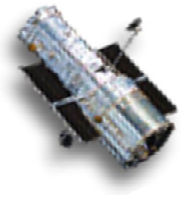
Hubble Facts



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HST Orbit Decay and Shuttle Re-boost

Orbit decay predictions for the Hubble Space Telescope spacecraft are performed on a continuous basis by Flight Dynamics. Daily orbit altitude determinations and short-term decay predictions are used to support daily operations planning and servicing mission planning. Long-term decay predictions are used to support lifetime strategy planning. Currently, orbit decay predictions are made with the Goddard Trajectory Determination System that uses the Jacchia-Roberts atmospheric model and Dr. Kenneth Schatten's solar flux predictions from November 2002. All contributing combinations of solar flux strength and timing are run in order to bound the orbit decay predictions from a nominal "kind" atmosphere (nominal solar cycle timing, mean solar flux) to a worst case "unkind" atmosphere (nominal timing, +2 sigma high flux). Orbit decay predictions have also examined the effects of Shuttle re-boost on the ability to maintain HST above the science operations floor. HST will start to encounter longer solar array slew times and degraded science approximately one year before re-entry due to the increase in atmospheric density overwhelming the control authority of the spacecraft. With no re-boost on SM4, HST could re-enter during late 2013 under worst-case conditions, while a re-boost of at least 10 nautical miles (nm) occurring in the 2009 timeframe would sustain the observatory orbit past the year 2020.

HST is currently (7/03) at an altitude of 307 nm and is flying through the down-slope of solar cycle 23. HST will continue to fly through this relatively benign solar flux activity until the year 2008, when the flux is expected to begin increased activity of solar cycle 24. HST's altitude will only decrease about 2-3 nm by the time of Servicing Mission 4 (SM4) in May of 2005.

With an "unkind" atmosphere and no re-boost on SM4, HST would re-enter the Earth's atmosphere late in 2013. Both predictions and flight experience (Tables 1 and 2) confirm that while Shuttle re-boosting during benign periods of solar activity helps prolong orbit decay by approximately 1-2 years, the most significant benefit from re-boost is derived by performing the re-boost during the cycle's climb to its peak activity where re-entry can be prolonged up to an entire decade. A re-boost of 4 nm during SM4 for this "unkind atmosphere" case would forestall re-entry by 2 years, while an additional re-boost of 10 nm in 2009 would prolong HST's orbital lifetime until 2021. This is further illustrated by observing that a 10 nm re-boost in 2009 would prolong re-entry until mid-2020 with no re-boost during SM4.

A nominal atmosphere with no re-boost on SM4 shows re-entry occurring very late in 2022. The same 4/10 nm re-boost case mentioned previously would prolong re-entry

until the year 2032 for nominal solar cycles 24 and 25.

Table 1 - HST Re-boost History

Mission	Date	Capture Altitude (nm)	Release Altitude (nm)	Re-boost (nm)	Solar Cycle Phase	Time to Next Re-boost	Altitude at Next Capture
Deploy	Apr. 1990	n/a	331.6	n/a	Solar Cycle 22 maximum	44 months	316.8
SM1	Dec. 1993	316.8	321.1	3.8	Solar Cycle 22 downside	38 months	319.7
SM2	Feb. 1997	319.7	327.8	8.6	Solar Cycle 23 minimum	61 months	323.5
SM3A	Dec. 1999	323.5	323.1	n/a	Solar Cycle 23 upside	27 months	312.7
SM3B	Mar. 2002	309.3	312.7	3.4	Solar Cycle 23 maximum		

Table 2 - HST Orbit Decay Prediction Runs

Run No.	Solar Cycle 24		Solar Cycle 25		Re-boost		Reentry
	Timing	Solar Flux	Timing	Solar Flux	Amount (nm)	Date	Date
1	Early	High (+2 sigma)	Early	Mean	0		03/27/2014
2	Early	High (+2 sigma)	Early	Mean	10	01/01/09	05/10/2020
3	Early	High (+2 sigma)	Early	Mean	4 10	06/01/05 01/01/09	07/26/2021
4	Nominal	High (+2 sigma)	Nominal	Mean	0		12/14/2013
5	Nominal	High (+2 sigma)	Nominal	Mean	4	06/01/05	12/02/2015
6	Nominal	High (+2 sigma)	Nominal	Mean	10	01/01/09	06/18/2020
7	Nominal	High (+2 sigma)	Nominal	Mean	4 10	06/01/05 01/01/09	11/15/2021
8	Nominal	Mean	Nominal	Mean	0		12/29/2022
9	Nominal	Mean	Nominal	Mean	4	06/01/05	04/03/2024
10	Nominal	Mean	Nominal	Mean	4 10	06/01/05 01/01/09	03/22/2032
11	Nominal	Mean	Nominal	High (+2 sigma)	0		10/24/2020
12	Nominal	Mean	Nominal	High (+2 sigma)	10	01/01/09	10/06/2021

Notes:
(1) All runs made with the Goddard Trajectory Determination System (GTDS)
(2) All runs used the Jacchia-Roberts atmospheric model
(3) All runs used Dr. Kenneth Schatten's November 2002 Solar Flux Predictions
(4) All runs used a mass of 11063.1 kg, an area of 69.975 m^{**2}, a Coefficient of Drag of 2.47, and Coefficient of Reflectivity of 1.5
(5) All runs used the Brouwer mean elements from June 22, 2003 at 00:00:00 GMT as the starting vector