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AeroCube 5/Peas Lifetime Analysis

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Background

- AeroCube 5 will deploy small brass tubes called “Peas” from its pea placer device as part of the mission.
- At the request of David Hinkley (Mechanics Research Office), a long-term orbit evolution analysis was performed.
- The analysis provided in this report will determine the lifetime of these Pea tubes as ejected from AeroCube 5 and will determine compliance with U.S. Debris Mitigation Standard Practice requirement of an on-orbit lifetime less than 25 years.

Long-Term Orbit Propagation Tools

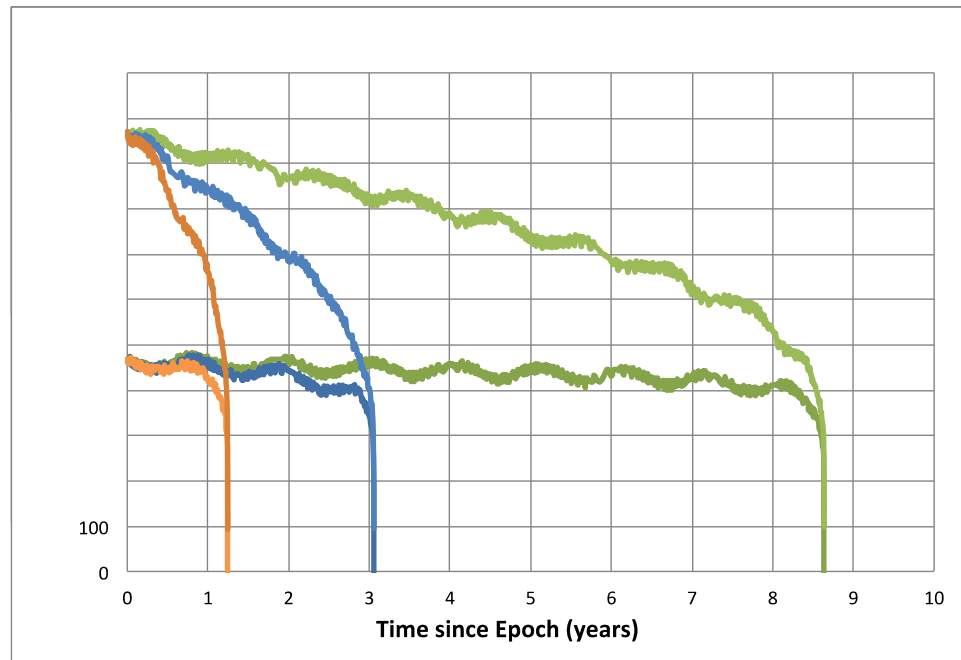
- Used precision integration code TRACE for orbit propagations
 - *Developed by Aerospace (TRACE is used throughout the industry, but we used the most recent Aerospace version)*
 - *MSISE-86 atmosphere model*
 - *70 x 70 modified EGM-96 Earth gravity model*
 - *Sun and Moon gravity*
 - *Solar radiation pressure (assumed reflectivity coefficient = 1.3)*
- The Pea tubes are assumed to be ejected soon after Aerocube 5 deployment from the launch vehicle.

Peas Initial Conditions

- Area estimation:
 - *Pea tube (assuming tumble) area = $1.007e-4 \text{ m}^2$*
- Mass estimate: 1.25 grams
- Atmospheric Assumption: Considered 5th, 50th, 95th percentile levels of solar flux ($F_{10.7}$) and geomagnetic index (A_p)
 - *Used NASA Marshall Space Flight Center monthly predictions (based on NOAA data) from January 2012 to 2030; for years after 2030, repeated last 11-years (2019-2030) of Marshall predicted data*
- Initial orbit (provided by David Hinkley)
 - *469 x 972 km perigee/apogee altitude, 120° Inclination, Epoch: December 1, 2013*
- Ejection velocity of the pea tubes at 1.2 m/s is considered negligible compared to the orbital velocity of spacecraft.

Lifetime: Pea tube

- The 5th, 50th, 95th percentile atmospheric profiles were used to determine the orbit lifetime
- The pea tube “nominal” 50th percentile lifetime is ~3.1 years
 - *This result is bounded by lifetimes of 1.2 and 8.6 years with high (95th) and low (5th) atmospheric profile assumptions.*
- The pea tube de-orbited within 25 years after launch for all three solar cycle cases



Conclusions

- The Peas tube that is ejected from the AeroCube 5 satellite has an orbital lifetime of ~3.1 years in a “nominal” 50th percentile atmosphere.
 - *The bounding cases of 95th or 5th percentile atmospheric profiles produce lifetimes of ~1.2 and 8.6 years.*
- All cases comply with U.S. Debris Mitigation Standard Practice requirement of an on-orbit lifetime less than 25 years