



AeroCube

1

Drag Augmentation Study for the AeroCube-2 Mission

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Background

2

- The AeroCube-2 CubeSat will be launched with a variety of other satellites and CubeSats along with the primary payload, the EgyptSat satellite, on a Dnepr launch vehicle
- The Federal Communications Commission (FCC) requires that post-mission orbital lifetime for low Earth orbit satellites be less than 25 years
- AeroCube-2 by itself will not satisfy this requirement due to high altitude of the mission orbit
- Study objective
 - Determine size of drag augmentation device needed to achieve various target orbital lifetimes



Study Analysts

3

- **Alan Jenkin (Astrodynamics Department)**
 - Generation of cases for sizing of drag augmentation device
 - Analysis of atmospheric pressure on drag augmentation device and resulting unrigidized Mylar balloon motion
- **Brenda Eichel (Astrodynamics Department)**
 - Orbital decay propagations and lifetime analysis



Methodology

4

- **Used long-term orbit decay modeling code LIFETIME**
 - Developed by Aerospace (C.C. Chao)
 - MSISE-90 atmosphere model
 - Gravity model J_2 through J_3
- **Considered 5, 50, and 95 percentile level of solar flux (F10.7) and geomagnetic index (A_p)**
 - NOAA predictions for jettison epoch



Study Assumptions and Ground Rules

5

- **Launch on December 1, 2006**
- **Injection orbit:**
 - Apogee altitude: 803 km
 - Perigee altitude: 658.5 km
 - Inclination: 97.43 deg (taken from AeroCube-1 mission)
 - RAAN: 88.07 deg (taken from AeroCube-1 mission)
- **Aerocube-2 mass: 0.825 kg (taken from AeroCube-1)**
- **Assumed AeroCube-2 tumbles randomly during decay**
 - CubeSat with 10-cm side will have an average projected area of 150 cm²
- **Assumed drag augmentation device is approximately spherical**
 - Inflatable Mylar balloon inside Aluminum foil
 - Aluminum foil retains shape after balloon loses pressure



AeroCube-2 Orbital Lifetime Without Drag Augmentation

6

- 50-percentile (median) solar activity : 30.4 years
- 95-percentile (extreme high) solar activity : 14.9 years
- 5-percentile (extreme low) solar activity: 107 years
- Based on 50-percentile result, FCC requirement is not met



Balloon Diameter for Specific Orbital Lifetimes

7

- 50-percentile solar cycle case

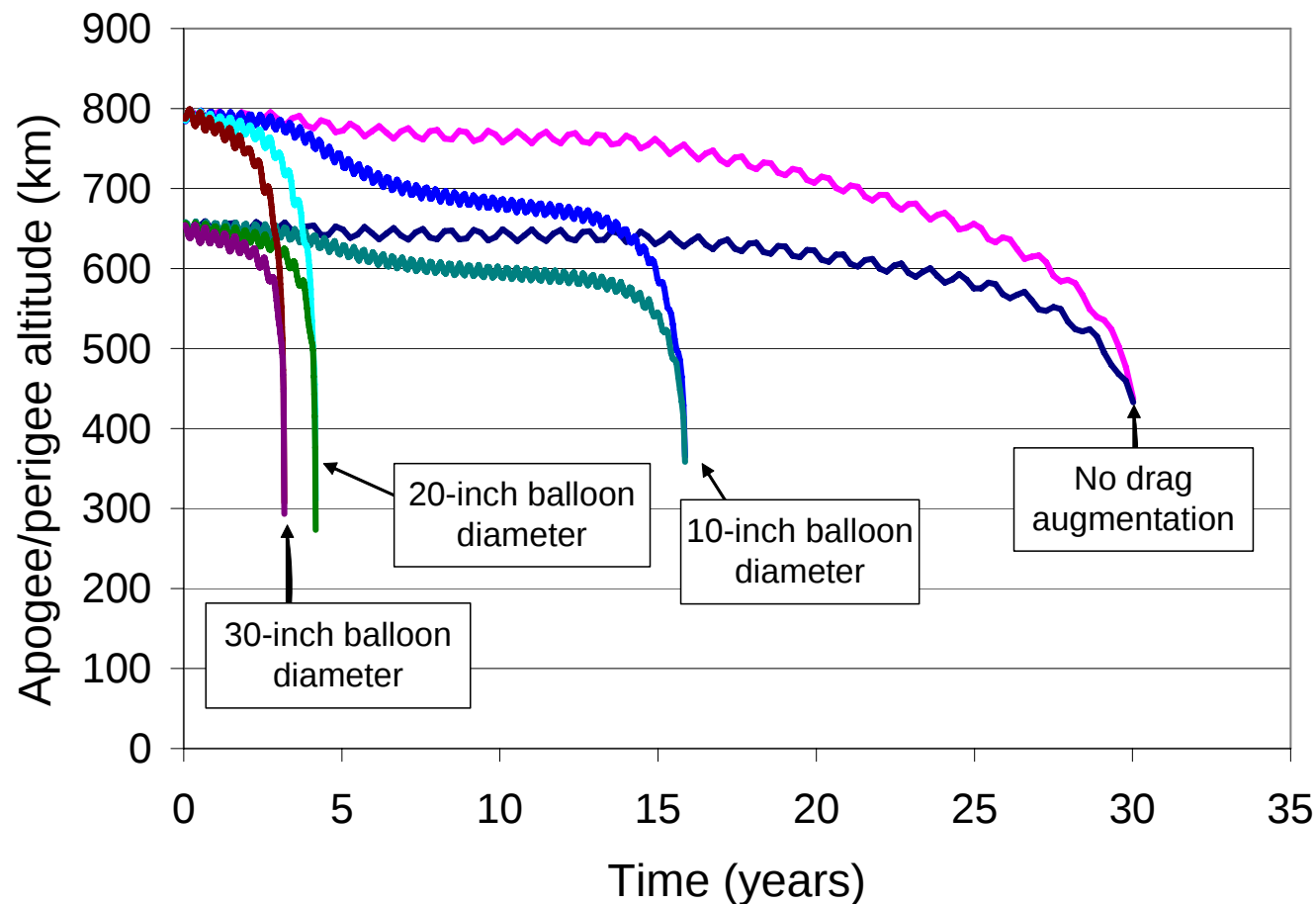
Orbital lifetime	Projected cross-sectional area	Balloon diameter	
		cm	in
Years	cm ²		
25	208.5	16.3	6.4
20	295.5	19.4	7.6
10	754.1	31.0	12.2
5	1307.0	40.8	16.1



Altitude Decay of AeroCube-2 With Drag Augmentation (50-percentile case)

8

- Plot shows decay profile for 10, 20, and 30-inch diameter balloons (50-percentile solar cycle case)





Conclusions

9

- A drag augmentation device with a spherical diameter of 10 inches or higher will adequately reduce orbital lifetime to meet the FCC requirement as long as the balloon remains effective (does not collapse or separate) for a sufficiently long time
- A 30-inch diameter is recommended for a drag augmentation device that is expected to survive two years or longer