# Viking Project Description

## Mission Overview

The Viking mission to Mars consisted of four spacecraft: the two orbiters VO1 and VO2, and the landers VL1 and VL2 (Soffen, 1977). During cruise to Mars the landers were attached to the orbiters; the combined spacecraft were then known as Viking 1 and 2. The role of the orbiters was to transport the landers to Mars, to carry reconnaissance instruments for certifying the landing sites, to act as relay stations for lander data, and to perform their own scientific investigations. The initial orbit periapses were placed over the candidate landing sites to allow for maximum viewing resolution and relay of the lander data. After the primary lander missions were completed, the orbiters’ orbits were allowed to drift so that the entire planetary surface could be systematically mapped by the three remote sensing experiments.

The Viking 1 spacecraft was launched August 20, 1975, and arrived at Mars on June 19, 1976. Lander 1 was deployed to the Mars surface on July 20, 1976. The VO1 orbital inclination of 38-39 degrees was chosen to optimize communication with VL1. Viking 2 was launched September 9, 1975 and arrived at Mars August 7, 1976. VL2 landed on September 3, 1976, at a more northerly site than VL1. The VO2 orbit was correspondingly more inclined than VO1; initially 55 degrees, it was later adjusted to 80 degrees, providing particularly good coverage of polar regions. The areocentric locations of VL1 and VL2 have since been determined to be (22.270N, 48.264W) and (47.669N, 226.032W), respectively (Yoder and Standish, 1997).  
  
Mission Phases

The timeline for the Viking Mission is divided into a number of mission phases in terms of the types of observations and level of activity. The references (Snyder, 1977), (Snyder, 1979),  
(Moore et al., 1987), and (Snyder and Moroz, 1992) provide detailed descriptions of these mission phases. A summary of the mission phases and the relevant dates are described below. Before Mars encounter and orbit insertion the orbiter and lander spacecraft are considered as one spacecraft with the same mission phases. The primary missions for all four spacecraft (VL1, VO1, VL2, and VO2) are listed separately because each has a different starting date. All mission phases after the primary mission are listed only once because all four spacecraft operated together.  
  
Viking 1 Mars Launch  
The Viking 1 spacecraft was launched on August 20, 1975 on a Titan Centaur 3 booster from Cape Canaveral, Florida.  
  
 Spacecraft Id: VO1, VL1  
 Target Name: MARS  
 Mission Phase Start Time: 1975-08-20  
 Mission Phase Stop Time: 1975-08-20  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking 1 Mars Cruise  
The Viking 1 spacecraft, consisting of the VO1 orbiter and VL1 lander, cruised to Mars for about 10 months, during which time the spacecraft was checked periodically.   
  
 Spacecraft Id: VO1, VL1  
 Target Name: MARS  
 Mission Phase Start Time: 1975-08-20  
 Mission Phase Stop Time: 1976-06-19  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking 2 Mars Launch  
The Viking 2 spacecraft was launched on September 9, 1975 on a Titan Centaur 3 booster from Cape Canaveral, Florida.   
  
 Spacecraft Id: VO2, VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1975-09-09  
 Mission Phase Stop Time: 1975-09-09  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking 2 Mars Cruise  
The Viking 2 spacecraft, consisting of the VO2 orbiter and VL2 lander, cruised to Mars for about 11 months, during which time the spacecraft was checked periodically.   
  
 Spacecraft Id: VO2, VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1975-09-09  
 Mission Phase Stop Time: 1976-08-07  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking Orbiter 1 Primary Mission  
The Viking Orbiter 1 spacecraft entered Mars orbit on June 19, 1976. Operations commenced by supporting the selection of a landing site for VL1. Throughout the Primary Mission, the VO1 spacecraft supported communications with the landers and made observations of the Martian surface and atmosphere. The Primary Mission ended at the start of the solar conjunction in November, 1976.  
  
 Spacecraft Id: VO1  
 Target Name: MARS  
 Mission Phase Start Time: 1976-06-19  
 Mission Phase Stop Time: 1976-11-15  
 Spacecraft Operations Type: ORBITER  
  
Viking Lander 1 Primary Mission  
The Viking Lander 1 spacecraft separated from the VO1 orbiter and descended to the Martian surface on July 20, 1976. The Primary Mission focused on the collection and analysis of soil samples and the characterization of the landing site and atmosphere. The Primary Mission ended at the start of the solar conjunction in November, 1976.  
  
 Spacecraft Id: VL1  
 Target Name: MARS  
 Mission Phase Start Time: 1976-07-20  
 Mission Phase Stop Time: 1976-11-15  
 Spacecraft Operations Type: LANDER  
  
Viking Orbiter 2 Primary Mission  
The Viking Orbiter 2 spacecraft entered Mars orbit on August 7, 1976. Operations commenced by supporting the selection of a landing site for VL2. Throughout the Primary Mission, the VO2 spacecraft supported communications with the landers and made observations of the Martian surface and atmosphere. The Primary Mission ended at the start of the solar conjunction in November, 1976.  
  
 Spacecraft Id: VO2  
 Target Name: MARS  
 Mission Phase Start Time: 1976-08-07  
 Mission Phase Stop Time: 1976-11-15  
 Spacecraft Operations Type: ORBITER  
  
Viking Lander 2 Primary Mission  
The Viking Lander 2 spacecraft separated from the VO2 orbiter and descended to the Martian surface on September 3, 1976. The Primary Mission focused on the collection and analysis of soil samples and the characterization of the landing site and atmosphere. The Primary Mission ended at the start of the solar conjunction in November, 1976.  
  
 Spacecraft Id: VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1976-09-03  
 Mission Phase Stop Time: 1976-11-15  
 Spacecraft Operations Type: LANDER  
  
Viking Extended Mission  
The Viking Extended Mission began after solar conjunction. The two orbiters continued to observe the surface and atmosphere of Mars. The two lander spacecraft analyzed additional soil samples and dug three deep holes in the surface. All four spacecraft monitored the planet through the cycle of seasons. During the winter season, the landers operated in an automatic manner designed to allow the spacecraft to survive the cold temperatures and still return some data.  
  
 Spacecraft Id: VO1, VL1, VO2, VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1976-11-15  
 Mission Phase Stop Time: 1978-05-31  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking Continuation Mission  
Primary objectives of the Continuation Mission were to make orbital observations at times of the Mars year that were missed due to landing site selection and solar conjunction and to collect high resolution surface images when the atmosphere was clear. A radio science solar conjunction relativity experiment was also done during the Continuation Mission. Lander activities consisted of measurements by the imaging, meteorology, and XRFS instruments operating in a fully automated manner. Viking Orbiter 2 developed a leak in its propulsion system and lost its attitude control gas. VO2 was turned off on July 25, 1978 after 706 orbits around Mars.  
  
 Spacecraft Id: VO1, VL1, VO2, VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1978-05-25  
 Mission Phase Stop Time: 1979-02-26  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking Interim Period  
The Interim Period mission phase occurred during the time of the Voyager 2 encounter with Jupiter. Thus, communications to and from the Viking spacecraft were limited. The landers continued to operate in an automated manner making imaging and meteorology observations. A final VL2 surface sampler sequence was conducted during this mission phase as an engineering test in the cold temperatures of mid winter. Orbital data stored on spacecraft tape recorders and not returned during the Continuation Mission were downlinked during the Interim Period.  
  
 Spacecraft Id: VO1, VL1, VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1979-02-26  
 Mission Phase Stop Time: 1979-07-19  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking Survey Mission  
The prime scientific objective for VO1 during the Survey Mission was to obtain high resolution images of possible future landing sites. The plan for the landers was to collect image and meteorology data for as long as possible. Because VL2 no longer had a direct downlink capability, it meant that VL2 could return data only as long as VO1 provided a relay link, once every seven weeks. Communications with VL2 ended on April 11, 1980 after its batteries could no longer hold a charge. VL2 operated on the surface of Mars for 1281 sols. VO1 consumed the last of its attitude control gas on August 7, 1980 and was turned off after 1485 orbits around Mars.  
  
 Spacecraft Id: VO1, VL1, VL2  
 Target Name: MARS  
 Mission Phase Start Time: 1979-07-19  
 Mission Phase Stop Time: 1980-08-07  
 Spacecraft Operations Type: ORBITER, LANDER  
  
Viking Completion Mission  
Viking Lander 1 continued to operated in its automatic mode during the Completion Mission. The observation sequences were cyclic. VL1 returned via direct downlink image and meteorology data about once a week with image sequences repeating every 37 sols. The VL1 high-gain antenna was programmed to track the Earth until December, 1994. However, communications were lost in November 1982 after a command sequence uplink.  
  
 Spacecraft Id: VL1  
 Target Name: MARS  
 Mission Phase Start Time: 1980-08-07  
 Mission Phase Stop Time: 1982-11-19  
 Spacecraft Operations Type: LANDER  
  
Mission Objectives

Exploration of Mars, and the Viking Mission in particular, has been part of a larger quest -- the search for better understanding of the formation and history of the solar system. For Mars, the specific objectives have included:   
 1) evolution and current structure of its interior;   
 2) characteristics of the surface, including its chemistry and physical nature;   
 3) evolution and current composition and structure of its atmosphere;  
 4) nature of the climate, including controls on both daily and seasonal variations;   
 5) whether life is, or ever has been, present.

Although most Viking investigations could be defended on one or more of the first four objectives, virtually all secondarily addressed the fifth. On the other hand, the investigations that focused primarily on objective #5 barely scratched the surface of that single question; the nature of life – and especially its expression on another planet -- is not well understood. According to Soffen (1977), "It was finally decided to send a set of biological tests that range in their environmental setting from a totally aqueous milieu, rich in organics, to a Marslike environment with no water or any other additives. Even so, only a very narrow set of all possibilities could be tested on the small samples acquired ...".

The Viking investigations and their primary objectives are summarized in the paragraphs below. More information is available in Soffen (1977), Snyder (1977, 1979), and Snyder and Moroz, (1992).   
   
*Orbiter Imaging*  
An early objective was assisting in landing site selection and certification. Once the landers were safely in place, the Orbiter imaging system was used to provide a geologic context for the surface observations. Globally, images were collected to provide high-resolution mosaics and maps at resolutions approaching 100 meters. Stereo pairs of images could be used to derive local topography; photoclinometry could be used on single images to derive elevations and slopes at lower accuracy. Images were also used to infer the origin and history of major terrain types, including disruptive events such as apparent catastrophic floods. Crater morphologies which suggest a permafrost layer pointed toward complex interactions of regolith and atmosphere. The Orbiter imaging system was also used to monitor atmospheric changes including clouds, hazes, and suspended particles. Images of the satellites Phobos and Deimos showed their surfaces from distances as close as 100 km.  
  
*Mars Atmospheric Water Detector (MAWD)*   
MAWD was designed to measure the water vapor content of the atmosphere from orbit. Patterns were sought as a function of local time, season, latitude, and elevation. Objectives of the investigation included better understanding of both diurnal and seasonal transport of water vapor as well as location of sources and sinks.   
  
*Infrared Thermal Mapping (IRTM)*  
IRTM measured reflections and emissions in several infrared bands from orbit. These data could be used to infer the physical properties of surface materials including the relative proportions of rock, sand, and dust. Apparent surface temperatures were used to infer the composition of polar ices, assisting in development of atmospheric circulation models.  
  
*Radio Science*  
Radio tracking of the Landers allowed determination of their positions on the surface, the planetary rotation axis, the spin rate, and moment of inertia. Tracking of the Orbiters allowed determination of a gravity field for Mars. Radio occultations yielded planetary radii and atmospheric temperature-pressure profiles at dozens of locations. Radio observations were also conducted to measure structure in the solar corona and to test a prediction of general relativity associated with passage of the radio path through the Sun's gravitational field.  
  
*Entry Science*  
During descent each landing module measured both the physical structure and chemical ionosphere allowed inference of dominant reactions. At lower altitudes isotopic ratios could be used to infer age of the atmosphere and an earlier composition. Measurements such as mean molecular weight, density profile, and composition near the surface could be used to interpret measurements from other instruments. Measurements at different altitudes could be used to determine how well the atmosphere was mixed.  
  
*Lander Imaging*  
Lander images were used to select samples for testing in the biology and physical properties investigations; they were also used to select sites for experiments using the sampler arm. Images recorded trenches that were dug, rocks that were overturned, footpads that penetrated the surface, and magnets that were covered by iron-bearing loose material. Images were used to determine the distribution and appearance of rocks and other materials near the landing sites, leading to improved understanding of both the local area and its history. Images of the atmosphere were used to estimate the opacity due to suspended particles; images of materials at the site were used to infer wind stress and rates of erosion. One unfulfilled objective of Lander imaging was detection of signs of life at each site.  
  
*Physical and Magnetic Properties*  
The sampler arm and sample collector on each Lander were used in conjunction with the Lander imaging system to determine density, cohesion, and other physical properties of the surface material. Repeated failure to collect rocks in the 1 cm size range suggested they are scarce, which has implications for creation and destruction of material in that size range. Visual evidence that magnets were saturated was important in estimating the concentration and state of iron in surface particles.  
  
*Seismology*  
The objectives of the Lander seismology investigation were to detect seismic events or to set limits on the activity level of Mars compared with Earth. One local event was detected at VL2, allowing estimation of crustal thickness and damping. In practice the seismology investigation supported the meteorology investigation since most seismic signals turned out to be caused by wind.  
  
*Meteorology*  
The Lander meteorology investigation sought to characterize local atmospheric conditions; those in turn would constrain global models. Diurnal and seasonal trends were sought; effects of dust storms were also measured.  
  
*Inorganic Chemistry*  
Elemental compositions of soils at each Lander site were determined using X-Ray Flourescence Spectrometers. Results were to be compared with compositions of terrestrial analogs but were found to be 'dissimilar to any single known mineral or rock type' (Toulmin et al., 1977). With addition of physical properties, the recent history of duricrust could be inferred. The fact that these materials were very similar at the two Landing sites can be used in modeling transport of dust and other small diameter particles.  
  
*Molecular Analysis*  
The Gas Chromatograph Mass Spectrometer (GCMS) gave composition of the atmosphere at each landing site; the result was consistent with the entry science composition. Isotope ratios were used to infer the amount of outgassing and, from that, the volume of volatiles which may have been lost from Mars over geologic time. Surface samples were analyzed in an attempt to detect organics and to measure the amount of water present. Both are questions important in the search for life.  
  
*Biology*  
The original objectives of the Lander biology experiment were to detect presumed Martian life forms by their release of metabolic products upon addition of heat, water, a dilute aqueous solution of simple nutrients, and a concentrated mixture of many organic compounds. After sudden and surprising positive results, which were not consistent with expectations or with other observations, the objectives were expanded to include abiotic interpretations.  
  
References

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