposal altitude of the spacecraft changed to 400 km?

RESPONSE: No, the expected altitude has not changed. AST is expecting an orbital insertion altitude of 400 km with a +/- 25 km uncertainty. This is consistent with the September filing which included a footnote on the orbit stating as follows:

"BW3 will occupy a circular orbit at an altitude between 375 km and 425 km. For purposes of the analysis here, AST assumes operations at 400 km."[1]

To meet mission duration requirements, AST is tentatively planning to orbit raise the BW3 to 415 km after insertion at 400 km. Since this altitude adjustment would affect the satellite lifetime, the analysis presented in the September filing used 415 km due to the larger impact this orbit presents to deorbit time; it also presents the worst-case dwell time. Analyses in the DAS have already been performed to demonstrate compliance at these bounding altitudes of 400 km and 415 km.

AST is attaching a second activity log that demonstrates compliance to all requirements using the 415 km orbit. The input parameters in this activity log are otherwise identical to the first activity log attachment for the 400 km case. As seen looking at both activity logs, the impact on the risk assessments between the two bounding altitudes is relatively small. The results for the 400 km case weregiven to the Commission because this is the established insertion altitude and the different between the two orbits is negligible according to AST's analysis. The satellite lifetime analysis presented in the September filing used 415 km due to the larger impact on deorbit time. AST is confidently expecting an operational altitude between 400 km and 415 km.

QUESTION 6: The DAS calculations presented show no changes between initial mass and final mass. Please indicate if the spacecraft will contain, and use, propellant as previously indicated.

RESPONSE: AST is confused by this statement. In the activity log attached to this response and the activity log attached to the October 15 filing, the initial mass of the ControlSat was ▮ kg with a final mass of ▮ kg, with the difference representing a propellant mass of 12 kg. The Phased Array mass is unchanged, but this is because the ControlSat contains the propulsion system and the required propellant for the budgeted maneuvers. So, yes, the BW3 will contain and use propellant as previously indicated.

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[1] Updated Orbital Debris Mitigation Unified Response at n.3.

```
10 22 2021; 13:00:03PM   Activity Log Started
10 22 2021; 13:00:03PM   Opened Project
████████████████████████████████████████
10 22 2021; 13:00:22PM   Processing Requirement 4.3-1:   Return Status :  Passed


==============
Project Data
==============
        Objects Passing Through LEO = True
        Number of Objects = 2

**INPUT**
        Quantity = 4
        ████████████████████████████████████
        Perigee Altitude = 400.000000 (km)
        Apogee Altitude = 400.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = -1.000000 (deg)
        Argument of Perigee = -1.000000 (deg)
        Mean Anomaly = -1.000000 (deg)
        Released Year = 2022.300000 (yr)


**OUTPUT**
        Perigee Altitude = -6378.136000 (km)
        Apogee Altitude = -6378.136000 (km)
        Inclination = 0.000000 (deg)
        Lifetime = 0.097603 (yr)
        Object Reentered within 25 years of Release = True
        Object-Time = 0.328542 (obj-yrs)
        Total Object-Time = 0.410678 (obj-yrs)
        Status = Pass
         Returned Error Message - Normal Processing


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**INPUT**
        Quantity = 1
        ████████████████████████████████████
        Perigee Altitude = 400.000000 (km)
        Apogee Altitude = 400.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = -1.000000 (deg)
        Argument of Perigee = -1.000000 (deg)
        Mean Anomaly = -1.000000 (deg)
        Released Year = 2022.300000 (yr)

**OUTPUT**
        Perigee Altitude = -6378.136000 (km)
        Apogee Altitude = -6378.136000 (km)
        Inclination = 0.000000 (deg)
```

```
        Lifetime = 0.097603 (yr)
        Object Reentered within 25 years of Release = True
        Object-Time = 0.082136 (obj-yrs)
        Total Object-Time = 0.410678 (obj-yrs)
        Status = Pass
         Returned Error Message - Normal Processing


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

=============== End of Requirement 4.3-1 ===============
10 22 2021; 13:00:24PM  Processing Requirement 4.3-2: Return Status : Passed

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

=============== End of Requirement 4.3-2 ===============
10 22 2021; 13:03:27PM  Processing Requirement 4.5-1:   Return Status :  Passed

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

**INPUT**

        Space Structure Name = ControlSat
        Space Structure Type = Payload
        Perigee Altitude = 400.000 (km)
        Apogee Altitude = 400.000 (km)
        Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ███████████████████████████████
        Start Year = 2022.300 (yr)
        ████████████████████████
        ██████████████████
        Duration = 2.000 (yr)
        Station-Kept = True
        Abandoned = True

**OUTPUT**

        Collision Probability = 4.6002E-06
        Returned Message: Normal Processing
        Date Range Message: Normal Date Range
        Status = Pass


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INPUT

    Space Structure Name = Phased Array ████████████
    Space Structure Type = Payload
    Perigee Altitude = 400.000 (km)
    Apogee Altitude = 400.000 (km)
    Inclination = 53.000 (deg)
    RAAN = 0.000 (deg)
    Argument of Perigee = 0.000 (deg)
    Mean Anomaly = 0.000 (deg)
    ██████████████████████████████████████

    Start Year = 2022.300 (yr)
    ████████████████████████████

    Duration = 2.000 (yr)
    Station-Kept = True
    Abandoned = True

OUTPUT

    Collision Probability = 6.3646E-05
    Returned Message: Normal Processing
    Date Range Message: Normal Date Range
    Status = Pass

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

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

10 22 2021; 13:03:32PM Project Data Saved To File
10 22 2021; 13:07:15PM Requirement 4.5-2: Compliant

==
Spacecraft = ControlSat
Critical Surface = Propellant Tank
==

INPUT

    Apogee Altitude = 400.000 (km)
    Perigee Altitude = 400.000 (km)
    Orbital Inclination = 53.000 (deg)
    RAAN = 0.000 (deg)
    Argument of Perigee = 0.000 (deg)
    Mean Anomaly = 0.000 (deg)
    ████████████████████████████████

    Station Kept = Yes
    Start Year = 2022.300 (yr)

Duration = 2.000 (yr)
        Orientation = Fixed Oriented

        ████████████████████████████
        ████████████████████████████████

        CS Pressurized = Yes

        ███████ ████████████ █████████████

OUTPUT

        Probability of Penetration = 6.7145E-06 (6.7145E-06)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = Avionics
==

INPUT

        Apogee Altitude = 400.000 (km)
        Perigee Altitude = 400.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ████████████████████████████
        ████████████████████

        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ████████████████████████████
        ████████████████████████████████

        CS Pressurized = No

        ███████ ████████████ █████████████

OUTPUT

        Probability of Penetration = 2.7269E-10 (2.7269E-10)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat

Critical Surface = ███████████████

==

INPUT

        Apogee Altitude = 400.000 (km)
        Perigee Altitude = 400.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ████████████████████████████████
        ███████████████████████

        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ████████████████████████████████
        ██████████████████████████████████████

        CS Pressurized = No

OUTPUT

        Probability of Penetration = 1.5317E-05 (1.5317E-05)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = ██████
==

INPUT

        Apogee Altitude = 400.000 (km)
        Perigee Altitude = 400.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ████████████████████████████████
        ███████████████████████

        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        █████████████████████████████

CS Pressurized = No

█████████   █████████████   █████████████

OUTPUT

      Probability of Penetration = 2.3476E-09 (2.3476E-09)
      Returned Error Message: Normal Processing
      Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = ████
==

INPUT

      Apogee Altitude = 400.000 (km)
      Perigee Altitude = 400.000 (km)
      Orbital Inclination = 53.000 (deg)
      RAAN = 0.000 (deg)
      Argument of Perigee = 0.000 (deg)
      Mean Anomaly = 0.000 (deg)
      ███████████████████████████
      █████████████████████
      Station Kept = Yes
      Start Year = 2022.300 (yr)
      Duration = 2.000 (yr)
      Orientation = Fixed Oriented
      ████████████████████
      ██████████████████████████
      CS Pressurized = No

█████████   █████████████   █████████████

OUTPUT

      Probability of Penetration = 1.0006E-07 (1.0006E-07)
      Returned Error Message: Normal Processing
      Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = ████
==

INPUT

    Apogee Altitude = 400.000 (km)
    Perigee Altitude = 400.000 (km)
    Orbital Inclination = 53.000 (deg)
    RAAN = 0.000 (deg)
    Argument of Perigee = 0.000 (deg)
    Mean Anomaly = 0.000 (deg)
    ████████████████████████
    ████████████████
    ████████████

    Station Kept = Yes
    Start Year = 2022.300 (yr)
    Duration = 2.000 (yr)
    Orientation = Fixed Oriented
    ████████████████████████
    ██████████████████████████

    CS Pressurized = No
    ████████   ████████████████   ████████████████

OUTPUT

    Probability of Penetration = 4.9741E-10 (4.9741E-10)
    Returned Error Message: Normal Processing
    Date Range Error Message: Normal Date Range

==
Spacecraft = Phased Array ████████████████
Critical Surface = Micron ████████████
==

INPUT

    Apogee Altitude = 400.000 (km)
    Perigee Altitude = 400.000 (km)
    Orbital Inclination = 53.000 (deg)
    RAAN = 0.000 (deg)
    Argument of Perigee = 0.000 (deg)
    Mean Anomaly = 0.000 (deg)
    ████████████████████████
    ████████████████

    Station Kept = Yes
    Start Year = 2022.300 (yr)
    Duration = 2.000 (yr)
    Orientation = Random Tumbling
    ████████████████████████
    ████████████████

██████████████████████████████████
CS Pressurized = No
████████   ████████████   ████████████

OUTPUT

        Probability of Penetration = 9.1989E-05 (9.1994E-05)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

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

10 22 2021; 13:07:16PM Processing Requirement 4.6   Return Status : Passed

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Project Data
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INPUT

        Space Structure Name = ControlSat
        Space Structure Type = Payload

        Perigee Altitude = 400.000000 (km)
        Apogee Altitude = 400.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = 0.000000 (deg)
        Argument of Perigee = 0.000000 (deg)
        Mean Anomaly = 0.000000 (deg)
        ███████████████████████████
        Start Year = 2022.300000 (yr)
        █████████████████████████
        ████████████████████
        Duration = 2.000000 (yr)
        Station Kept = True
        Abandoned = True
        PMD Perigee Altitude = 400.000000 (km)
        PMD Apogee Altitude = 400.000000 (km)
        PMD Inclination = 53.000000 (deg)
        PMD RAAN = 0.000000 (deg)
        PMD Argument of Perigee = 0.000000 (deg)
        PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

        Suggested Perigee Altitude = 400.000000 (km)
        Suggested Apogee Altitude = 400.000000 (km)
        Returned Error Message = Passes LEO reentry orbit criteria.

        Released Year = 2024 (yr)

```
        Requirement = 61
        Compliance Status = Pass


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

**INPUT**

        Space Structure Name = Phased Array ███████████
        Space Structure Type = Payload

        Perigee Altitude = 400.000000 (km)
        Apogee Altitude = 400.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = 0.000000 (deg)
        Argument of Perigee = 0.000000 (deg)
        Mean Anomaly = 0.000000 (deg)
        ███████████████████████████
        Start Year = 2022.300000 (yr)
        ██████████████████████
        ███████████████████
        Duration = 2.000000 (yr)
        Station Kept = True
        Abandoned = True
        PMD Perigee Altitude = 400.000000 (km)
        PMD Apogee Altitude = 400.000000 (km)
        PMD Inclination = 53.000000 (deg)
        PMD RAAN = 0.000000 (deg)
        PMD Argument of Perigee = 0.000000 (deg)
        PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

        Suggested Perigee Altitude = 400.000000 (km)
        Suggested Apogee Altitude = 400.000000 (km)
        Returned Error Message = Passes LEO reentry orbit criteria.

        Released Year = 2024 (yr)
        Requirement = 61
        Compliance Status = Pass


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

=============== End of Requirement 4.6 ===============
10 22 2021; 13:07:25PM  *********Processing Requirement 4.7-1
        Return Status :  Passed

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


██████████████████
```

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

name = ControlSat
Demise Altitude = 77.992874
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = ControlSat Structure ████████
Demise Altitude = 0.000000
Debris Casualty Area = 2.667737
Impact Kinetic Energy = 154547.828125

****
████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
████████
Demise Altitude = 0.000000

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[REDACTED]
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[REDACTED]
Demise Altitude = 0.000000

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

****
██████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

***********INPUT****
 Item Number = 2

name = Phased Array ████████████
████████
██████
████████

```
**************OUTPUT****
Item Number = 2

name = Phased Array███████████████
Demise Altitude = 77.990089
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000


**********************************
████████████████████████
Demise Altitude = 75.562752
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000


**********************************
██████████████
Demise Altitude = 76.588097
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000


**********************************
█████████████
Demise Altitude = 76.416061
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000


**********************************
███████████
Demise Altitude = 0.000000
Debris Casualty Area = 33.478802
Impact Kinetic Energy = 12.651192


**********************************
██████████████████
Demise Altitude = 66.942238
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000
```

```
**********************************
██████████████████
Demise Altitude = 77.247917
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

**********************************
██████████████████
Demise Altitude = 76.724319
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

**********************************
██████████████████
Demise Altitude = 77.603447
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

**********************************
██████████████████
Demise Altitude = 77.585381
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

**********************************
██████████████████
Demise Altitude = 77.077644
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

***********INPUT****
 Item Number = 3

name = LVA Panel - Debris
```

***************OUTPUT****
Item Number = 3

name = LVA Panel - Debris
Demise Altitude = 77.991196
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
[redacted]
Demise Altitude = 68.612709
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

***********INPUT****
 Item Number = 4

name = LVA Base - Debris

***************OUTPUT****
Item Number = 4

```
name = LVA Base - Debris
Demise Altitude = 77.992432
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
████████
Demise Altitude = 66.405739
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

=============== End of Requirement 4.7-1 ===============
10 22 2021; 13:07:25PM  Project Data Saved To File
```

```
10 22 2021; 13:11:51PM  Activity Log Started
10 22 2021; 13:11:51PM  Opened Project
███████████████████████████████████████████████

10 22 2021; 13:11:55PM  Processing Requirement 4.3-1:   Return Status :  Passed


==============
Project Data
==============
        Objects Passing Through LEO = True
        Number of Objects = 2

**INPUT**
        Quantity = 4
        ████████████████████████████████████
        Perigee Altitude = 400.000000 (km)
        Apogee Altitude = 400.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = -1.000000 (deg)
        Argument of Perigee = -1.000000 (deg)
        Mean Anomaly = -1.000000 (deg)
        Released Year = 2022.300000 (yr)


**OUTPUT**
        Perigee Altitude = -6378.136000 (km)
        Apogee Altitude = -6378.136000 (km)
        Inclination = 0.000000 (deg)
        Lifetime = 0.097603 (yr)
        Object Reentered within 25 years of Release = True
        Object-Time = 0.328542 (obj-yrs)
        Total Object-Time = 0.410678 (obj-yrs)
        Status = Pass
         Returned Error Message - Normal Processing


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

**INPUT**
        Quantity = 1
        ████████████████████████████████████
        Perigee Altitude = 400.000000 (km)
        Apogee Altitude = 400.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = -1.000000 (deg)
        Argument of Perigee = -1.000000 (deg)
        Mean Anomaly = -1.000000 (deg)
        Released Year = 2022.300000 (yr)

**OUTPUT**
        Perigee Altitude = -6378.136000 (km)
        Apogee Altitude = -6378.136000 (km)
        Inclination = 0.000000 (deg)
```

```
        Lifetime = 0.097603 (yr)
        Object Reentered within 25 years of Release = True
        Object-Time = 0.082136 (obj-yrs)
        Total Object-Time = 0.410678 (obj-yrs)
        Status = Pass
         Returned Error Message - Normal Processing


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

============== End of Requirement 4.3-1 ==============
10 22 2021; 13:11:56PM  Processing Requirement 4.3-2: Return Status : Passed


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

============== End of Requirement 4.3-2 ==============
10 22 2021; 13:15:34PM  Processing Requirement 4.5-1:   Return Status :  Passed


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

**INPUT**

        Space Structure Name = ControlSat
        Space Structure Type = Payload
        Perigee Altitude = 415.000 (km)
        Apogee Altitude = 415.000 (km)
        Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ██████████████████████████████
        Start Year = 2022.300 (yr)
        ████████████████████████
        ███████████████████
        Duration = 2.000 (yr)
        Station-Kept = True
        Abandoned = True

**OUTPUT**

        Collision Probability = 6.0294E-06
        Returned Message: Normal Processing
        Date Range Message: Normal Date Range
        Status = Pass


==============
```

INPUT

        Space Structure Name = Phased Array ███████████████
        Space Structure Type = Payload
        Perigee Altitude = 415.000 (km)
        Apogee Altitude = 415.000 (km)
        Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ██
        Start Year = 2022.300 (yr)
        ████████████████████████
        ████████████████
        Duration = 2.000 (yr)
        Station-Kept = True
        Abandoned = True

OUTPUT

        Collision Probability = 8.2784E-05
        Returned Message: Normal Processing
        Date Range Message: Normal Date Range
        Status = Pass

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

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

10 22 2021; 13:15:37PM Project Data Saved To File
10 22 2021; 13:19:53PM Requirement 4.5-2: Compliant

==
Spacecraft = ControlSat
Critical Surface = Propellant Tank
==

INPUT

        Apogee Altitude = 415.000 (km)
        Perigee Altitude = 415.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ████████████████████████████████
        ████████████████████████
        Station Kept = Yes
        Start Year = 2022.300 (yr)

Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ███████████████████████████████
        ███████████████████████████████████
        ███████████████████████████████████████
        CS Pressurized = Yes
        ████████   ███████████████   ███████████████

OUTPUT

        Probability of Penetration = 8.9766E-06 (8.9766E-06)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

===
Spacecraft = ControlSat
Critical Surface = Avionics
===

INPUT

        Apogee Altitude = 415.000 (km)
        Perigee Altitude = 415.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ████████████████████████████████
        ███████████████████████
        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ███████████████████████████████
        ███████████████████████████████████
        ███████████████████████████████████████
        CS Pressurized = No
        ████████   ███████████████   ███████████████

OUTPUT

        Probability of Penetration = 2.8600E-10 (2.8600E-10)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

===
Spacecraft = ControlSat

Critical Surface = ██████████████

==

INPUT

        Apogee Altitude = 415.000 (km)
        Perigee Altitude = 415.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ███████████████████████████████
        ███████████████████████

        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ████████████████████████████████
        ████████████████████████████████████

        CS Pressurized = No

OUTPUT

        Probability of Penetration = 1.6000E-05 (1.6000E-05)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = ███████
==

INPUT

        Apogee Altitude = 415.000 (km)
        Perigee Altitude = 415.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ███████████████████████████████
        ███████████████████████

        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ███████████████████████████

CS Pressurized = No

███████████   ████████████████   ████████████████

OUTPUT

        Probability of Penetration = 2.3926E-09 (2.3926E-09)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = ████
==

INPUT

        Apogee Altitude = 415.000 (km)
        Perigee Altitude = 415.000 (km)
        Orbital Inclination = 53.000 (deg)
        RAAN = 0.000 (deg)
        Argument of Perigee = 0.000 (deg)
        Mean Anomaly = 0.000 (deg)
        ████████████████████████████
        ████████████████████
        Station Kept = Yes
        Start Year = 2022.300 (yr)
        Duration = 2.000 (yr)
        Orientation = Fixed Oriented
        ████████████████████████
        ████████████████████████████
        CS Pressurized = No

███████████   ████████████████   ████████████████

OUTPUT

        Probability of Penetration = 1.3131E-07 (1.3131E-07)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

==
Spacecraft = ControlSat
Critical Surface = ████
==

INPUT

      Apogee Altitude = 415.000 (km)
      Perigee Altitude = 415.000 (km)
      Orbital Inclination = 53.000 (deg)
      RAAN = 0.000 (deg)
      Argument of Perigee = 0.000 (deg)
      Mean Anomaly = 0.000 (deg)

      Station Kept = Yes
      Start Year = 2022.300 (yr)
      Duration = 2.000 (yr)
      Orientation = Fixed Oriented

      CS Pressurized = No

OUTPUT

      Probability of Penetration = 5.1789E-10 (5.1789E-10)
      Returned Error Message: Normal Processing
      Date Range Error Message: Normal Date Range

==
Spacecraft = Phased Array
Critical Surface = Micron
==

INPUT

      Apogee Altitude = 415.000 (km)
      Perigee Altitude = 415.000 (km)
      Orbital Inclination = 53.000 (deg)
      RAAN = 0.000 (deg)
      Argument of Perigee = 0.000 (deg)
      Mean Anomaly = 0.000 (deg)

      Station Kept = Yes
      Start Year = 2022.300 (yr)
      Duration = 2.000 (yr)
      Orientation = Random Tumbling

███████████████████████████████
CS Pressurized = No
█████████   ███████████████   ███████████████

OUTPUT

        Probability of Penetration = 1.2723E-04 (1.2724E-04)
        Returned Error Message: Normal Processing
        Date Range Error Message: Normal Date Range

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

10 22 2021; 13:19:54PM Processing Requirement 4.6   Return Status : Passed

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

INPUT

        Space Structure Name = ControlSat
        Space Structure Type = Payload

        Perigee Altitude = 415.000000 (km)
        Apogee Altitude = 415.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = 0.000000 (deg)
        Argument of Perigee = 0.000000 (deg)
        Mean Anomaly = 0.000000 (deg)
        ██████████████████████████████
        Start Year = 2022.300000 (yr)
        ██████████████████████████
        ███████████████████████
        Duration = 2.000000 (yr)
        Station Kept = True
        Abandoned = True
        PMD Perigee Altitude = 415.000000 (km)
        PMD Apogee Altitude = 415.000000 (km)
        PMD Inclination = 53.000000 (deg)
        PMD RAAN = 0.000000 (deg)
        PMD Argument of Perigee = 0.000000 (deg)
        PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

        Suggested Perigee Altitude = 415.000000 (km)
        Suggested Apogee Altitude = 415.000000 (km)
        Returned Error Message = Passes LEO reentry orbit criteria.

        Released Year = 2024 (yr)

```
        Requirement = 61
        Compliance Status = Pass


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

**INPUT**

        Space Structure Name = Phased Array██████████████
        Space Structure Type = Payload

        Perigee Altitude = 415.000000 (km)
        Apogee Altitude = 415.000000 (km)
        Inclination = 53.000000 (deg)
        RAAN = 0.000000 (deg)
        Argument of Perigee = 0.000000 (deg)
        Mean Anomaly = 0.000000 (deg)
        ██████████████████████████
        Start Year = 2022.300000 (yr)
        ████████████████████
        ██████████████████
        Duration = 2.000000 (yr)
        Station Kept = True
        Abandoned = True
        PMD Perigee Altitude = 415.000000 (km)
        PMD Apogee Altitude = 415.000000 (km)
        PMD Inclination = 53.000000 (deg)
        PMD RAAN = 0.000000 (deg)
        PMD Argument of Perigee = 0.000000 (deg)
        PMD Mean Anomaly = 0.000000 (deg)

**OUTPUT**

        Suggested Perigee Altitude = 415.000000 (km)
        Suggested Apogee Altitude = 415.000000 (km)
        Returned Error Message = Passes LEO reentry orbit criteria.

        Released Year = 2024 (yr)
        Requirement = 61
        Compliance Status = Pass


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

=============== End of Requirement 4.6 ===============
10 22 2021; 13:19:58PM  *********Processing Requirement 4.7-1
        Return Status :  Passed

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


████████████████████
```

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

name = ControlSat
Demise Altitude = 77.992874
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

***********************************
name = ControlSat Structure ████████████
Demise Altitude = 0.000000
Debris Casualty Area = 2.667737
Impact Kinetic Energy = 154547.828125

***********************************
████████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

***********************************
████████████
Demise Altitude = 0.000000
```

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
█████████████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
███████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
██████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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**********************************
████████████████████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

**********************************
█████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Demise Altitude = 0.000000

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
████████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
████████████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
█████████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
██████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
██████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
██████████
Demise Altitude = 0.000000
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

***********INPUT****
 Item Number = 2

name = Phased Array ████████████
████████
██████
████████

***************OUTPUT****

Item Number = 2

name = Phased Array ████████████
Demise Altitude = 77.990089
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
████████████████
Demise Altitude = 75.562752
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
██████████
Demise Altitude = 76.588097
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
████████
Demise Altitude = 76.416061
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
██████
Demise Altitude = 0.000000
Debris Casualty Area = 33.478802
Impact Kinetic Energy = 12.651192

****
████████████
Demise Altitude = 66.942238
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

```
************************************
███████████████████
Demise Altitude = 77.247917
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
███████████████████
Demise Altitude = 76.724319
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
███████████████████
Demise Altitude = 77.603447
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
███████████████████
Demise Altitude = 77.585381
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
███████████████████
Demise Altitude = 77.077644
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

***********INPUT****
  Item Number = 3

name = LVA Panel - Debris
```

***************OUTPUT****
Item Number = 3

name = LVA Panel - Debris
Demise Altitude = 77.991196
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

Demise Altitude = 68.612709
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

***********INPUT****
 Item Number = 4

name = LVA Base - Debris

***************OUTPUT****
Item Number = 4

```
name = LVA Base - Debris
Demise Altitude = 77.992432
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

************************************
███████
Demise Altitude = 66.405739
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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

=============== End of Requirement 4.7-1 ===============
10 22 2021; 13:19:58PM  Project Data Saved To File
```