Recalling the Viking Mars Lander Mission

By Dr. Ben Clark and Ray Ziehm

It is very encouraging to see the renewed interest in solar system exploration that we are experiencing today. The recent New Horizons flyby mission to Pluto enjoyed well deserved good publicity and was a topic of discussion for several weeks. However, one issue related to space exploration is that many of today's space enthusiasts are not familiar with the outstanding accomplishments of the two Viking orbiter/lander missions back in the 1976 time frame. Many of these interested folks were not born when these missions took place. The great success of the Viking program speaks loudly to the boldness of the project as well as the capability of the United States, NASA, JPL, and Martin Marietta to mount such an effort considering all the new challenges and uncertainties involved.

NASA's Langley Research Center had been studying a mission to Mars for some time, and had identified a complement of science objectives as well as many of the difficult technical areas that existed with such a mission. Viking was, of course, NASA's first attempt at landing on another planet in the solar system. Mars was the highest priority because it was the one place in our solar system that scientists thought there was the possibility that some form of life might exist or have previously existed.

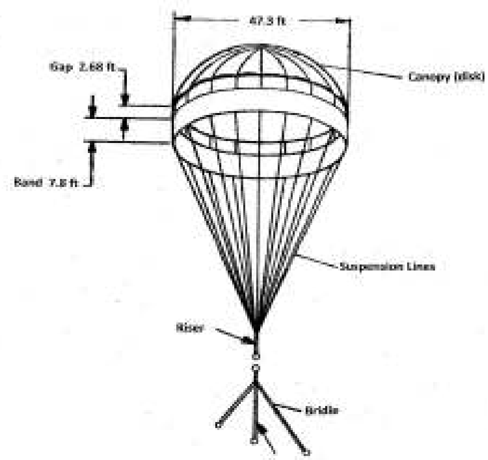
The Soviet landing attempts had been failures in spite of some of their claims, and we knew it was going to be technically the most challenging place to land compared to the straightforward landings with rockets on the moon or simple parachutes when touching down on Earth. The thin atmosphere of Mars is just dense enough to make rockets tricky at high speeds, but not enough for parachutes to do the total job.

In late 1966, a program called the Planetary Entry Parachute Program (PEPP) was awarded to Martin Marietta by NASA Langley to continue a series of rocket launches and one balloon launch intended to select a Viking Lander parachute design from three candidates being considered. Rocket launched parachute tests were done at White Sands Missile Test Range, filming parachute deployment and inflation at an altitude where the Earth's atmospheric density was representative of that expected at Mars. We successfully conducted the last flights of the rocket launched program.

The next level of testing was to open and inflate a parachute in the wake of an aeroshell of the design planned for Viking. This part of the program was to include four launches of helium filled balloons to lift the aeroshell containing a separable payload from a launch site at Roswell, New Mexico, to one hundred and thirty thousand feet altitude as it arrived over the missile range. The aeroshell and payload were dropped from the balloon, eight rocket motors were fired to achieve a supersonic velocity, and the test parachute was mortared out to deploy and to extract the payload from the aeroshell as it slowed to the transonic velocity regime.

The balloon launched vehicle ready for launch

Three balloon launched tests were successfully conducted, one for each test candidate. Inflating a parachute in this low density atmosphere and in the turbulent airflow behind an aeroshell is no simple matter. A new chute design, called a disk-gap-band (DGB), the Langley team was considering appeared to perform the best of the three chute design concepts.



The disk-gap-band Parachute

The DGB was eventually selected as the Viking Lander chute design. Interestingly, this entry, landing, and parachute design has been used on all follow-on planetary atmospheric landings. NASA had originally scheduled four PEPP flights, assuming one failure might occur; however, all three were successful and the fourth flight was cancelled. A similar balloon launched program called BLDT was conducted during the Viking program to qualify the parachute system. (A subsequent Mars article will describe the PEPP program in more detail).

JPL was designated to build two vehicles to serve as lander busses during the cruise to Mars, and then go into Mars orbit and conduct their own science missions, as well as relay lander mission data to earth. Following a competitive proposal activity, Martin Marietta was awarded the program to design and develop two Viking Mars lander spacecraft as well as to craft the mission operations. Martin Marietta was also selected to provide its Titan Launch Vehicles.

The planetary community had already defined the mission objectives and outlined the proposed experiments to satisfy them; they included study of surface characteristics, details of the atmosphere, the soil composition and its magnetic properties, as well as photos of the general terrain, and of course, the presence of indications of life.

Two Mars landers were designed, built, and flown (actually, a third was mostly built, and there were enough flight spares for four). The reasoning was that if there was only a 70/30 chance that any given spacecraft might land successfully, by flying two there would be a 91% probability that at least one would be successful. One huge concern was the multiple sets of technologies that had to be developed, especially within the new requirements for heat sterilization, under which the landers would be encapsulated, and then heated to a temperature above boiling water for 30 hours. No other spacecraft, before or since, have had to meet such stringent environmental conditions. Furthermore, this heat-resistant spacecraft also had to be cold tolerant and able to operate under external temperatures as low as –184 deg F on the cold, nighttime surface of Mars.


Carl Sagan, posing with the Viking Lander (not on Mars, of course)

During the cruise to Mars there were some technical issues, but no mission-stopping events. The insertions into Mars orbit went exactly as planned and achieved extremely accurate orbits. As everyone on the project and most of the free world watched breathlessly on live TV, the first lander performed a separation from its orbiter, then deorbit burns and entry into the atmosphere, followed further by deployment of the supersonic parachute, separation of the capsule to release the lander, and finally, the acquisition of altitude and velocity information by the specialized radar system to guide the propulsion engines for a highly controlled vertical descent onto the surface of Mars. During all those activities, a relatively high data rate of 2,000 bps was continuously sending information back through the orbiters. Everything had to be preplanned and occur autonomously under computer control, back when computers were still in their infancy. To the somewhat startled surprise of almost everyone, the landings were virtually picture-perfect.

Whether Viking actually discovered life on Mars is still under some dispute, although most scientists suspect that the life-like chemical signals seen by one experiment were actually due to chemical peculiarities of the Martian soil, possibly having to do with perchlorates and their long-term exposure to cosmic rays.

Viking made a large variety of often surprising discoveries. Although Mars is a desert, the relative humidity can be high enough during nighttime to condense water, and the Viking-2 lander observed frost on the ground in wintertime because it was located at a higher latitude (48^{o} N, higher than Fargo, ND). It is possible it could have discovered ice if it could have dug a few feet deeper into the ground. We also discovered that the argon content of the atmosphere is much lower than implied by a previous Soviet measurement, which has strong implications that Mars has not outgassed water and other volatiles nearly as much as our own planet. Nonetheless, orbital pictures revealed many examples of evidence of ancient rivers, tributaries, and floodplains, as well as today's water icecaps beneath the frozen carbon dioxide polar caps. Atmospheric pressure varied by about one-third during the year as the CO_2 caps sublimated. The atmosphere is more than a hundred times less than ours, but measurements of nitrogen isotopes showed that it must have been much more massive in the past.

At their peak, the global dust storms reduced visibility down to a few dozen feet. The source of the dust, the Martian soil, is very iron-rich (producing the red color), but enriched in sulfates, probably similar to Epsom salts. The soils at both Viking sites, on opposite sides of the planet, are virtually identical and apparently are part of a global unit that is homogenized by the giant global dust storms. More than 4,000 images were taken by the landers and over 50,000 by the orbiters (mapping 97% of the planet). The orbiters also mapped the surface temperatures across the entire planet for all four seasons and measured the spread of water vapor as it sublimated from the polar caps.

Close orbiter flybys of Mar's moons, Phobos and Deimos, revealed their dark, cratered surfaces and low densities, which may be due to organics and ice in their subsurface. The results are also consistent with them being remnants of one original object, broken apart during the encounter and captured by Mars.

The plans for the Viking mission uncovered several technical issues that had not been encountered before, or at least not to the same levels. One of the most difficult of these was the sterilization process required to avoid contaminating the Mars environment with Earth bacteria. Even assembly in a laminar flow clean room, with white coveralls and booties, and repeatedly washing parts with disinfectants was not sufficient. Many components had to be redesigned using only materials compatible with the heat sterilization requirements. Recent Mars missions have avoided the heat sterilization because they have not carried instrumentation to detect life on Mars, and no strong evidence of live bacteria has been found to date.

This was our first use of nuclear electrical (RTG) power thought to be necessary because of the frequent dust storms. There were also many other new issues to be resolved here. The soil-sampler was a design that evolved slowly as many concepts were considered and tested.


InSight Mars lander being readied for shipment

Look familiar? It should. No, it is not Viking. It is a new vehicle called InSight developed for a new Mars mission. This is one of the daughters-of-Viking. It will study the interior of Mars by monitoring for Marsquakes. It was originally planned for launch in March 2016, but the French seismometer instrument was not ready in time, and the launch had to be delayed.

The first daughter-of-Viking, the Phoenix lander, already performed its mission in the polar regions of Mars (in 2008), making many far-reaching discoveries, including that a portion of the chlorine we detected in the soils with Viking are actually perchlorate salts, a super-duper ice melting salt much more powerful that what we put on our roadways or driveways in wintertime. Recently, this discovery was extended, as announced in a recent press conference about the confirmation of active gullies on Mars. For those of us who were fortunate to be working as engineers, scientists or support staff at the time of the Viking landings, the thrill of those first images from the surface of Mars was the jewel in the crown that topped off the Apollo moon landings. Today, there are more than one thousand engineers and scientists whose part- or full-time job is operating the plethora of spacecraft at Mars (4 orbiters, 2 rovers, and 9 new missions in the development phase by NASA, Europe, Russia, Japan, China, and even the United Arab Emirates). Where Viking started as a revolution in exploration of the red planet, has now also become the official long-term goal of NASA's astronaut exploration program.

Mark your calendars for the time period on or near July 20th, 2016, for a reunion celebration being planned for everyone who touched the Viking project, or were inspired by it (follow the website of the Viking Preservation Project, at Vikingpreservationproject.org.