Historian's Corner

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The Viking Mars Lander Cameras

By **Vincent Corbett**

The Martin Marietta Space Systems Denver Division was awarded a contract to design, build, and fly two Viking spacecraft systems to orbit and land on the planet Mars. The mission was to be composed of two spacecraft, Viking I, and Viking II, each consisting of a spacecraft bus, a Mars orbiter, and a vehicle containing the lander capable of entering the atmosphere and safely landing on the Martian surface. The primary mission objectives were:

-characterize the composition of the Mars atmosphere and surface
-characterize the planets structure
-search for evidence of life
-obtain high-resolution images of the Martian surface

Viking I was launched from Cape Kennedy on August 20 ,1975, and was inserted into Mars orbit some 304 days later on June 19 1976. The original plan was to land on Mars on July 4 1976, however, late data from Arecibo Observatory in Puerto Rico showed that the planned landing site was too rocky, and therefore dangerous. More time was required to find a more suitable landing site. Mission planners studied imagery data from the orbiter as it surveyed the surface and found that Chryse Planetia was acceptable, and on July 20, 1976 the Viking I lander touched down successfully.

Chryse Planetia is a smooth circular plain in the northern equatorial region of Mars. The Viking II lander touched down safely on September 3 1976. These were the first successful landings on Mars with fully functional craft. The Soviet Union had earlier landed spacecraft on Mars but they were not successful. It is unfortunate that the lander did not come into view when Mark Watney was walking through the area in the book and movie "The Martian."

The Viking spacecraft lander is a six-sided aluminum structure 18.2 inches deep enclosed by top and bottom plates and supported on three landing legs. The interior is environmentally controlled and contains many of the electronic equipment and sensor boxes.

The lander camera system consists of two redundant facsimile type cameras. The cameras are two cylindrical objects on the top of the vehicle and were mounted one meter apart to enable collecting stereo images and to provide a baseline from which the sizes of objects could be calculated. The camera's field of view was 0.04 degrees per pixel for high resolution, and 0.12 for low resolution.

Elevation capability was 40 degrees above the horizon to 60 degrees below, with a scan capability of 342 degrees in azimuth. Twelve photo diodes formed the Photo Sensor Array. Actual size of the array is in the order of a 25-cent coin. The camera's primary function was to characterize the landscape from near the lander to the horizon. It also became a part of the mission operations to support the soil sampler site selection, to image its trenches, and to survey parts of the lander for accumulation of dust.

The scientists were interested in the Meteorology, Biology, Molecular Analysis, Seismology and other scientific areas, but the general public (and probably also the scientists) were more interested in viewing the photographs to look for signs of life: canals? The paramount science interest was to see just what Mars looked like. During a weight reduction meeting a suggestion was made to remove one camera, but the answer was, "we can't go to Mars with a one-eyed lander."

The cameras divide the scene of interest into a grid of many tiny squares called pixels. The subject is scanned one line at a time via a nodding mirror that is sequentially indexed in azimuth, and each element of light energy from each pixel, is converted into electrical energy. The tiny photo sensor array senses the signal and sends it to the signal processing electronics.

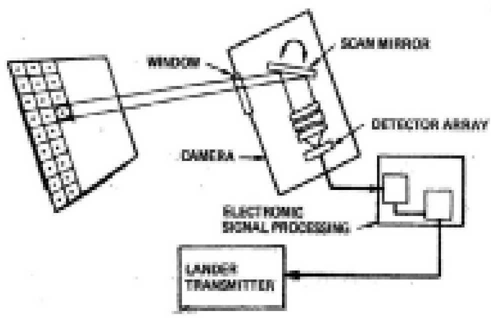


Image Generation via the Nodding Mirror

Martin Marietta (MMC) selected the ITEK Corporation to provide the camera for the Viking mission. There were seven bidders; however ITEK's proposal displayed excellent experience with satellite imaging using a facsimile camera. ITEK is located in Burlington, Massachusetts, and Martin management decided that a resident team would be required to preclude communication problems due to the distance between Denver and Burlington that could jeopardize the tight program schedule. I was "asked" to be the manager of this team for an approximate period of three years. The team consisted of three electronic engineers, a quality control person, and a sub-contract administrator.

The concept of a resident team was accepted by ITEK senior management, but at the worker bee level, things were not so smooth. After the first review with the NASA customer, they all recognized that we were part of the solution, and team operations improved. The design and test phase proceeded with expected type of development issues which were exacerbated by the requirement that only parts on a NASA approved parts list could be used and the design had to be compatible with worst case mission events.

The photo diodes for the Photo Sensor Array were to be provided by an ITEK subcontractor who was familiar with this area of microelectronics and had experience working in a laboratory environment. However, their culture did not respond to a schedule, consider failure analysis, use of parts only from an approved parts list, and operation in a clean room environment. A major speed bump was encountered with the photo sensor diodes reliability as there were many diode failures following what proved to be some "random successes", and the camera system was put on the NASA Viking Top Ten Problem List. This brought constant attention of Martin Marietta top management as well as NASA. Twice monthly meetings with the lead NASA Langley imagery engineer and MMC top management were conducted considering technical, schedule, and cost issues.

The ITEK designers were very good, but their history was to work on cameras in a controlled environment. However, the signal amplification in the data processor was completely changed because the resistance, capacitance, and delay times of the photo diodes changed due to the extreme cold temperature required by the worst case analysis. Their design schedule was thrown out of whack, and a joint effort by MMC and ITEK was required to solve the problem. Finally, after many reviews with MMC management and NASA, Bill Purdy stood up and said, "MMC will make the photo diodes for you." The contract with the sub-contractor was cancelled, and MMC provided the diodes to ITEK. This created a complex contractual situation, but we worked through it and the worst of the setbacks was over.

The very first image taken by the breadboard camera was of a Playboy centerfold. The technician rushed into the status review with the "exciting" image and was told to go back and try again. He came into the meeting with an image taken through a laboratory window of the company parking lot. It was still "exciting" and the scientists and NASA officials wanted copies to take back to their peers. Finally, we knew the system would work as planned.

One day, Tim Mutch, the head of the NASA lander imagery team and I were in my office listening to the litany of problems and he suggested I take the day off and go sailing with him in Narraganset Bay. Tim, my teenage son, and I met him there, and as my son had just finished summer camp and having learned to sail a small boat, did the sailing while Tim Mutch and I talked through the issues. It was a beautiful day and the trees were outstanding. Tim Mutch said he would do the mooring approach, but when we stepped out of the boat, it floated away. My son Tim immediately dove into the cold water and retrieved the line. Since the boat was named Viking, Tim Mutch surmised that lately anything related to Viking was subject to a problem, but he left our meeting convinced that the camera was a doable project.

Another issue that came later in the game was that Mars wind velocities were estimated to sometimes reach 200 MPH and could damage the nodding camera mirror, and fill the camera housing with dust. This caused a fix that included a dust cover (called the mast) in front of the mirror when the camera was not in use, along with a labyrinth passageway to the camera. Denver testing proved out the system.

A Proof Test Capsule (PTC) camera was also built to undergo the environmental testing at ITEK, and later testing while situated in the lander, in Denver. The two environments that were the most worrisome were the sterilization procedure (high temperature: 140 degrees F for 110 hours, and a low temperature test at minus 190 degrees F). The high temperature proved not to be a problem, but at about minus 150 degrees the camera stopped its scanning rotation. Everyone immediately thought this was some serious problem, but it turned out to be a slight interference with the mast that bound up the camera. Sometimes you get lucky.

Shipping the PTC camera to Denver was done with it strapped in a first class seat of a commercial airliner. The captain announced over the plane's intercom what the strange thing in a first class seat was, and that it was to fly to Mars. We were the last to deplane and several of the passengers patted the drum holding the camera and said, "See you on Mars."

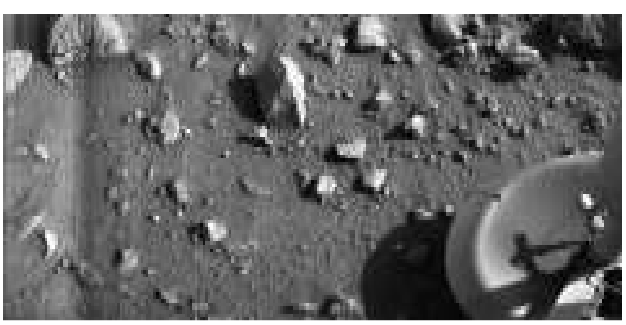
With the camera in Denver there was an immediate demand to use it for myriad tests. The science team wanted to do some testing outside in the red rocks above the plant. Two engineers had built a camera controller (since the camera would be normally be controlled by the lander electronics) that allowed the science team to do their thing. They made image after image and were very pleased with the results. They also liked the geology found there, and had written on the rocks an annotation of each image. They didn't understand that we just do not paint on the rocks around here, but they later bought some thinner and cleaned everything up.

The thinking in the early 1970s was that Mars contained significant sandy areas, so it easy to sell the idea of a special test at the Great Sand Dune National Park. We rented a truck to carry the equipment, and John Montgomery, the camera technician, drove the truck to the dune proper. He went as far as we could go into the sand, knowing we get the truck towed out if necessary. The camera was set up on a small hill using a 50-foot long umbilical and protected by a large golf umbrella, and the testing began. Carl Sagan was there as part of the team, and bought two live turtles and a snake to image in the event life forms were found on Mars. They imaged the turtles going the same direction as the camera scan movement, and then going in the opposite direction. As to be expected the turtles going with the camera scan were elongated, and in the other direction they were shortened. Carl stated he didn't expect to see any turtles on Mars anyway.

We stayed in a motel in Alamosa, Colorado, and that evening I was sitting out on the second floor deck drinking a cool one when Carl Sagan came up and sat beside me, also with a cool one. I had only talked to him a time or two, but the night sky was spectacular, and he made it more so. His discussion was sort of a prelude to his successful TV series, *Cosmos*. When the testing was complete, Tim Mutch suggested we take a group photo using the camera. Once the camera slit passed him in the lineup, he would run behind the camera and be photographed again. He was in the same photo at seven different positions.

During the Viking prelaunch checkouts the cameras performed flawlessly, and after the launch the cameras were placed in a sleep mode during the journey to Mars. There were concerns as to whether they would turn on after landing, but there was no problem with either camera. The day after the first landing I was in the ground station and Bill Purdy and Tom Pownell were in the executive lounge. After about forty minutes the television monitors showed the camera line scans beginning, and when about six scan lines appeared it was evident that the cameras were working properly.

The first image showed some of the Mars terrain and also part of the lander leg. Bill and Tom came out to join everyone and they both had tears in their eyes. There were many tears that day.



The Famous First Mars Image (Lander foot in lower right corner)


The Soil Color


A Mars Panorama

Both landers' cameras were used extensively, surveying in all directions in all phases of high resolution, low resolution, color, and infrared over a period of several years. Thousands of images of outstanding quality were made and now fill a large library of magnetic tapes. One of my friends from the Denver Museum of Nature and Science was awarded his PHD based on his study of the Viking images. During the landed life on the Martian surface all cameras performed flawlessly. They provided detailed images of Martian features of all sizes, via color, infrared, panoramic, and stereo photos. The Viking I landing site on Mars was later named The Thomas A. Mutch Memorial Station.