MARS GLOBAL SURVEYOR: MAPPING ORBIT EVOLUTION AND CONTROL THROUGHOUT ONE MARS YEAR

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This paper presents the evolution and control of Mars Global Surveyor's (MGS) mapping orbit throughout one Mars year of the primary mapping mission. MGS's orbit represents the first short period (117 minutes), low altitude (≈370 km at periapsis passage), circular (e=0.005), polar (I=93.0 deg), frozen-orbit (argument of periapsis =270 deg) and sun-synchronous (≈2:00 pm LMST at ascending equator crossing) orbiter of Mars. Topics to be presented include orbit evolution and control, perturbations especially due to the spacecraft's angular momentum desaturations, variation in the ground track walk pattern and the degree of non-uniformity in the ground tracks.

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This paper presents the evolution and control of Mars Global Surveyor's (MGS) mapping orbit throughout one Mars year of the primary mapping mission. Starting on 3/9/99, after the completion of the second phase of aerobraking (Ref. 1), this phase had a duration of 695 days or 8,505 orbits and ended on 2/1/01. The MGS orbit is the first short period, low altitude, circular, polar, frozen-orbit and sun-synchronous orbiter of Mars. Osculating orbital parameters at three epochs during the mapping phase are given in Table 1.

Table 1

ORBIT ELEMENTS DURING THE MAPPING PHASE

Element	Periapsis 1	Periapsis 4253	Periapsis 8505
Semi-major axis, km	3767.096	3765.622	3767.690
Eccentricity	0.00548	0.004995	0.005551
Inclination, deg	92.908	93.001	92.971
Arg of periapsis, deg	264.878	269.451	269.403
Long of ascend node, deg	7.971	189.526	11.775
Epoch, ET	03/09/99	02/19/00	01/31/01
Epoch, hr:min:sec	02:41:35	12:23:00	22:54:56
Period, minutes	117.0	116.9	117.0
Altitude, km	370.533	371.035	370.999
LMST, hr:min:sec	02:02:46	02:00:45	02:01:30

The two major effects influencing the orbit evolution are a) the gravity field of Mars and b) small, nearly instantaneous, velocity perturbations induced by the spacecraft's angular momentum desaturations (AMD). Because of the characteristics of this orbit, progressive and significant improvements were made to the model of Mars' gravity field. With respect to the velocity perturbations, their character was variable and complicated by thruster plume impingement on the spacecraft's high gain antenna (HGA). On average, the spin-axis AMDs occurred every 7.5 hours throughout the mission and generated a perturbation of several mm/sec along the X-axis of the spacecraft (Ref. 2). Their influence is clearly seen in the period and ground-track-walk (GTW) evolution.

Three orbit trim maneuvers (OTM) were executed during the first five months of mapping to adjust the GTW and refine the frozen orbit elements. Thereafter, no additional OTMs were executed because of the stability of the orbit and a wide tolerance accepted on the GTW variation. Table 2 provides a summary of each of the OTMs.

Table 2

MGS ORBIT TRIM MANEUVERS

Event/Parameter	OTM-1	OTM-2	OTM-3
Purpose	Adjust GTW and frozen orbit	Refine GTW	Refine GTW
Date, ET	05/07/99	06/10/99	08/11/99
Orbit	729	1144	1905
Delta-vel, m/s	3.54	0.181	0.373
Delta-hydrazine,kg	-1.19	-0.059	-0.12
Burn duration, s	93.5	5.3	11.1
True anomaly, deg	64.1	-84.0	-128.
Delta-GTW, km	29.*	25.	-22.
Delta-a, km	-0.45*	-0.42	0.39
Delta-period, s	-1.26*	-1.17	1.09

* Not achieved due to thruster plume impingement on the HGA.

Orbit element evolution over one Mars year is summarized in Figures 1-3. The state of the frozen-orbit (Ref. 3) is shown in Fig.1 and the osculating orbit period and GTW variation are given in Fig. 2 and Fig. 3 respectively. Fig. 4 gives the frequency distribution of longitudes at the descending equator crossings (DEQX). This distribution covers a band of 0-15 degrees in longitude with a resolution of 0.1 degree (i. e. 6 km spacing or bins). While the ground track spacings are fairly uniform some gaps in ground coverage are evident.

Mapping orbit element evolution, orbital perturbations especially due to AMDs, GTW variation and the resulting gaps in the ground tracks are some of the topics to be presented in this paper.

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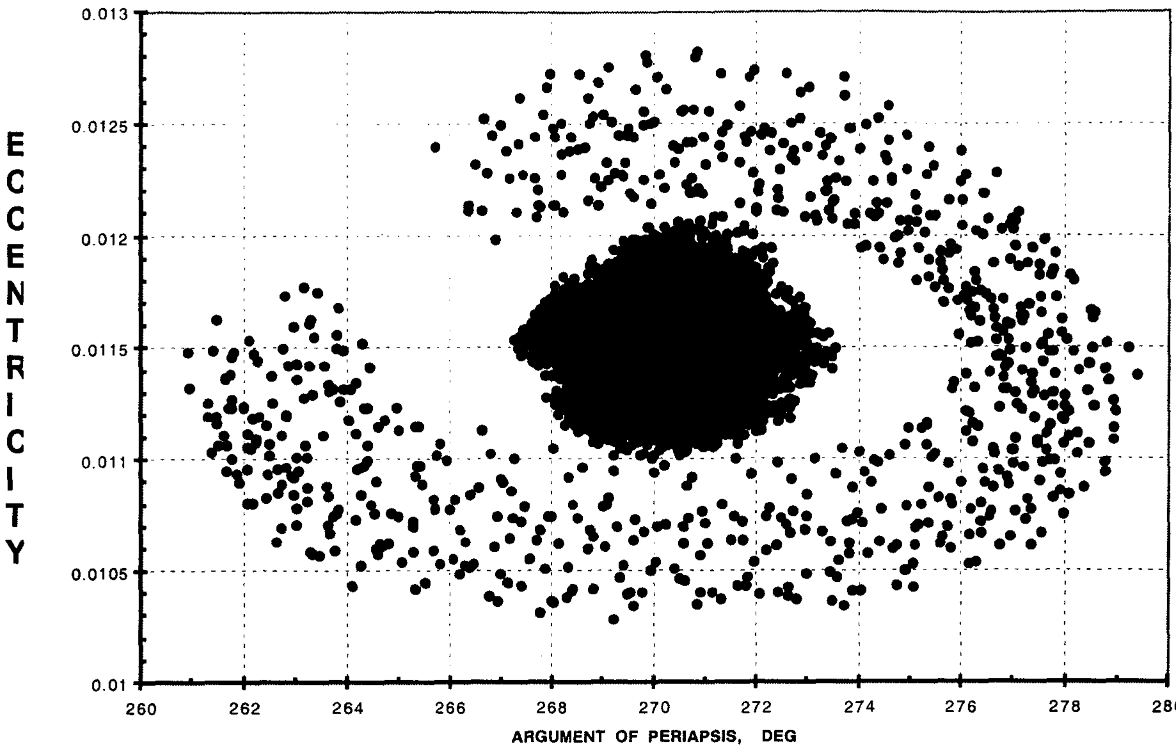

Figure 1 MGS Frozen Orbit

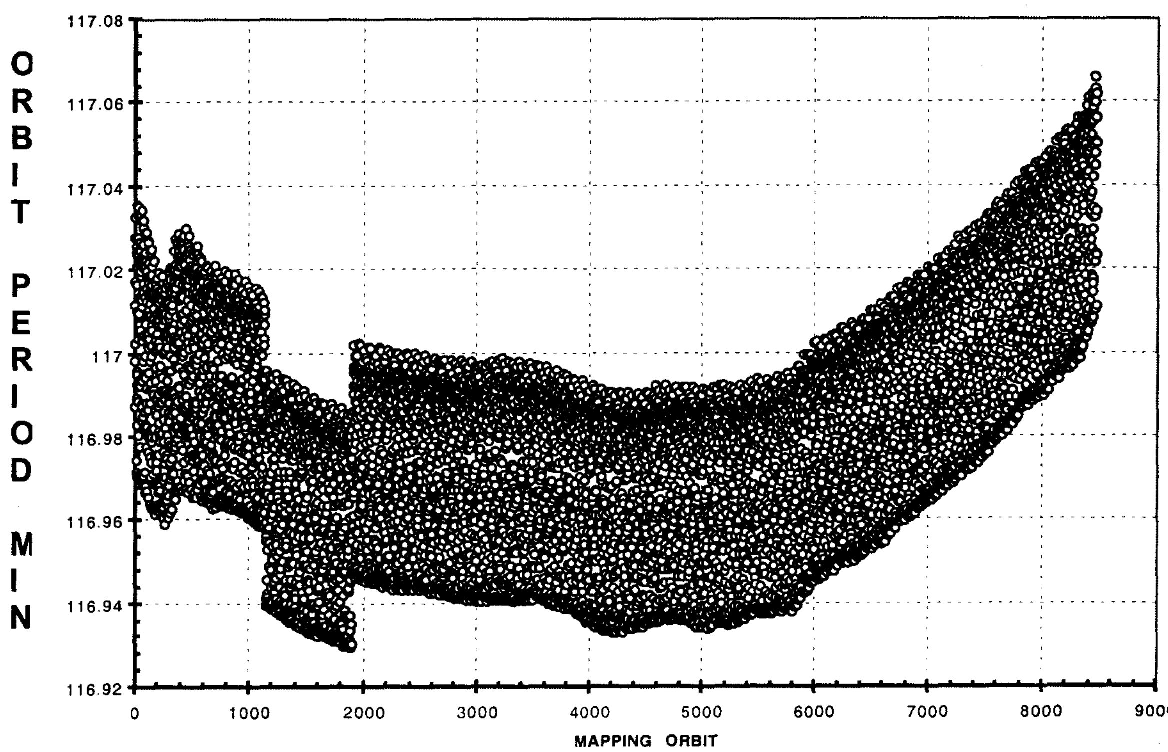

Figure 2 Osculating Orbit Period, At Apoapsis-Passage, Throughout Mapping

Figure 3 Ground Track Walk Throughout The Primary Mapping Phase
Figure 4 Distribution of Longitudes at Descending Equator Crossings. This Figure Covers the Band From 0 to 15 Degrees With 0.1 Degree Intervals.