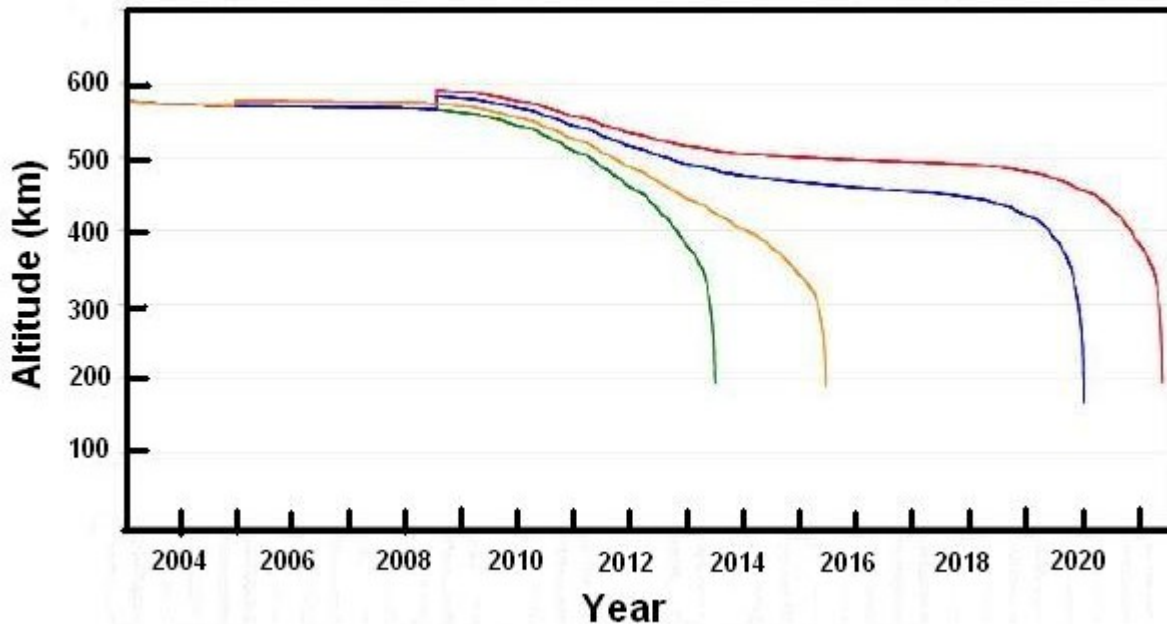


Satellite Drag and the Hubble Space Telescope

The Hubble Space Telescope was never designed to operate forever. What to do with the observatory remains a challenge for NASA once its scientific mission is completed in ca 2012. Originally, a Space Shuttle was proposed to safely return it to Earth, where it would be given to the National Air and Space Museum in Washington DC. Unfortunately, after the last Servicing Mission, STS-125, scheduled for May, 2009, no further Shuttle visits are planned. In time, the HST orbit will decay, and the satellite will burn up in the atmosphere. The predictions for when this will happen depend on the just how intense the next sunspot cycle will be between 2009-2018. As solar activity increases, the upper atmosphere heats up and expands, causing greater friction for low-orbiting satellites like HST, and a more rapid re-entry. The curves show four re-entry scenarios. Green is with no re-boosts at all. Brown is with one, 5-km re-boost in 2004. Blue is with one re-boost in 2009 by 18-km; Red is with one 5-km re boost in 2005 and one 18-km re-boost in 2009.



Problem 1 – The last Servicing Mission in 2009 will only extend the science operations by another 5 years. Which scenario keeps the HST operating just long enough to support the science goals?

Problem 2 – Once HST reaches an altitude of 400 km, with no re-boosts, about how many weeks will remain before the satellite burns up? (Hint: Use a millimeter ruler.)

Problem 1 – The last Servicing Mission in 2009 will only extend the science operations by another 5 years. Which scenario keeps the HST operating just long enough to support the science goals?

Answer: The Servicing Mission will occur in 2009. The upgrades and gyro repairs will extend the satellite's operations by 5 more years, so if it re-enters after 2014 it will have maximized its usefulness. This occurs in the scenario where there is only one re-boost in 2004 and none in 2009, which is the brown curve.

Problem 2 – Once HST reaches an altitude of 400 km, with no re-boosts, about how many weeks will remain before the satellite burns up? (Hint: Use a millimeter ruler.)

Answer: Use a millimeter ruler to determine the scale of the horizontal axis in weeks per millimeter. For the green curve, mark the point on the curve that corresponds to a vertical value of 400 km. Draw a line to the horizontal axis and measure its distance from 2013 in millimeters. Convert this to weeks using the scale factor you calculated.

"HST science lifetime could potentially be limited by HST spacecraft orbital decay. Long-term orbit decay predictions are developed based on atmospheric models and solar flux predictions. All contributing combinations of solar flux strength and timing are run in order to bound the orbit decay predictions from a best case atmosphere to a worst case ("unkind") atmosphere. The predictions also consider the effects of Space Shuttle re-boost during HST Servicing Missions. The figure shows the model results for a worst case, 2-sigma high solar cycle (Cycle 24), followed by an early Cycle 25 of average intensity. Figure 3 depicts four curves for various shuttle re-boost scenarios. For the case of no further HST re-boost in any future servicing mission, the prediction is that HST will reenter the Earth's atmosphere in late 2013 or early 2014. The HST science program will cease approximately one year prior to re-entry due to loss of the precise attitude control capability required for science observing, as the atmospheric drag increases. The earliest expected end of the HST science program due to orbital decay is thus late 2012. Further information about this topic is contained in the accompanying Hubble Fact Sheet, entitled "HST Orbit Decay and Shuttle Re-boost." [From "Expected HST Science Lifetime after SM4", HST Program Office; July 21, 2003]