

Aerobraking Trajectory Options for the 2004 Mars Micro Mission Telecom Orbiter

by

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A small spacecraft bus is being developed to take advantage of the excess launch capacity of the Ariane 5 launch vehicle. The first such MicroMission option is a telecom orbiter mission to Mars. The telecom orbiter would be the first in a planned constellation of relay spacecraft at Mars. The request for proposal to build the first spacecraft has been released, and the selection process is nearly complete.

The Mars MicroMission concept has a tremendous cost leverage in that it flies "for free" as a piggyback payload on a launch of a geosynchronous communications spacecraft. The MicroMission spacecraft separates from the primary payload in a Geosynchronous Transfer Orbit, and must carry sufficient propellant for the remainder of the mission. Nearly two thirds of the total 222 kg launch mass is propellant. About 1500 m/s and several flybys of the Moon and Earth are required to inject the spacecraft on a trajectory to Mars. Another 900 m/s is required to capture the spacecraft into orbit at Mars. Aerobraking will be used to remove another 1200 m/s in order to shrink the orbit apoapsis from 60,000 km (2 day capture orbit) down to 800 km. A final 148 m/s propulsive maneuver is required to raise periapsis from the 100 km altitude required for aerobraking to achieve the final 800 km circular orbit.

This paper will describe and contrast two of the aerobraking trajectories that have been investigated: a two day capture orbit and a three day capture orbit. Capturing into a larger period orbit saves about 33 m/s at Mars Orbit Insertion, but it increases the number of days and orbits that must be spent in the aerobraking phase. Solar perturbations are much more noticeable on the three day capture orbit, because the apoapsis is much further from the planet, and the geometry relative to the Sun at apoapsis results in a significant perturbation in the periapsis altitude. For the three day capture orbit, a maneuver to raise periapsis would be required every orbit to counteract the solar perturbation until the orbit period is reduced below about 40 hours.

Since the duration of the aerobraking phase for the three day capture orbit is much longer than for the two day capture orbit, the conditions at the end of aerobraking are changed. In order to maintain a minimum 1 day orbit lifetime during the final stages of aerobraking, the three day capture trajectory requires a much longer walkout phase than the two day capture trajectory, primarily because the longer aerobraking duration allows the argument of periapsis to drift to a point where gravitational perturbations tend to pull periapsis down, requiring larger propulsive corrections. Similarly, the three day capture trajectory has a greater risk of power problems near the end of aerobraking, because there is no overlap between the drag pass and the eclipse. Since the spacecraft attitude during the drag pass is determined by the aerodynamic properties of the vehicle, the attitude during the drag pass is not optimum for solar power collection. When the drag pass overlaps the eclipse, there is usually enough time to fully recharge the batteries every orbit, even when the orbit period is only 2 hours at the end of aerobraking. Since the duration of the drag pass increases rapidly near the end of aerobraking to about 15 minutes, and since additional time is required to accommodate timing errors and turns to and from the drag attitude, the time spent in the drag attitude can be a significant fraction of the orbit period at the end of aerobraking. Whether power issues will place constraints on aerobraking operations will depend on the spacecraft configuration that is ultimately selected.