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Date:	06/27/2012
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Applicant:	Aprize Satellite, Inc.
File Number:	0023-EX-ML-2012
Correspondence Reference #:	17195
Date of Original Email:	06/12/2012

Re: Orbital Debris Mitigation Study AprizeSats 7-10

Background:

After considering the possibility of orbital debris and contamination, Aprize is able to provide the following information: The expected operational lifetime of the Aprize satellites is 7 to 10 years based on the history of previous satellites of this class. With a perigee altitude of 600 km and an apogee altitude of 680 km, the Aprize experimental satellites are calculated to re-enter the Earth's atmosphere and burn up completely in 22 years or less. The actual orbital lifetime will be reduced by the presence of nine fixed antenna elements that will increase satellite drag and dissipate energy.

The Aprize satellites will be in a polar, sun-synchronous orbit. Due to its higher orbital inclination angle and much higher altitude, there is no possibility of collision between the Aprize satellites and the International Space Station.

Technical Information:

1. The Aprize satellites will be disposed of by uncontrolled atmospheric re-entry.

2. Due to the small size of the Aprize satellites (25-cm cube) and soft metal structure (Aluminum), the entire satellite will burn up and be consumed due to atmospheric heating. No large or small pieces of the spacecraft will survive to the Earth's surface.

3. There is 0% probability of human casualty resulting from surviving fragments of the satellites due to the fact that all pieces will disintegrate during atmospheric re-entry.

4. These conclusions are based on the formulas and calculations in NSS 1740.14, *NASA Guidelines and Assessment Procedures for Limiting Orbital Debris*, dated August 1995.

5. The assumptions and parameters used in developing the estimates are:
   a. Apogee 680 km
   b. Perigee 600 km
   c. Inclination 97.8 degees
   d. Mass 10 kg
   e. Area 0.123 square meters
   f. Appendages 9 antenna elements.
   g. Area/Mass 0.0123 m^2/kg

6. The NASA Debris Assessment Software confirmed that the AprizeSat spacecraft satisfies all of the Requirements for Limiting Orbita Debris including:
   a. Mission-Related Debris Passing Through LEO
   b. Mission-Related Debris Passing Near GEO
   c. Long-Term Risk from Planned Breakups
   d. Probabiliy of Collision With Large Objects
   e. Probability of Damage from Small Objects
   f. Postmission Disposal
   g. Casualty Risk from Reentry Debris

7. Results from running the NASA Debris Assessment Software are provided in Figure 1.

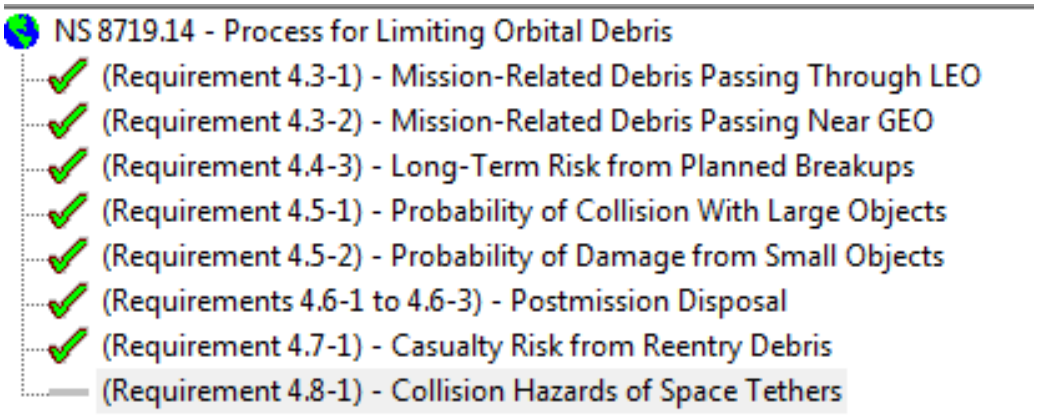

Figure 1. Aprize Satellites Satisfy All of the NASA Debris Assessment Requirements

Orbital Debris Mitigation Requirement Analysis Results

In accordance with ***Orbital Debris Mitigation Standard Practice***s, the following information regarding the operation of the Aprize satellites is hereby submitted:

Requirement 1. Control of Debris Released During Norma Operations.

1-1. ***For all oprerational orbit regimes:*** The Aprize spacecraft are designed to eliminate the release of any debris larger than 5 mm in any dimension during its orbital lifetime.

Requirement 2. Minimizing Debris Generated By Accidental Explosions.

2.1. ***Limiting the risk to other space systems from accidental explosions during mission operatons****:* The Aprize satellites have no on-board fuels, no explosives, or pressure vessels. The only stored energy on board the satellites is contained in the six nickel-cadmium batteries, which are non-explosive and will be fully discharged at end-of-life. Similar nickel-cadmium cells have been used successfully on many small satellite programs without incident. Thus, the Aprize satellites will not generate additional sources of debris.

2.2. ***Limiting the risk to other space systems from accidental explosions after completion of mission operations****.* After completion of its mission operations, the Aprize Satellites will remain domant until they re-enter the atmosphere and disintegration during their return to Earth.

Requirement 3. Selection of Safe Flight Profile and Operational Configuration.

3.1 ***Collision with large objects during orbital lifetime.*** The probability of the Aprize satellites colliding with an object larger than 1 meter is less than 0.005% as shown in Figure 3.

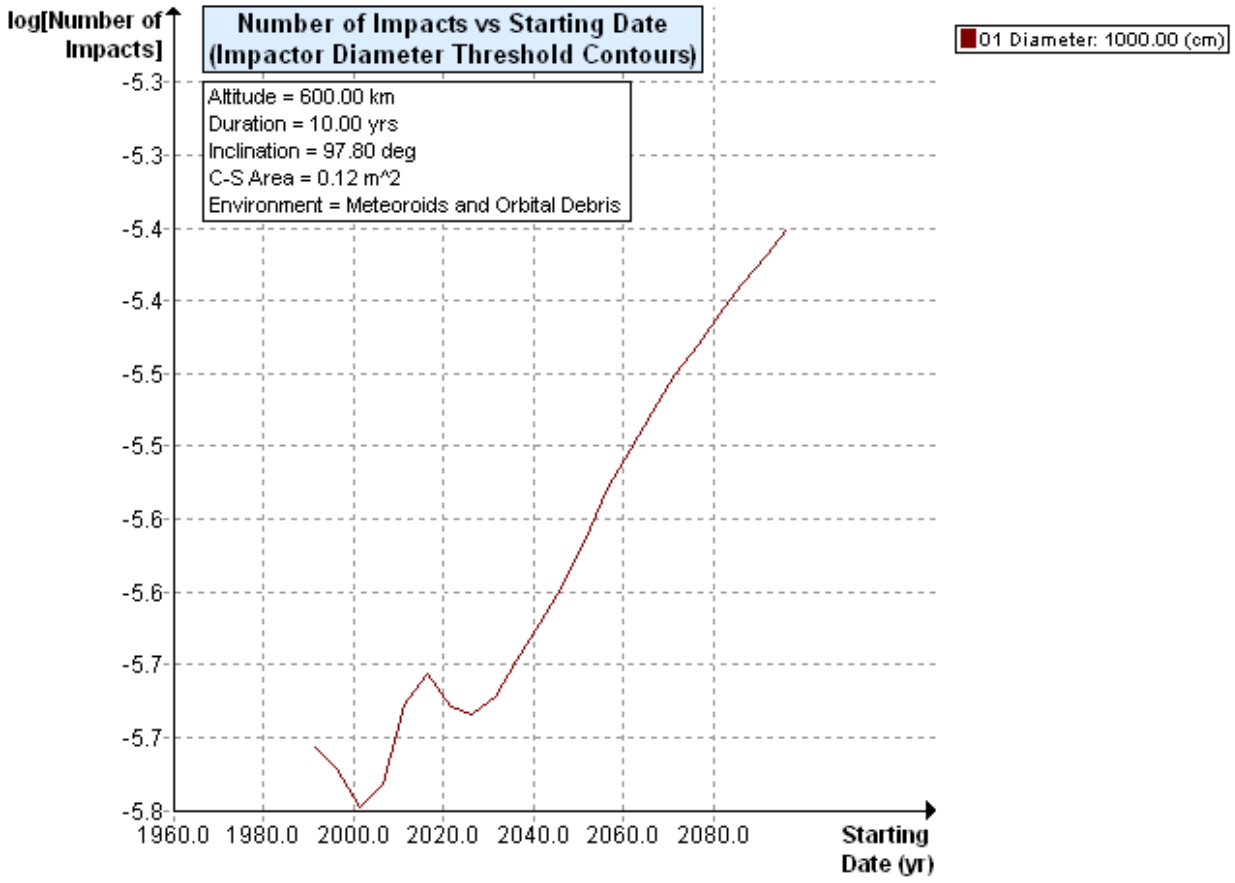

Figure 3. Log Number of Impacts of 1 Meter Objects Vs. Time

3.2 ***Colision with small debris during mission operations*:** Colision with debris smaller than 1 cm diameter will not prevent post-mission disposal as the Aprize satellites will re-enter the atmosphere without any action taken by the spacecraft itself. Figures 4, 5 and 6 show the probability of impact with small debris.

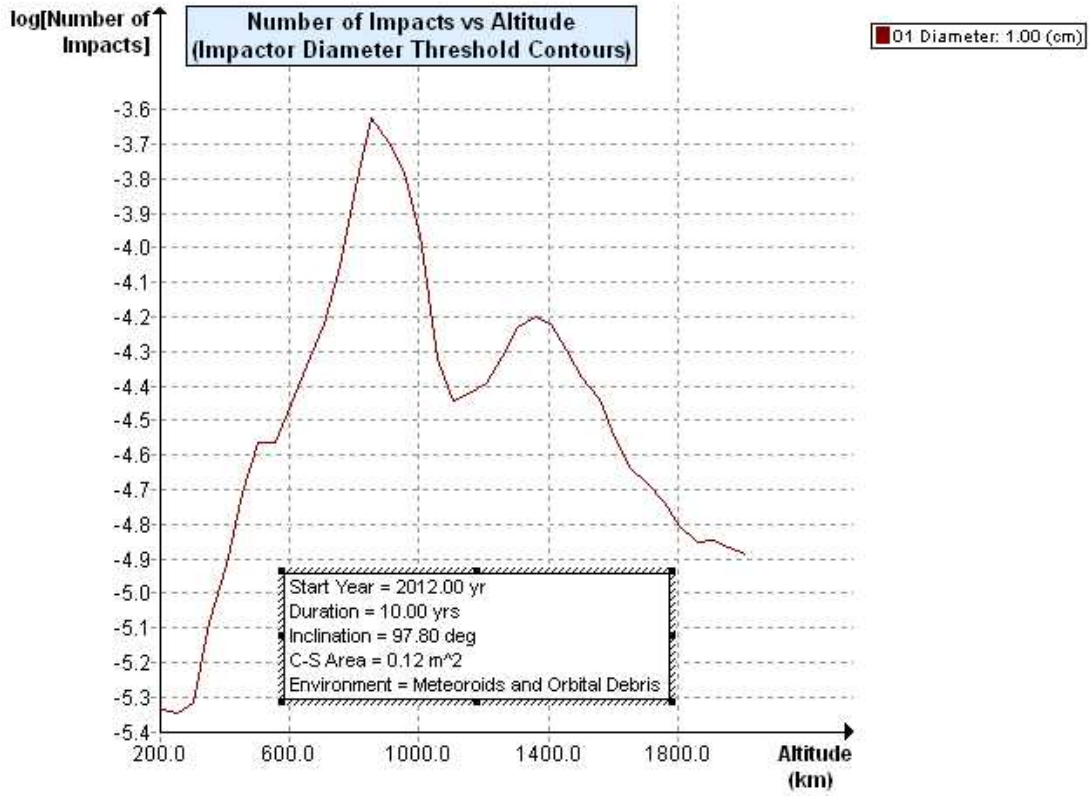

Figure 4. Log Number of Impacts of 1 cm Objects Vs. Satellite Altitude

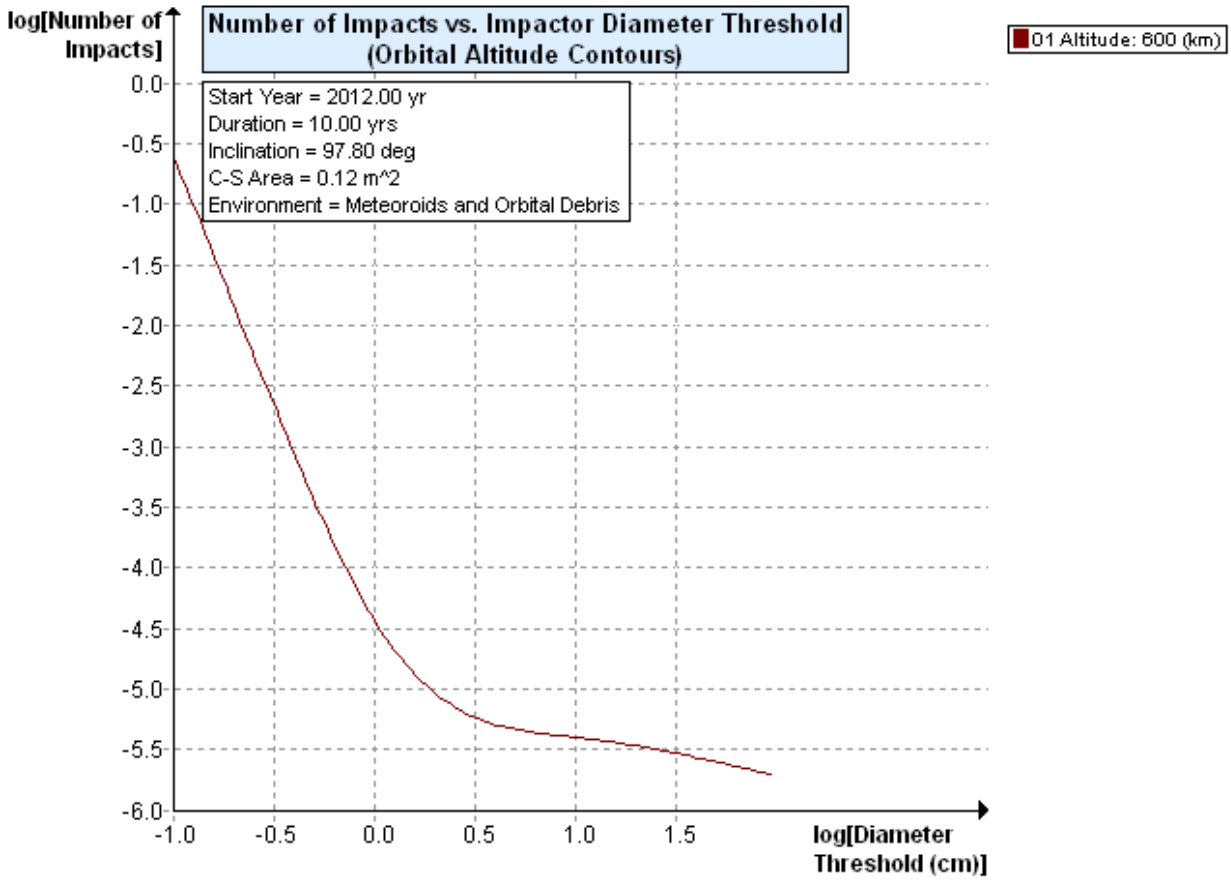

Figure 5. Log Number of Impacts Vs. the Log Diameter of Particles

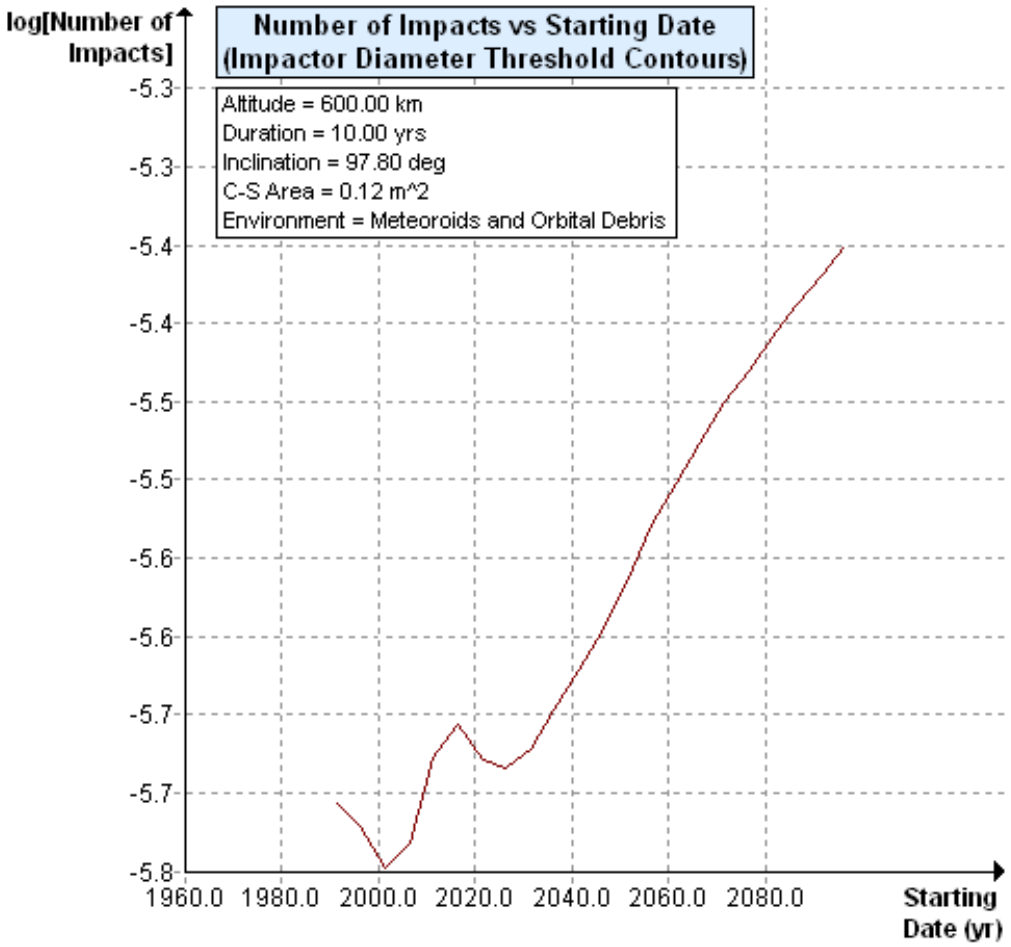

Figure 6. Log Number of Impacts of 1 cm Objects Vs. Time

Requirement 4. Postmission Disposal of Space Structures.

4.1 *Disposal for final mission orbits:*

a. Atmospheric reentry option: The requirement is to ***"Leave the structure in an orbit in which, using conservative projections for solar activity, atmospheric drag will limit the lifetime to nolonger than 25 years after completion of mission"***

Using conservative projections for solar activity and atmospheric drag, the total orbital lifetime of the Aprize satellites will be less than 22 years after launch in 2012. The multiple antenna elements will increase the overal atmospheric drag causing the satllites to decay faster than the orbital prediction model. A plot of the orbital decay history for the Aprize satellites calculated using the NASA Debris Assessment Software is shown in Figure 7.

b. Maneuvering to a storage orbit: Not Applicable

c. Direct Retrieval: Not Applicable

4.2 *Tether systems*. Not Applicable

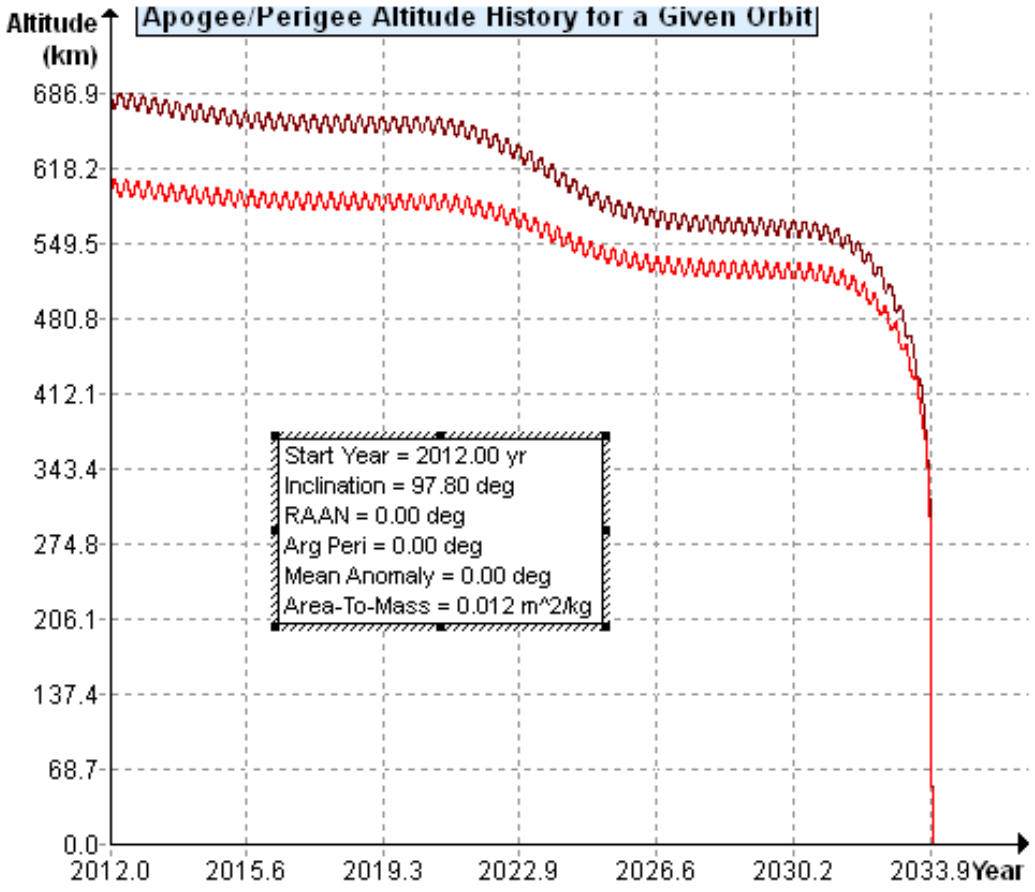

Figure 7. NASA DAS Predicts the Aprize Satellites Will Decay in About 22 years.

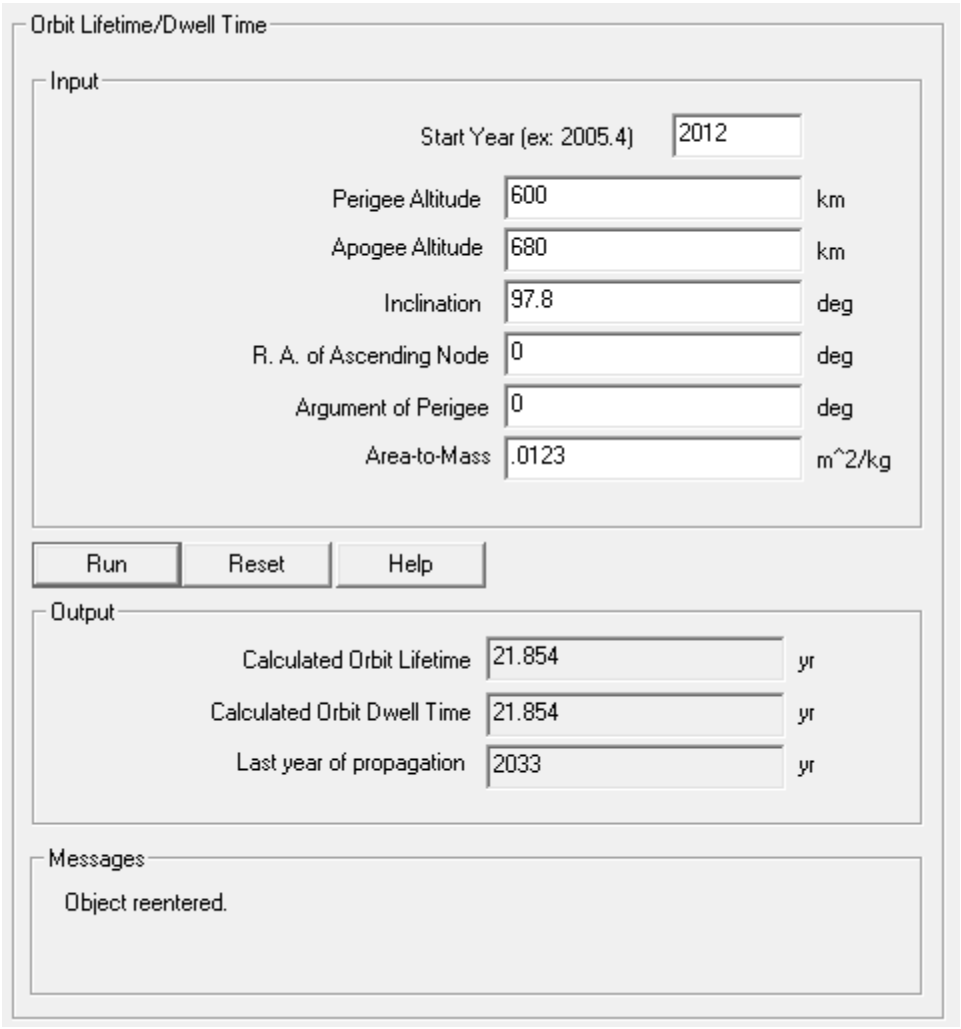

Figure 7. The Aprize satellites will decay and burn up in the atmosphere in less than 22 years.

Atmospheric reentry option: The requirement is that ***"If a space structure is to be disposed of by reentry into the Earth's atmosphere, the risk of human casualty will be less than 1 in 10,000."***

According to the calculations made with the NASA Debris Assessment Software there will be no risk of human casuality as the small spacecraft will completely disintegrate at an altitude of 58.2 km during re-entry. The results of these calculations are shown in Figure 8.

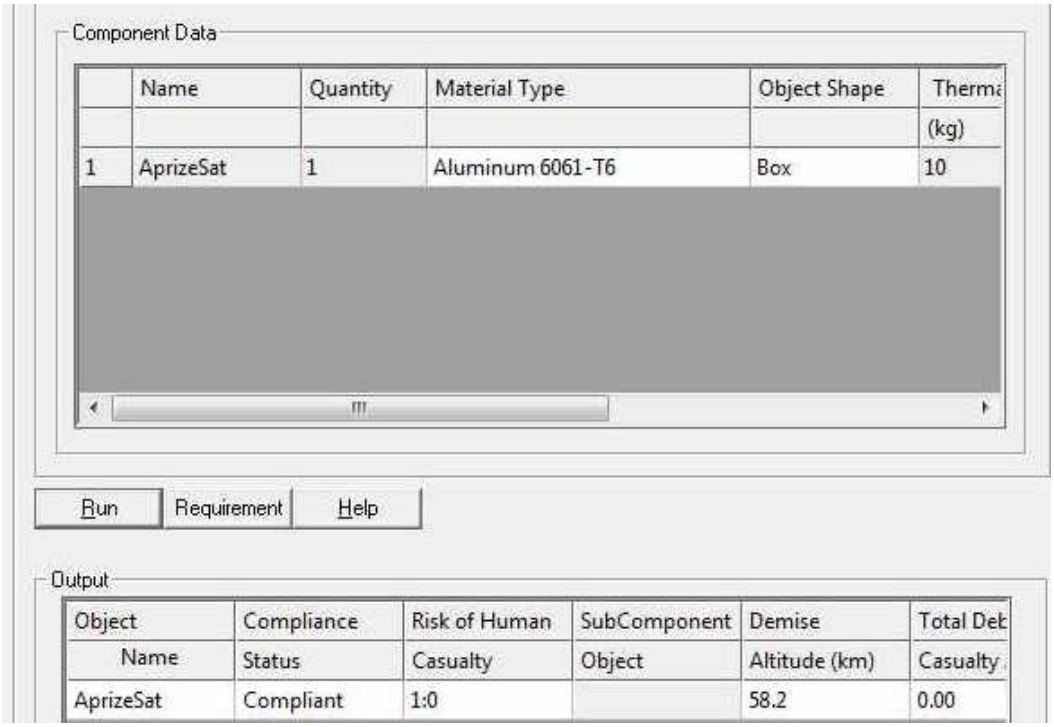

Figure 8. The AprizeSats Will Burn Up and Disintegrate at an Altitude of 58.2 km