Primary Science Orbit Design for the Mars Reconnaissance Orbiter Mission

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Extended Abstract

In 2005 NASA will launch the Mars Reconnaissance Orbiter (MRO) towards the planet Mars. The primary objective of the MRO mission is to deliver a single spacecraft in orbit around Mars in order to perform remote sensing science observations, conduct site characterization for future potential landers, and provide telecom / navigation relay capability for follow-on missions.[i] After arrival at Mars in early 2006 and approximately six months of aerobraking, the orbiter will be delivered into the Primary Science Orbit (PSO) and will begin the collection of science data for the following two years.

In order to provide global access to Mars and to satisfy the science and mission objectives, a low altitude orbit at Mars is preferred for the MRO mission. The reference payload of the spacecraft consists of instruments involved in global mapping, regional investigations, and targeted investigations. Thus, an orbit with a groundtrack that repeats within one to two weeks to provide repeated targeting opportunities is desired. An orbit with a groundtrack that provides uniform global coverage over the course of the two-year science period for global mapping is desired as well.

The PSO is designed with these requirements in mind as well as additional spacecraft considerations such as atmospheric drag effects. The orbital elements for the PSO produce the following characteristics: a Sun-synchronous ascending node at 3:00 pm local mean solar time (daylight equatorial crossing); a periapsis altitude near 250 km; an apoapsis altitude near 320 km; a near-polar inclination of 92.66 degrees; a near circular mean eccentricity of 0.0087, which, along with an argument of periapsis of –90.0 degrees, results in a frozen orbit.[ii] The Sun-synchronous orientation provides observations of the Martian surface at nearly constant lighting conditions. This orientation is desirable because it removes any daily variations on the ground from seasonal variations. The exact semi-major axis of the PSO is chosen to be consistent with the desired short-term groundtrack repeat cycle, which maintains approximately 300 km separation on the surface every five to six days and repeats every 17 days with 100 km separation. The final separation between adjacent groundtracks after the full 349 Martian day (sol) repeat cycle is 5 km.

The frozen orbit condition of the PSO causes the periapsis location to remain stationary from orbit to orbit at –90 degrees, or nearly over the South Pole of Mars. With the periapsis location fixed, the altitudinal variation with latitude across the Martian surface resembles a flattened letter S in shape and is referred to as the 'S-curve'. The figures below show the spacecraft altitude variation with latitude throughout the two-year science period and the periapsis and apoapsis altitude variations as a function of time from a particular epoch.

This paper addresses the constraints, analysis, and design evolution of the MRO Primary Science Orbit. The discussion details the tradeoffs made to satisfy science objectives within the capability of the spacecraft and mission cost. Science objectives and the corresponding requirements levied on the orbit mission design are presented. Atmospheric effects on both the orbit itself and the spacecraft are discussed in terms of their impact on the final PSO selection. The decision rationale for the final selection of the orbital altitude and frozen orbit is also presented.

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[i] Halsell, C. Allen, and M.D. Johnston. *Mars Reconnaissance Orbiter Trajectory Characteristics Document*, p. 1-2. July 17, 2002.
[ii] Halsell, C. Allen, and M.D. Johnston. *Mars Reconnaissance Orbiter Trajectory Characteristics Document*, p. 6-1. July 17, 2002.

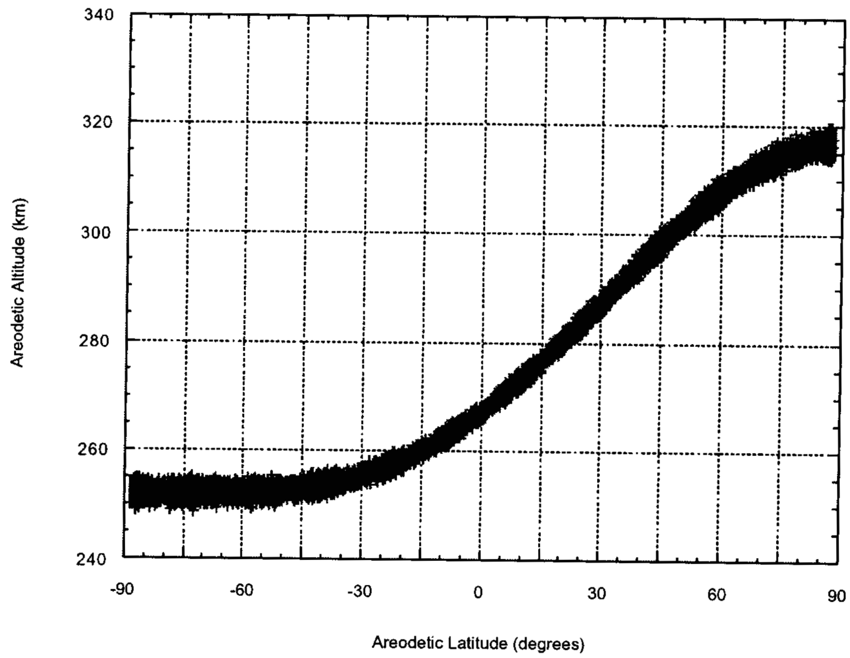

Figure 1: Altitude Variation with Martian Latitude

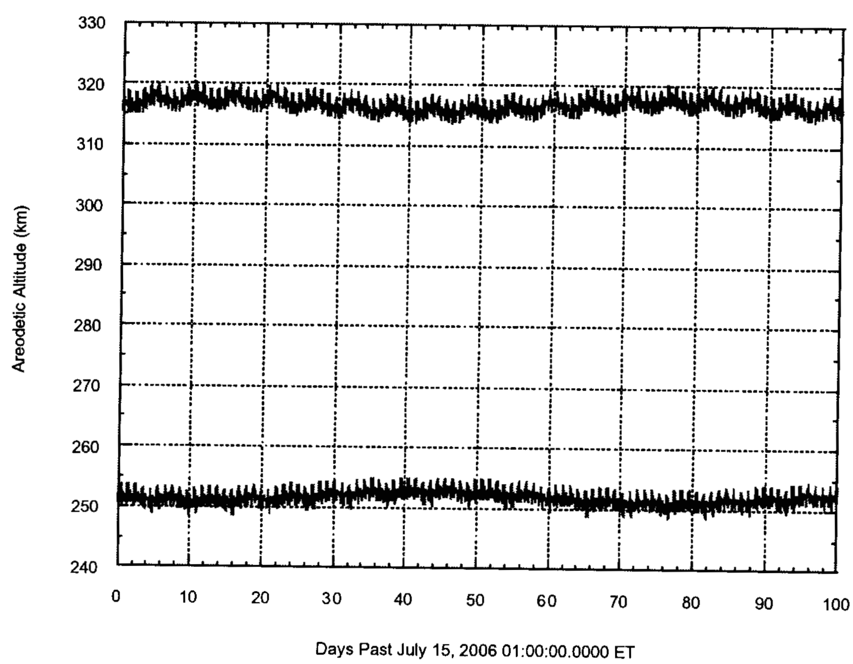

Figure 2: Periapsis and Apoapsis Altitudes

Condensed Abstract

This paper addresses the constraints, analysis, and design evolution of the Mars Reconnaissance Orbiter Primary Science Orbit. The discussion details the tradeoffs made to satisfy science objectives within the capability of the spacecraft and mission cost. Science objectives and the corresponding requirements levied on the orbit mission design are presented. Atmospheric effects on both the orbit itself and the spacecraft are discussed in terms of their impact on the final PSO selection. The decision rationale for the final selection of the orbital altitude and frozen orbit is also presented.