National Aeronautics and Space Administration
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Extending the Mission, but Meeting the Disposal Requirement

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Orbital Debris Limitation

To limit the chance that an Earth-orbiting spacecraft will generate orbital debris, NASA requires that a spacecraft in low Earth orbit (LEO)

- Must reenter Earth's atmosphere within 25 years of end of mission,
- Cannot remain in LEO for more than 30 years.

Orbital Debris Limitation

NASA-Standard 8714.19

Requirement 4.6-1.

Disposal for space structures in or passing through LEO:

"Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch"

Orbital Debris Limitation

Question from the flight project:

How long can we do an extended mission and still have enough propellant to comply with the disposal requirements?

Case Study: CloudSat

Orbit: ~700 km alt.; 98 deg inclination

Launched April 28, 2006

30 year requirement => reentry by April 2036

Mission length to date is more than 5 years,

=> Decay lifetime must be less than 25 years.

Case Study: CloudSat

Estimated fuel & fuel budget for operations:

Delta V =98 m/s as of June 2013

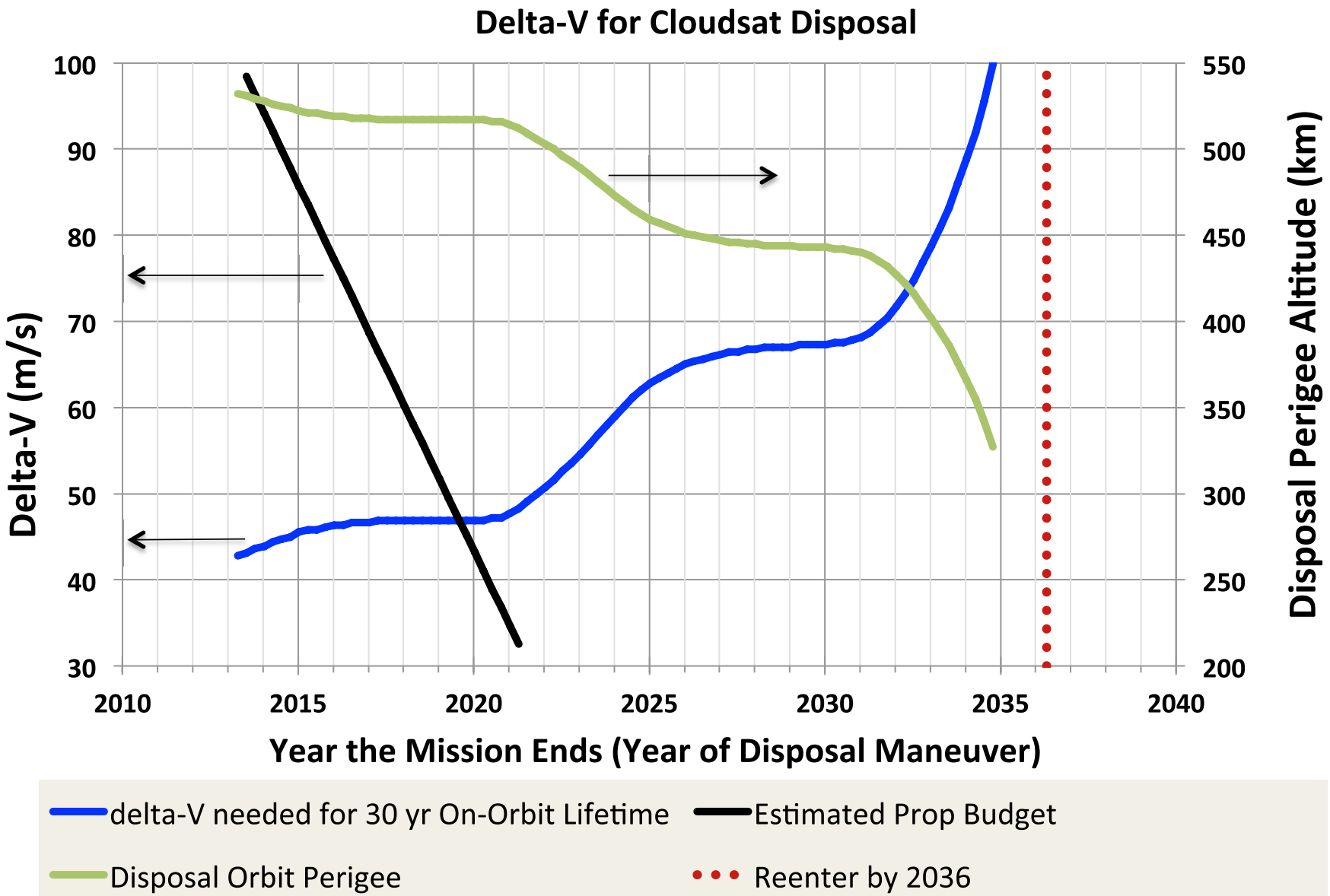
8.5 m/s per year for operations

A mission extension requires more fuel for two reasons:

More used for operations;

More needed for disposal, to shorten decay time.

Case Study: CloudSat



Case Study: CloudSat

Procedure

Plot was generated from results of Debris Analysis Software (DAS) tool.
http://orbitaldebris.jsc.nasa.gov/mitigate/das.html

Procedure utilizes DAS "Science and Engineering Utilities" to determine disposal perigees and corresponding delta-V values.

First, use "Orbit Lifetime/Dwell Time" utility:
Populate input boxes with orbit information.
"Year" (date of disposal) and "Perigee" (of disposal orbit) will be varied.

Case Study: CloudSat

Procedure (continued)

The disposal date and the launch date determine the maximum allowable decay lifetime:
“Reentry Date” = “Launch Date” + 30 yr
“Max Decay Lifetime” = “Reentry Date” - “Disposal Date”.

For each of several future dates, run the utility for different Perigees until you find the Perigee at which the decay orbit closely matches the required “Max Decay Lifetime”.

Case Study: CloudSat

Procedure (continued)

Generate a Table such as this:

Disposal Date (year.fraction)	Max Decay Lifetime (years)	Disposal Perigee (km)	De-orbit Time for given Perigee (years)
2013.30	23	532	22.9
2013.55	22.75	531	22.7
2013.80	22.5	529	22.4
2014.05	22.25	528	22.2
2014.3	22	526	21.9
2014.55	21.75	525	21.7
…	…	…	…
2034.30	2	355	2.0
2034.55	1.75	342	1.7
2034.80	1.5	327	1.5
2035.05	1.25	311	1.2
2035.30	1	292	0.98

Case Study: CloudSat

Procedure (continued)

Now use "Delta-V for Orbit-to-Orbit Transfer" from Science and Engineering Utilities to determine the delta-V that is needed in order to reach the required disposal Perigee from the initial orbit.

Plot the results as in Slide 7, adding estimate of fuel as a function of time.