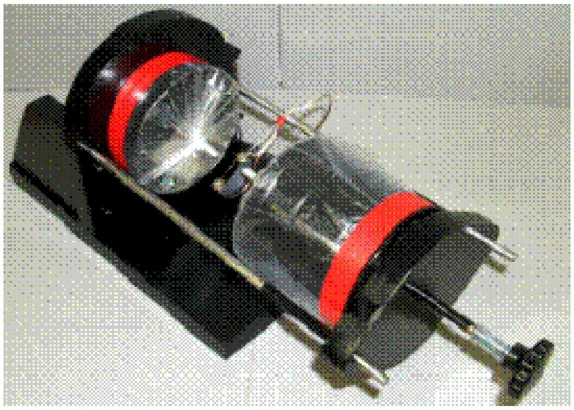
Sample Handling Techniques and Long-Lived Mars Lander Subsystems. M. S. McGee[1], N. G. Smith[1] and E. B. Bierhaus[1], Martin Space Systems Company, 12257 S. Wadsworth Blvd., Littleton, CO 80125. (michael.s.mcgee@lmco.com)

Introduction: The exploration of Mars has captivated scientists and engineers, as well as the public, for the past five decades. Lockheed Martin is proud to have supported NASA in many of these endeavors. This abstract within Challenge Area #3 focuses on Mars surface subsystems and sample accommodation. Sample handling and contamination control are critical to the science for sample return as well as the human exploration requirement to assess toxicity.

Lockheed Martin has significant experience in Mars surface missions, such as Viking and Phoenix. This presentation will highlight some of the unique challenges with sample handling/control and long-lived landers. Innovative sample handling and contamination control concepts will be discussed, including bio-barriers, asceptic transfer, and heat sterilization. Key lander subsystems and design features will be summarized, such as encapsulated landers, Advanced Stirling Radioisotope Generators (ASRG), thermal control and avionics.

Sample Handling and Contamination Control: Protection of the Earth from contamination by Martian life forms during a sample return mission is of the utmost importance. Current schemes for accomplishing aseptic transfer employ an explosive sealing and separation of the sample container from the fairing of the Mars Ascent Vehicle (MAV). This explosive method does not allow functional test of the actual flight hardware and requires additional mass to focus the energy of the pyrotechnics at the critical joint. The new concept described in this abstract uses a simple mechanism to close, encapsulate (loose particles), sterilize, and sever a Teflon bio barrier. This method of aseptic transfer has the advantages of zero shock, low mass and ease of testability for flight hardware.

An improved method for aseptic transfer uses a Teflon tube or throat through which the Martian samples are passed. The inner wall of the tube is contaminated by the sample as it is passed through while the outer wall is maintained uncontaminated. Next, a mechanism twists one end of the tube relative to the other causing it to neck down in the center of the span. This section has been previously coated with an adhesive that melts at a lower temperature than the Teflon tube. The temperature of this necked down section of the tube is next raised to a point where the adhesive melts and encapsulates all contamination trapped in the folds of the Teflon. The temperature is maintained for the time required to thoroughly sterilize the necked down section. Finally, after the adhesive



has cooled and solidified, a hot wire is used as a knife to sever and cauterize the Teflon tube in the center of the sterilized section.

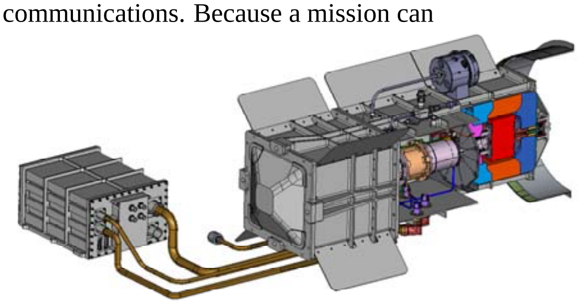
As opposed to the explosive method, the overriding advantage of this concept is that it allows relatively inexpensive repeated testing of the development, qualification and flight hardware. No part of the aseptic transfer mechanism, other than the inexpensive Teflon tube, is destroyed during a sealing test. Literally thousands of Teflon tubes may be twisted, sterilized, adhesively bonded, severed, and inspected for contamination. In this way, the true reliability of the system can be fully established by large numbers of tests on the flight hardware, rather than only being inferred from a smaller number of Lot Acceptance Tests performed on similar hardware.

Sterilization Techniques: Many future missions under consideration will require Planetary Protection IV-B and IV-C levels of cleanliness, including life detection, sample return, and radioisotope power missions. Dry Heat Microbial Reduction (DHMR) is currently the only approved method for achieving these levels of microbial reduction. Recent internal studies have been conducted to evaluate DHMR for such missions. Lockheed Martin successfully implemented DHMR for the Viking landers. Using that campaign as a template, the design modifications, processes and facilities necessary to apply DHMR to a modern spacecraft have been evaluated. Preliminary results suggest the additional cost should be affordable within current Discovery and/or New Frontiers caps. Most parts and materials can already tolerate the sterilization temperatures at non-operating temperatures (in fact, on Phoenix entire flight elements and pieces were baked including harness, thermal blankets, aeroshells, etc). The few exceptions have easily identifiable replacement parts. A short list of delta-qual items was developed for those areas where a part or material would need to be changed out. The DHMR campaign necessary for a modern Discovery/ New Frontiers class mission was laid out and applied to a sample mission concept and was shown to be affordable.

Long-Lived Lander Subsystems: The described subsystems are part of a compact instrumented lander which is capable of operating on the surface of Mars for multi-seasonal data collection and communication. The streamlined, centralized, single-body system derives from multiple generations of Lockheed Martin spacecraft including seven atmospheric entry vehicles. Nearly all critical components are contained inside the lander and operate in a protected, warm environment. ASRG accommodation and efficient use of waste heat were key factors in the design.

Structure. The lander structure utilizes a highly-efficient composite facesheet/aluminum core design, which has been refined over five generations of spacecraft. The interior structure uses the same materials and provides an efficient load path through the vehicle, maximizes surface area for accommodating mission and science related equipment, and provides efficient distribution of ASRG waste heat throughout the capsule when operating in the cold Martian winter environment.

Power. The power subsystem design consists of two ASRGs, two Li-ion batteries, a pyro and propulsion unit (PAPU), and the power distribution and drive unit (PDDU). Two ASRGs supply continuous power during all mission phases, augmented by batteries during communications. Because a mission can



operate for years in extreme cold environments, the use of ASRGs is enabling. After being coupled to the power bus via enable plugs, the full ASRG power output is fed into the lander power bus at all times. ASRG internal power shunting capability is necessary for preflight integration activities, but once it is switched in to the lander power bus, all excess ASRG power is managed via lander shunts. This shunting is controlled by the power supply module and occurs through a dedicated shunt resistor bank, located on the lander main radiator.

Thermal Control. The Thermal Control Subsystem (TCS) maximizes thermal efficiency and minimizes heater power and system mass by strategic utilization of the significant amount ASRG waste heat. The TCS transports ASRG waste heat to different “layers” of the lander, from the interior to the exterior. At specific junctures, the TCS can slow or eliminate heat transport to outer layers. With this flexible design the TCS can shed unneeded waste heat in the summer season, and yet retain heat during the winter season, when waste heat is a valuable resource. The ASRGs are surrounded by honeycomb panels that are embedded with heat pipes to isothermalize the structure around the ASRG, and carry ASRG waste heat to a to carry to a cruise radiator.

C&DH. The C&DH subsystem is the culmination of more than a decade of effort within Lockheed Martin Space and Exploration Systems. The subsystem is an internally block redundant assembly, comprised of circuit card assemblies with significant Juno flight heritage (MRO, Juno, GRAIL) and MAVEN design commonality. The lander C&DH realizes redundancy by carrying two identical card strings: one string is powered and is the active side, while the other is an unpowered back-up. The RAD750 spaceflight computer provides all of the computing resources required by flight software and is the master of the internal PCI bus. The PCI bus provides a high bandwidth communication path, up to 300 Mbps using direct memory access, between four slave cards and the master. The memory and payload interface card, currently flying on GRAIL, provides interfaces between instruments and the SFC, including synchronous LVDS interfaces and asynchronous interfaces. The subsystem contains flash memory for non-volatile storage of science data, as well as SDRAM volatile memory storage. All memory on the MPIC is protected with error detection and correction circuitry. Finally, the MPIC is the master of the heritage multi-function bus, which provides serial command and telemetry communications to the electrical power subsystem.

Connection to Human Exploration: Key lander subsystems, such as ASRGs, enable long-term surface missions needed to answer critical science questions and obtain important human exploration data, particularly in the polar regions of Mars. LM has been working closely with the planetary community to develop low-cost, innovative landed mission concepts to explore subsurface ice. Long-lived lander missions also offer the opportunity to assess extant life, surface radiation, and long term weather on Mars.