# Odyssey Mars Orbiter – Thirteen Years of On-Orbit Navigation

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The Odyssey spacecraft began the Mars mapping or science phase on February 19, 2002 and has continued until the present day. The initial orbit was short period (1.96 hours), low altitude (388 to 450 km), near polar (I = 93.1 deg) and sun-synchronous (3:55 pm/3:55 am at the equator crossings). The science instruments included a Thermal Emission Imaging System, a Gamma-Ray Spectrometer Suite and a Radiation Environment Detector. This paper will describe navigation analyses and results associated with the following topics.

A principal objective of the mission was to maintain the local mean solar time (LMST) within limits for science data acquisition and also for spacecraft health and safety. This variation, at the descending equator crossing, went from 3:45 pm during July-August 2009 and will reach 6:45 pm during November 2015. Small changes in the inclination were responsible as estimated from LMST-rate and nodal-rate changes. The largest inclination change was -0.56 deg due to a maneuver executed on September 30, 2008. The reasons for this variation and the corresponding local true solar time variation will also be discussed.

Odyssey was required to be overhead and serve as a relay link for Phoenix and Mars Science Laboratory during the critical minutes of their entry, descent and landing (EDL) on Mars. This could be accomplished by propulsive maneuvers but also by a technique called event time phasing. The latter utilized the velocity perturbations, usually several mm per sec, generated by spacecraft angular momentum desaturations. Using this method, Odyssey's arrival time for the Phoenix EDL was changed by 42 minutes resulting in a successful over-flight. The results of both over-flights will be described in detail.

During mapping, nine orbit trim maneuvers (OTM) were executed. The purpose, orbit parameter change, maneuver velocity, propellant required and accuracy achieved will be discussed. The next OTM is scheduled for mid-November 2015 and will maintain the LMST at 6:45 pm/6:45 am at the equator crossings. Science is particularly interested in acquiring data during the expected early morning fog, haze and clouds.

Trajectory prediction accuracy is a key objective for navigation and the mission. For Odyssey, the predicted time of descending equator crossing was the key parameter and the time intervals were 7 to 10 days and 56 days. The former was required for ephemeris utilization on-board the spacecraft and science observations. The latter was required for sequence-of-events development and operational usage. Representative errors are 0.1 second over 7 to 10 days and 20

seconds over 56 days. The major error source and effect of unexpected events, such as Odyssey entering safe mode, will be discussed.

Another interesting topic includes risk reduction associated with comet Siding Spring's Mars flyby on October 19, 2014. While Siding Spring's close approach was 135,000 km, particles and ions released along it's hyperbolic orbit represented a unique and potential risk to all orbiting spacecraft. Based on analysis conducted by cometary specialists, Odyssey was maneuvered to be behind Mars as seen from the expected intersection with the comet's tail and debris. More information on this event and collision avoidance with other orbiting spacecraft will be provided.