Aerocube 3
Lifetime Analysis

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Background

- **The analysis provided in this report will determine if the Aerocube 3 mission orbit is compliant with U.S. Debris Mitigation Standard Practice of an on-orbit lifetime less than 25 years**
  - **If the orbit lifetime is greater than 25 years, then a drag device will need to be incorporated**

- **At the request of Dave Hinkley (Mechanics Research Office), a long-term orbit evolution analysis was performed**

Long-Term Orbit Propagation Tool

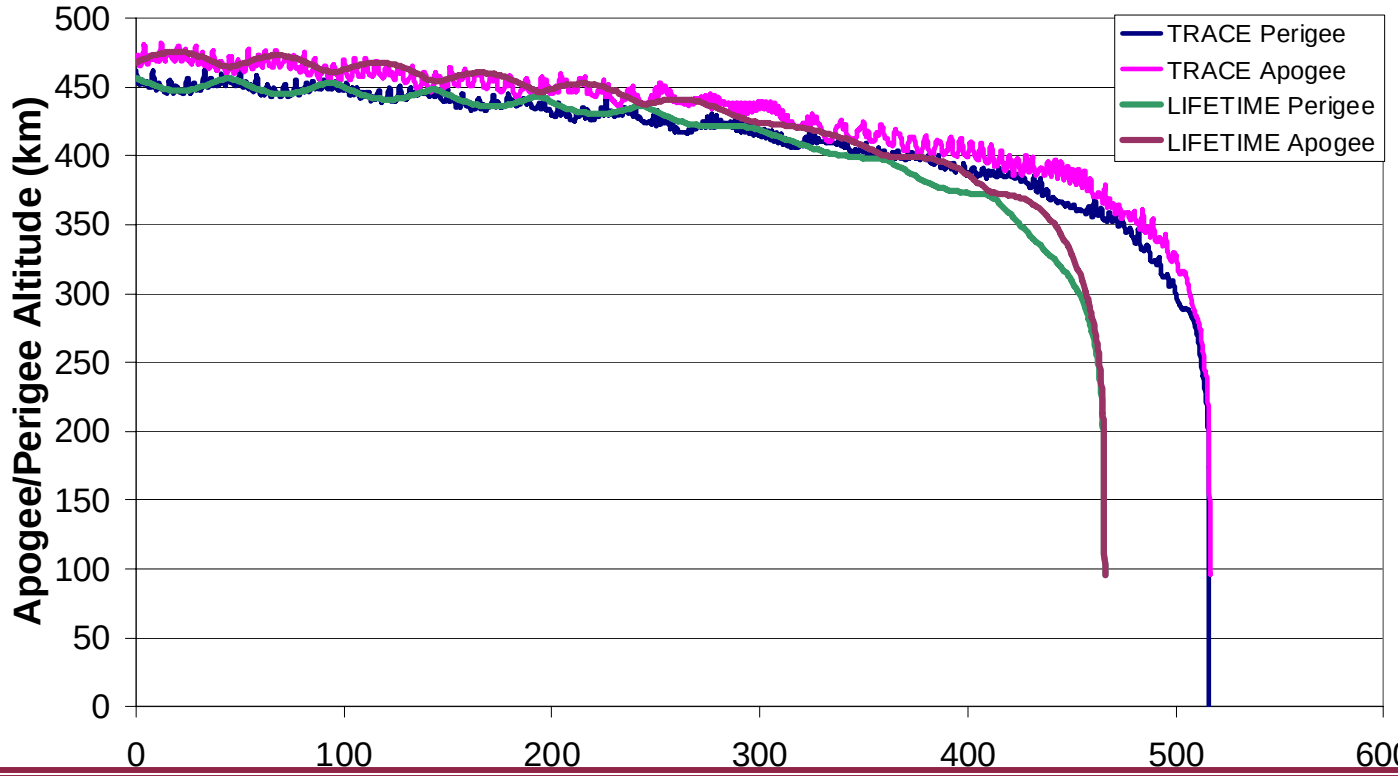
- Used two independent tools for verification of results: LIFETIME 6.0 and TRACE
- LIFETIME 6.0: Low Altitude Orbit Decay and Maintenance (developed by George Chao)
  - MSISE-00 atmosphere model
  - J3-J4 Earth gravity model
  - Sun and moon gravity
  - Solar radiation pressure
- Precision integration code TRACE (used to verify select LIFETIME runs)
  - Developed by Aerospace (TRACE is used throughout the industry, but we used the most recent Aerospace version)
  - MSISE-86 atmosphere model
  - 16 x 16 modified WGS-84 Earth gravity model
  - Sun and Moon gravity
  - Solar radiation pressure (assumed reflectivity coefficient = 1.3)

Orbit Propagation Inputs

- Area and mass estimation
  - Mass: 0.825 kg
  - CubeSat 10 cm on each side, assumed tumbling
  - Also considered a drag enhancement device: a 1-meter diameter balloon
- Considered 95, 50, and 5 percentile levels of solar flux (F10.7) and geomagnetic index (Ap)
  - For LIFETIME, used NASA Marshall Space Flight Center monthly predictions released March 2008 (based on NOAA data)
  - For TRACE, used NASA Marshall Space Flight Center predictions every 3 months due to program restrictions for long-term propagation.
- AeroCube 3 orbit was taken from TACSAT-3 launch trajectory supplied by Orbital Sciences Corporation
  - Taken from DEPLY_CTD event
  - Steve Hast provided conversion to classical orbital elements in ECI

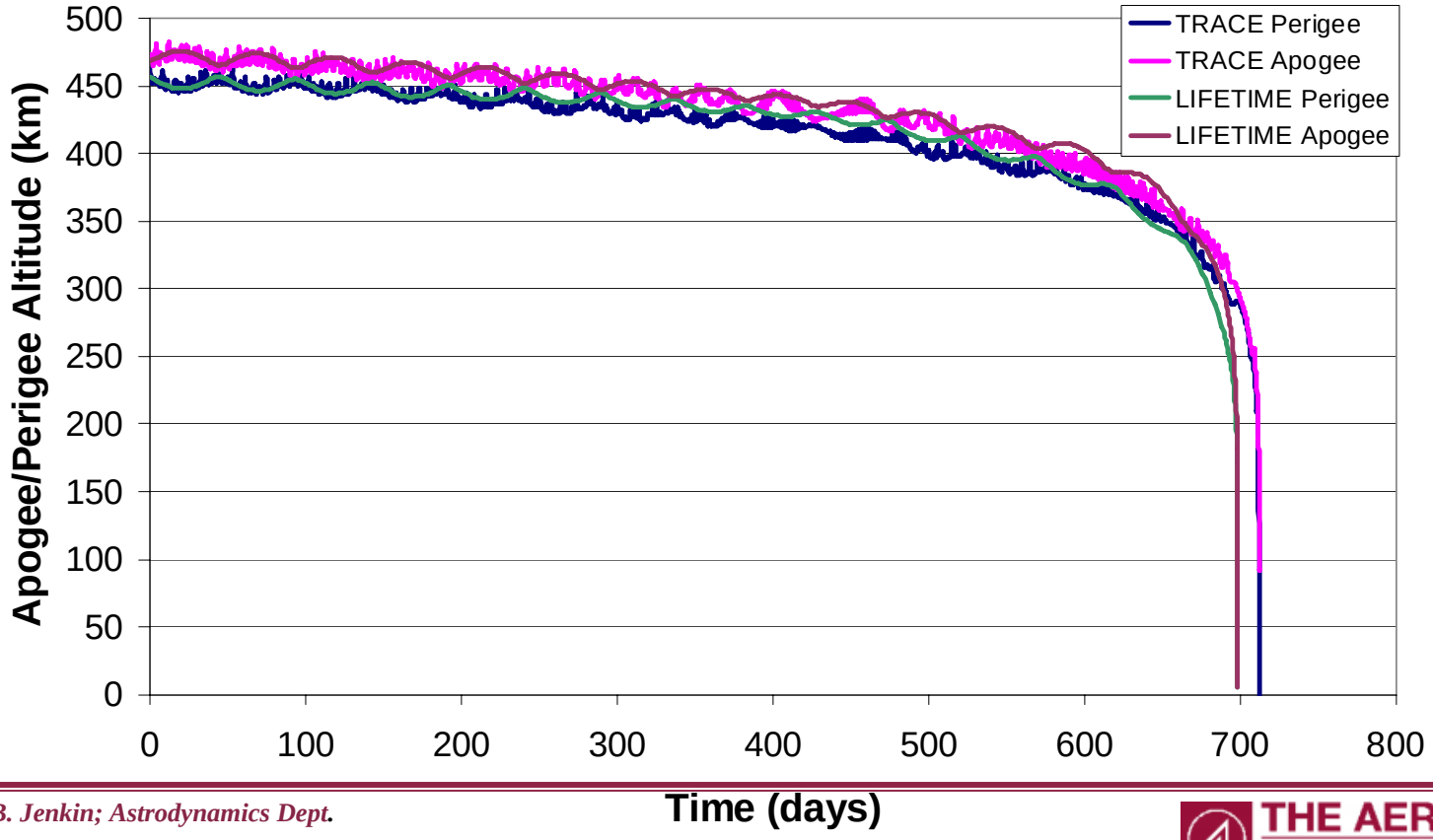
Aerocube 3 (no balloon)
Orbit Lifetime 95th Percentile

- With an 95th percentile atmosphere assumption (high solar activity), the orbit lifetime shown in TRACE and LIFETIME differ a bit due to the 3 month gap in atmospheric predictions in TRACE where LIFETIME is modeling the fluctuations every month. The result is a longer orbit lifetime prediction by TRACE . In this case, the LIFETIME prediction should be more accurate.
- LIFETIME = 465 days of orbit life
- TRACE = 516 days of orbit life



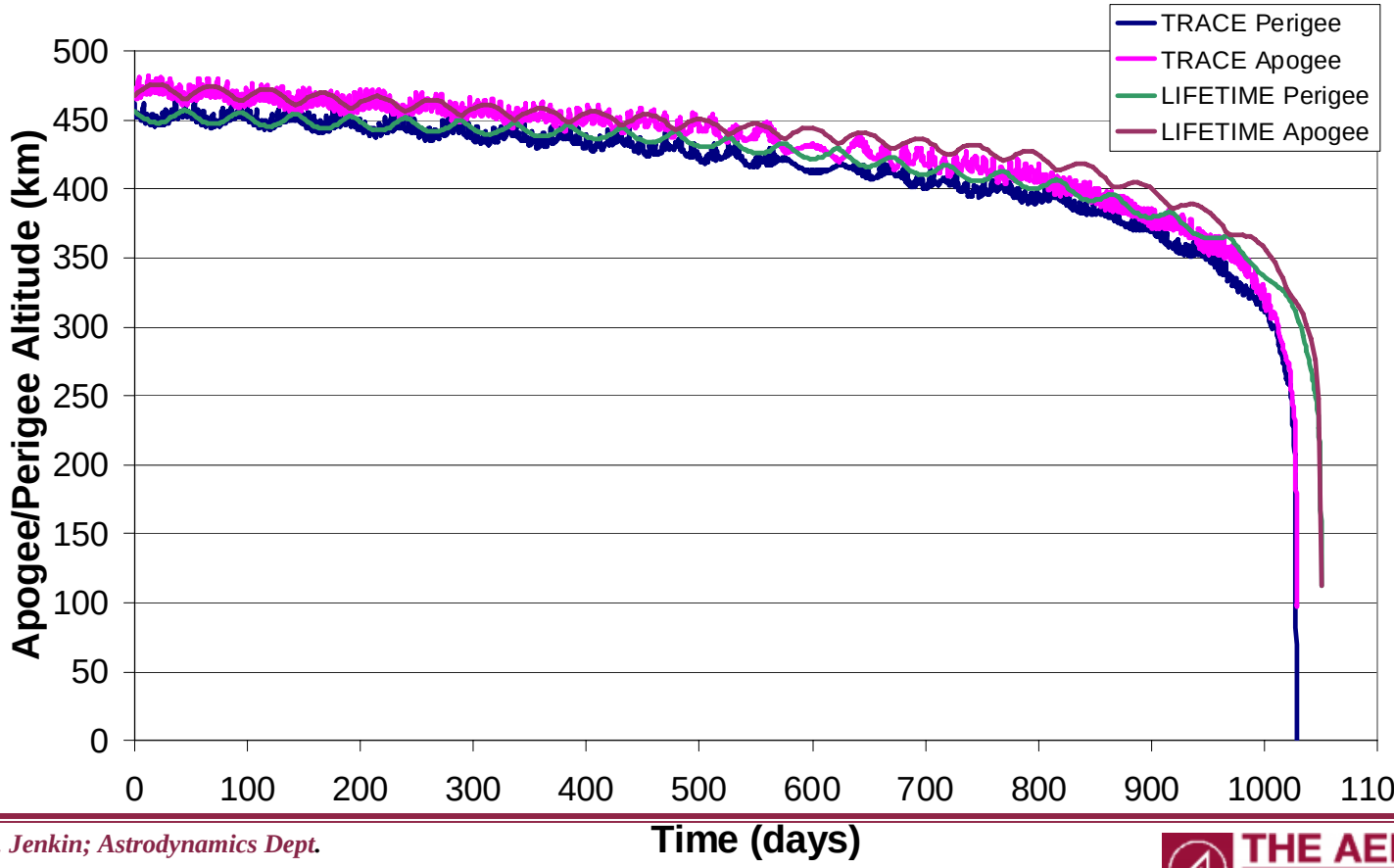
Aerocube 3 (no balloon)
Orbit Lifetime 50th Percentile

- For a 50th percentile atmosphere assumption. TRACE and LIFETIME agree quite well because the fluctuation in solar activity from month to month is not as large as the 95th percentile.
- LIFETIME = 698 days of orbit life
- TRACE = 712 days of orbit life



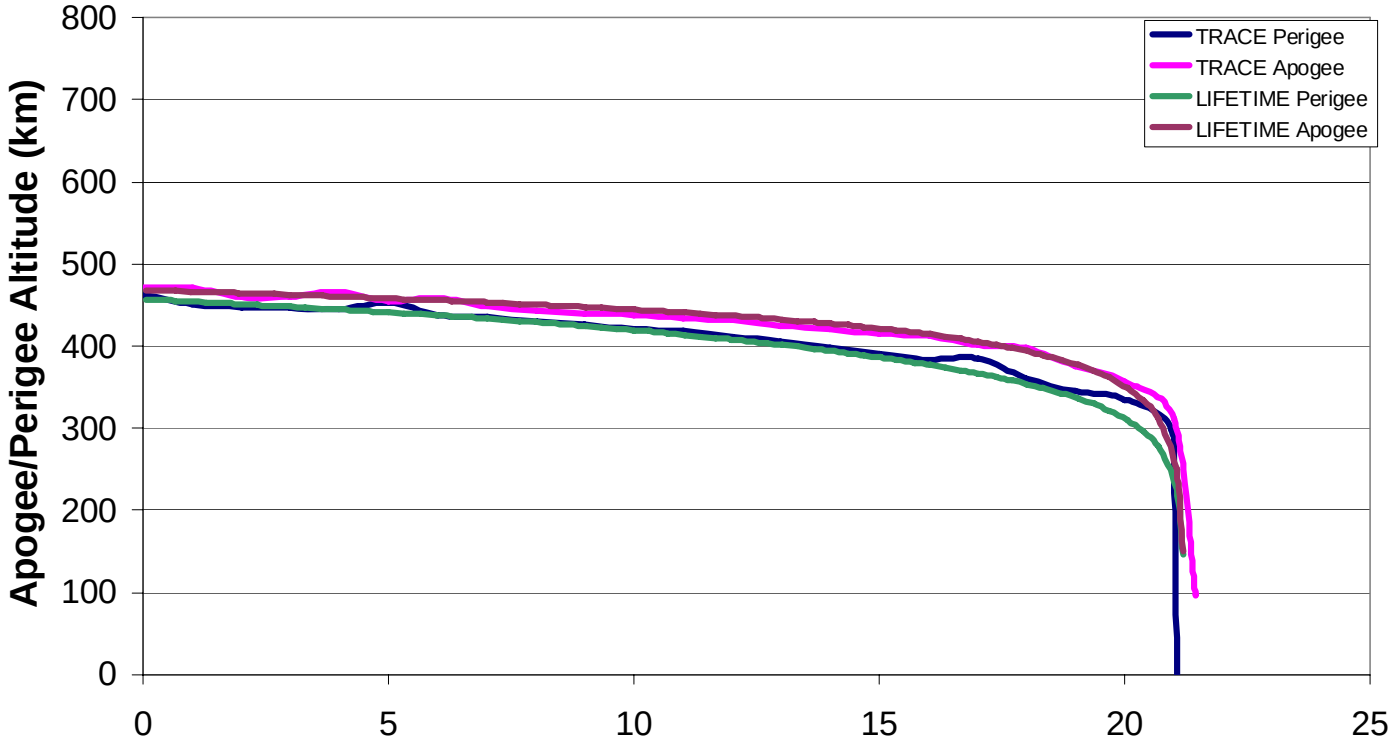
Aerocube 3 (no balloon)
Orbit Lifetime 5th Percentile

- For a 5th percentile atmosphere assumption. TRACE and LIFETIME agree quite well because of the low fluctuation in solar activity.
- LIFETIME = 1051 days of orbit life
- TRACE = 1028 days of orbit life



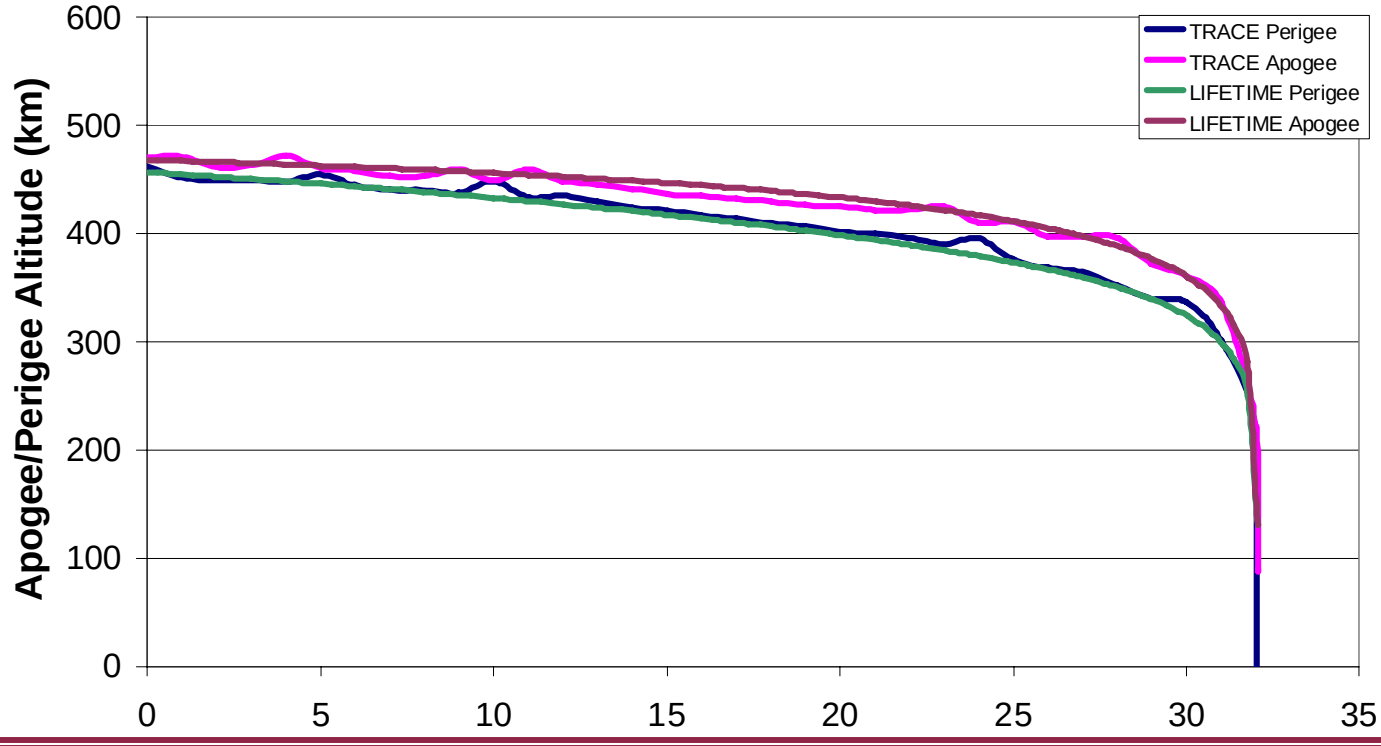
Aerocube 3 w/Balloon Deployed
Orbit Lifetime 95th Percentile

- For a 95th percentile atmosphere assumption. TRACE and LIFETIME agree quite well because the time is short enough to more accurately model the solar activity.
- With the balloon deployed, the orbit lifetime is dramatically decreased compared to the non-deployment.
- LIFETIME = 21.1 days of orbit life
- TRACE = 21.4 days of orbit life



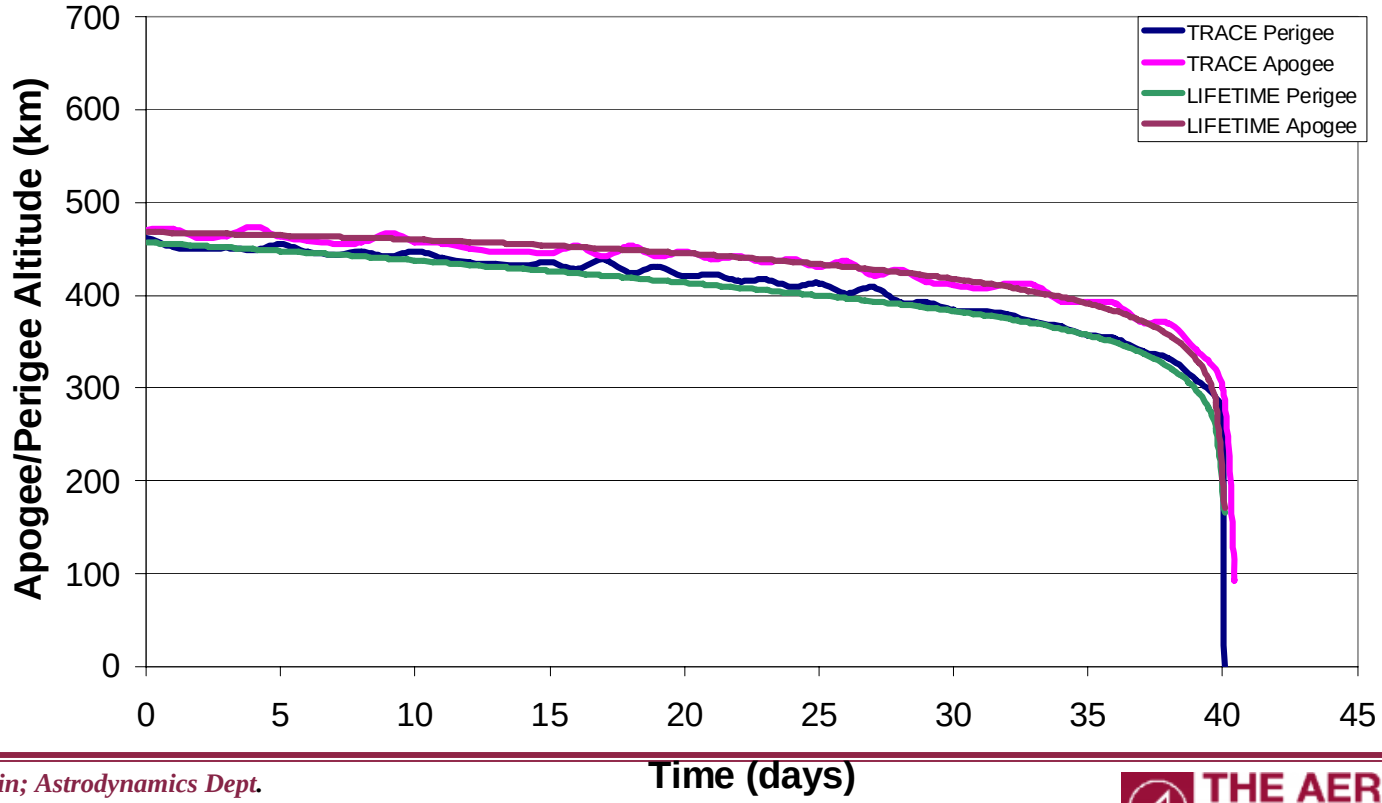
Aerocube 3 w/Balloon Deployed
Orbit Lifetime 50th Percentile

- For a 50th percentile atmosphere assumption. The balloon will help decay the satellite in a little over a month.
- LIFETIME = 32.1 days of orbit life
- TRACE = 32.1 days of orbit life



Aerocube 3 w/Balloon Deployed Orbit Lifetime 5th Percentile

- For a 50th percentile atmosphere assumption. The balloon still decays the satellite in a little over a month.
- LIFETIME = 40.1 days of orbit life
- TRACE = 40.4 days of orbit life



Conclusions

- **The Aerocube 3 satellite is predicted to remain on-orbit until the end of 2009 at the earliest to mid-year of 2011 at the latest.**
  - **This complies with U.S. Debris Mitigation Standard Practice of an on-orbit lifetime less than 25 years.**
  - **The Aerocube 3 mission will be approaching solar max in 2011**
  - **A drag device will not be needed for this mission in terms of meeting U.S. Debris Mitigation Guidelines.**
- **If a drag device such a balloon is deployed, this will dramatically decrease the orbit lifetime from hundreds of days to about one month in time.**
- **LIFETIME and TRACE results agree fairly well**

Cases:	LIFETIME	TRACE
Orbit Lifetime (days) 95 Percentile	465	516
Orbit Lifetime (days) 50 Percentile	698	712
Orbit Lifetime (days) 5 Percentile	1051	1028
Orbit Lifetime (days) 95 Percentile w/Balloon	21	21
Orbit Lifetime (days) 50 Percentile w/Balloon	32	32
Orbit Lifetime (days) 5 Percentile w/Balloon	40	40