

**TO:** Federal Communications Commission (FCC)

**FROM:** Richard Prasad, Senior Systems Engineer, Tyvak Nano-Satellite Systems INC

**DATE:** August 11, 2015

**SUBJECT:** Orbital Debris and Assessment Report for CICERO

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**Purpose:**

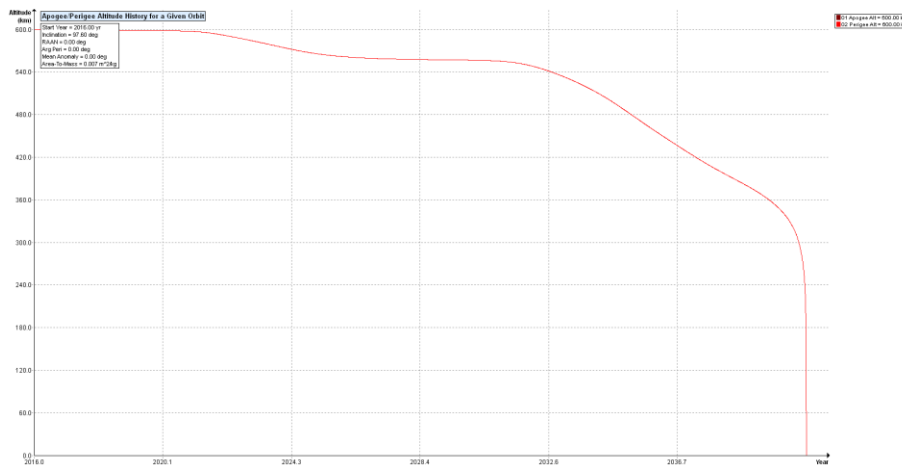
The purpose of this memorandum is to provide the overview for the CICERO CubeSat in regards to satisfying requirements for the NASA-STD-8719.14: Process for Limiting Orbital Debris

**Scope:**

This memorandum provides the assessment for satisfying this requirement using NASA Debris Assessment Software (DAS) version 2.0.2. This only covers the CICERO demo mission, currently scheduled to launch in March 2016 with a two year primary mission lifetime.

**Summary:**

The CICERO spacecraft will de-orbit in approximately 25 years following its 2 year primary mission. CICERO will change orientation to increase the drag on the vehicle following mission completion as part of decommissioning. The final orientation will have the 3U x 2U solar panel face in the velocity direction. The plot below shows the orbit decay for this period:



**Recommendation/Conclusion:**

The CICERO spacecraft should be re-assessed should any of the orbital parameters change prior to launch of the vehicle. Spacecraft mass must remain under 9 kg in order to satisfy the analysis completed in this memo.

## 1.0 Software Background

The analysis completed for the Orbital Debris and Assessment Report was performed using the NASSA Debris Assessment Software (DAS) version 2.0.2. This is the recommended software from NASA Orbital Debris Program Office for assessing reentry requirements.

## 2.0 DAS Analysis

DAS requires the user to input orbital parameters as well as some basic geometry and mass for the spacecraft. Since CICERO has a simple geometry and no substantial deployable components, this assessment is satisfactory.

### 2.1 DAS Inputs

The following was used as inputs to the DAS Mission Editor as a Payload:

Name	Duration (years)	Perigee Alt (km)	Apogee Alt (km)	Inclination (deg)	Initial Mass (kg)	Final Mass (kg)	Area-to-Mass (m <sup>2</sup> /kg)
CICERO	2	600	600	97.6	9	9	0.0066667

**NOTE:** Other parameters such as R.A. of Ascending Node, Argument of Perigee, and Mean Anomaly were left as 0 deg

### 2.2 DAS Output

The following is from the DAS Activity Log for the CICERO spacecraft and shows validation of requirements associated with the DAS analysis:

#### DAS Activity Log

```

08 11 2015; 13:46:05PM DAS Application Started
08 11 2015; 13:46:06PM Opened Project C:\Program Files (x86)\NASA\DAS 2.0\project\
08 11 2015; 13:46:08PM Project Data Saved To File
08 11 2015; 13:46:12PM Opened Project C:\Program Files (x86)\NASA\DAS 2.0\project\
08 11 2015; 13:46:27PM Mission Editor Changes Applied
No Project Data Available
=====
===== End of Requirement 4.3-1 =====
08 11 2015; 13:46:36PM Processing Requirement 4.3-2: Return Status : Passed
=====
No Project Data Available
=====
===== End of Requirement 4.3-2 =====
08 11 2015; 13:46:38PM Requirement 4.4-3: Compliant
===== End of Requirement 4.4-3 =====
08 11 2015; 13:46:43PM Processing Requirement 4.5-1: Return Status : Passed

```

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

\*\*INPUT\*\*

Space Structure Name = CICERO  
Space Structure Type = Payload  
Perigee Altitude = 600.000000 (km)  
Apogee Altitude = 600.000000 (km)  
Inclination = 97.600000 (deg)  
RAAN = 0.000000 (deg)  
Argument of Perigee = 0.000000 (deg)  
Mean Anomaly = 0.000000 (deg)  
Final Area-To-Mass Ratio = 0.006667 (m<sup>2</sup>/kg)  
Start Year = 2016.000000 (yr)  
Initial Mass = 9.000000 (kg)  
Final Mass = 9.000000 (kg)  
Duration = 2.000000 (yr)  
Station-Kept = False  
Abandoned = True  
PMD Perigee Altitude = -1.000000 (km)  
PMD Apogee Altitude = -1.000000 (km)  
PMD Inclination = 0.000000 (deg)  
PMD RAAN = 0.000000 (deg)  
PMD Argument of Perigee = 0.000000 (deg)

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DAS Activity Log

PMD Mean Anomaly = 0.000000 (deg)

\*\*OUTPUT\*\*

Collision Probability = 0.000004  
Returned Error Message: Normal Processing  
Date Range Error Message: Normal Date Range  
Status = Pass

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

08 11 2015; 13:46:46PM Requirement 4.5-2: Compliant

08 11 2015; 13:46:48PM Processing Requirement 4.6 Return Status : Passed

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

\*\*INPUT\*\*

Space Structure Name = CICERO  
Space Structure Type = Payload  
Perigee Altitude = 600.000000 (km)  
Apogee Altitude = 600.000000 (km)  
Inclination = 97.600000 (deg)  
RAAN = 0.000000 (deg)  
Argument of Perigee = 0.000000 (deg)  
Mean Anomaly = 0.000000 (deg)  
Area-To-Mass Ratio = 0.006667 (m<sup>2</sup>/kg)  
Start Year = 2016.000000 (yr)  
Initial Mass = 9.000000 (kg)  
Final Mass = 9.000000 (kg)  
Duration = 2.000000 (yr)

Station Kept = False  
Abandoned = True  
PMD Perigee Altitude = 598.470303 (km)  
PMD Apogee Altitude = 598.470303 (km)  
PMD Inclination = 97.652854 (deg)  
PMD RAAN = 342.705920 (deg)  
PMD Argument of Perigee = 15.421054 (deg)  
PMD Mean Anomaly = 0.000000 (deg)  
\*\*OUTPUT\*\*  
Suggested Perigee Altitude = 598.470303 (km)  
Suggested Apogee Altitude = 598.470303 (km)  
Returned Error Message = Passes LEO reentry orbit criteria.  
Released Year = 2040 (yr)  
Requirement = 61  
Compliance Status = Pass

=====

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DAS Activity Log

===== End of Requirement 4.6 =====

08 11 2015; 13:46:52PM \*\*\*\*\*Processing Requirement 4.7-1

Return Status : Passed

\*\*\*\*\*INPUT\*\*\*\*

Item Number = 1  
name = CICERO  
quantity = 1  
parent = 0  
materialID = 8  
type = Box  
Aero Mass = 9.000000  
Thermal Mass = 9.000000  
Diameter/Width = 0.200000  
Length = 0.300000  
Height = 0.100000  
name = CICERO  
quantity = 1  
parent = 1  
materialID = 8  
type = Box  
Aero Mass = 9.000000  
Thermal Mass = 9.000000  
Diameter/Width = 0.200000  
Length = 0.300000  
Height = 0.100000  
\*\*\*\*\*OUTPUT\*\*\*\*

Item Number = 1  
name = CICERO  
Demise Altitude = 77.994082  
Debris Casualty Area = 0.000000  
Impact Kinetic Energy = 0.000000  
\*\*\*\*\*

name = CICERO  
Demise Altitude = 57.477565  
Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

\*\*\*\*\*

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

08 11 2015; 13:47:39PM Science and Engineering - Re-Entry Survivability Analysis

\*\*\*\*\*INPUT\*\*\*\*

Item Number = 1

name = Root Object

quantity = 1

parent = 0

materialID = 8

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DAS Activity Log

type = Box

Aero Mass = 9.000000

Thermal Mass = 9.000000

Diameter/Width = 0.200000

Length = 0.300000

Height = 0.100000

name = Root Object

quantity = 1

parent = 1

materialID = 8

type = Box

Aero Mass = 9.000000

Thermal Mass = 9.000000

Diameter/Width = 0.200000

Length = 0.300000

Height = 0.100000

\*\*\*\*\*OUTPUT\*\*\*\*

Item Number = 1

name = Root Object

Demise Altitude = 77.995590

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

\*\*\*\*\*

name = Root Object

Demise Altitude = 52.383366

Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

\*\*\*\*\*

===== End of Re-Entry Survivability Analysis =====

08 11 2015; 13:48:13PM Science and Engineering - Apogee/Perigee History for a Given Orbit

\*\*INPUT\*\*

Perigee Altitude = 600.000000 (km)

Apogee Altitude = 600.000000 (km)

Inclination = 97.600000 (deg)

RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)

Mean Anomaly = 0.000000 (deg)

Area-To-Mass Ratio = 0.006670 (m<sup>2</sup>/kg)

Start Year = 2016.000000 (yr)

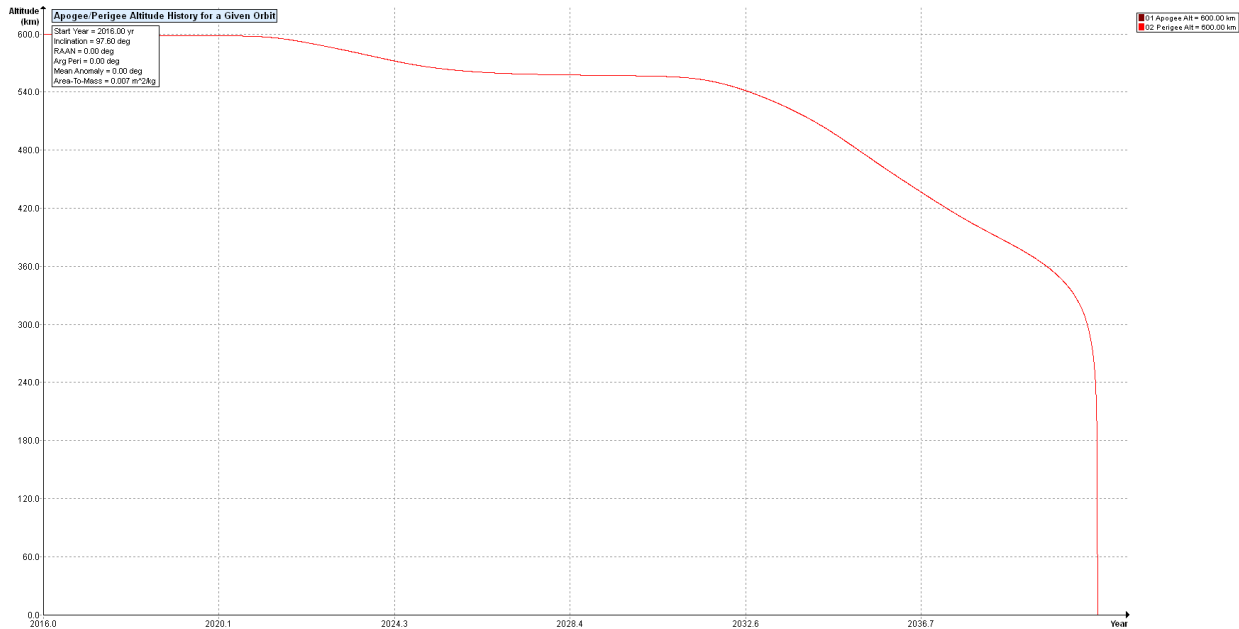
Integration Time = 25.000000 (yr)

\*\*OUTPUT\*\*

Plot  
08 11 2015; 13:48:38PM Science and Engineering - Orbit Lifetime/Dwell Time  
\*\*INPUT\*\*  
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DAS Activity Log  
Start Year = 2016.000000 (yr)  
Perigee Altitude = 600.000000 (km)  
Apogee Altitude = 600.000000 (km)  
Inclination = 97.600000 (deg)  
RAAN = 0.000000 (deg)  
Argument of Perigee = 0.000000 (deg)  
Area-To-Mass Ratio = 0.006670 (m<sup>2</sup>/kg)  
\*\*OUTPUT\*\*  
Orbital Lifetime from Startyr = 24.843258 (yr)  
Time Spent in LEO during Lifetime = 24.843258 (yr)  
Last year of Propagation = 2040 (yr)  
Returned Error Message: Object reentered  
08 11 2015; 13:49:14PM Project Data Saved To File  
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### 2.3 DAS Plot

The following plot shows the orbit decay of the CICERO spacecraft in its final orientation.



NOTE: The output of the requirements for DAS show a predicted orbit decay of 24.8 years. Since the primary mission finishes after 2 years we are well within the maximum 30 years allowed for LEO.