An Affordable Mars Sample Return Mission. R. T. Gamber, B. M. Sutter, B. C. Clark, C. E. Faulconer, S. D. Jolly, Lockheed Martin (M.S. 8001, PO Box 179, Denver, Co 80201)

Introduction: High program cost has been a major reason that Mars Sample Return missions have not yet occurred. A low cost Mars Sample Return mission is proposed that can be launched in the 2005/2007 time-frame (see Fig. 1). This mission concept minimizes the total energy required by avoiding capture of the Earth Return Vehicle, ERV, at Mars. Deep Space Rendezvous, DSR, with a Martian sample offers significant cost savings over Mars Orbital rendezvous. The ERV rendezvous with the sample sphere is significantly simpler than under orbital conditions. The ERV propulsion system can use a simple monoprop design. The ERV carries a Sample Return Capsule (SRC) and the design is derived from the spacecraft for the Stardust comet sample return Discovery Mission. Many of the other hardware elements are derived from previous MSR project and concept studies by JPL and LMA.

Mission Concept: The Affordable Mars Sample Return Mission can be accomplished in this decade with conjunction class transfers to Mars and Type III returns to Earth. The landed element would be launched first on a direct entry trajectory to Mars. The ERV would be launched about 15 days later on a free return trajectory. Only Delta II - class launch vehicles are required. The MAV would launch from the Mars surface within 15 days of the ERV flyby and rendezvous would occur over the next few months in deep space as shown in Figure 2. A typical interplanetary trajectory is shown in Figure 3. The DSR concept was first published in 1995 in the reference.

Lander design. The lander would carry a two stage Mars Ascent vehicle and sample acquisition elements. The stay time on the martian surface is sufficient to acquire a diverse sample of 500 g of rocks and soils. Our nominal stay time is up to 60 days and allows time for either vertical drilling for core samples or operation of a small tethered rover. A small robotic arm is used for sample transfer and for a contingency sample. The rugged lander would have three fixed legs, crushable materials, and a hazard avoidance system. The lander would have small solar arrays and passive thermal control due to the short stay time on the surface. The lander can be launched on a Delta 7925H class vehicle in most opportunities.

ERV design. The Earth Return Vehicle is derived from the Stardust spacecraft. The spacecraft propulsion is monoprop and requires no large main engine. It uses four small 4.5 N thrusters for delta V. The spacecraft is fully redundant, has a fixed solar array, and fixed medium gain antenna. The small Sample Return Capsule and capture hardware is carried on one end of the rectangular box enclosure, just as Stardust carries its SRC. The ERV provides the capability for 1 km/s in delta V. This is sufficient to correct for up to 45 day shifts in the MAV launch. The ERV is targeted to arrive about 15 days after the landing. The MAV could launch anytime between Day 1 and Day 60 and allow for a successful rendezvous. The ERV/SRC can be launched on a Delta 7425 class vehicle. The Mars flyby geometry is shown in Figure 4.

MAV design. The Mars Ascent Vehicle is a two stage rocket with a solid first stage with a gimballed nozzle. The second stage can either be a spin-stabilized solid or an advanced liquid stage. Compared to a MAV intended to inject into a low Mars orbit, the delta-V requirement is about 50% greater, but the injection accuracy's are less stringent since the ERV compensates for the rendezvous and since the launch is directly to zenith and does not require sophisticated guidance.

OS design. The solar Orbiting Sphere is derived from the JPL concept for the Mars orbiting sphere but is slightly larger in diameter. The sphere is covered by triple junction GaAs solar cells that operate a beacon. The beacon is enhanced to put out a stronger pulsed UHF signal that can be tracked from Earth.

Rendezvous and Sample Transfer. The ERV is guided to within rendezvous range by Earth-based tracking of both the OS and ERV. Acquisition by optical or beacon methods is simpler than in Mars orbit because there are no occultation's or 3-body orbital dynamics. Proximity operation are especially simplified by posing the rendezvous in a OS-ERV-Earth linear geometry, with constant (no-occultation) telecommunications and full sun illumination. If need be, the final closures and docking could be done in days or even weeks with no impact or complications, compared to the orbital case.

Sample Reentry. After aseptic transfer of the sample using special techniques which eliminate elaborate back-contamination procedures on the surface of Mars, the OS is quarantined inside a cocoon and then placed in a high-integrity vault inside the SRC. Reentry at Earth is performed just as with Stardust, drawing upon already developed and tested designs. The Stardust samples return in early 2006, and the Mars samples would arrive approximately mid-2008.

References::

[1] Author B. M. Sutter (1995) *AAS Spaceflight Mechanics, 95-151,* "Trajectory Optimization of Nodal Re-encounter Martian Transfer Orbits", p 367-375.

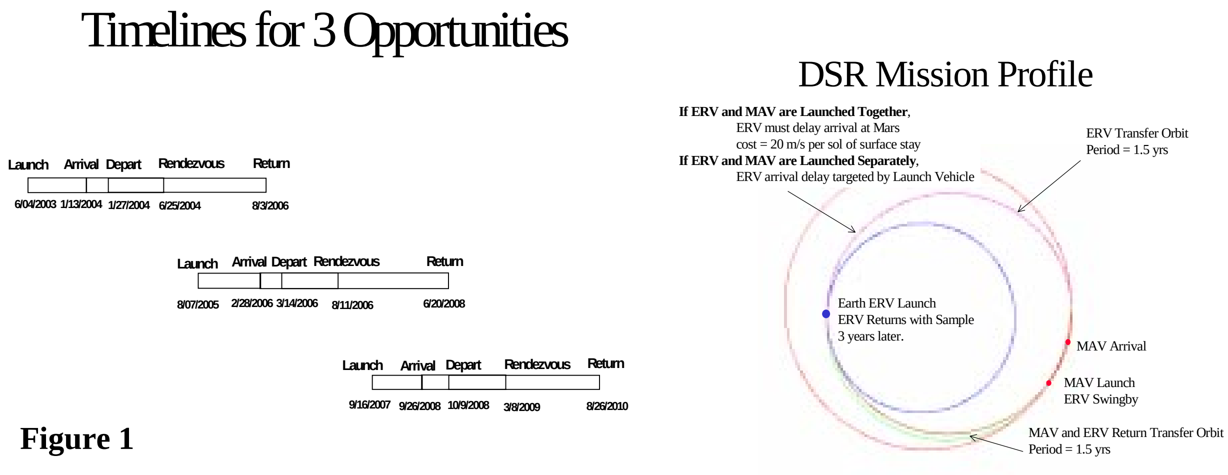

Figure 1

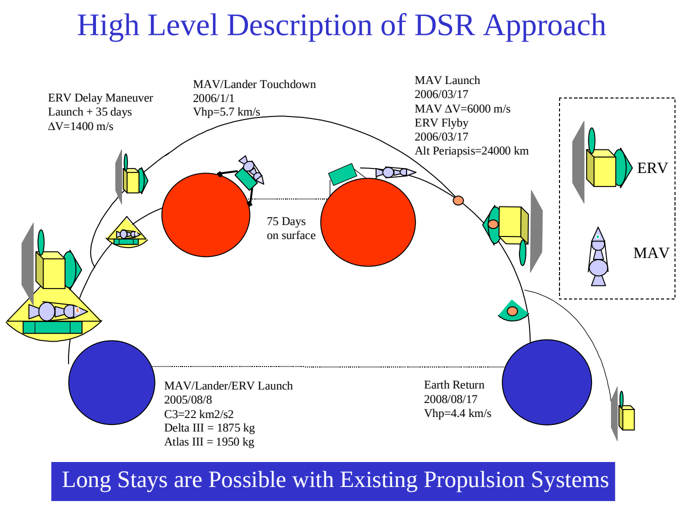

Figure 2