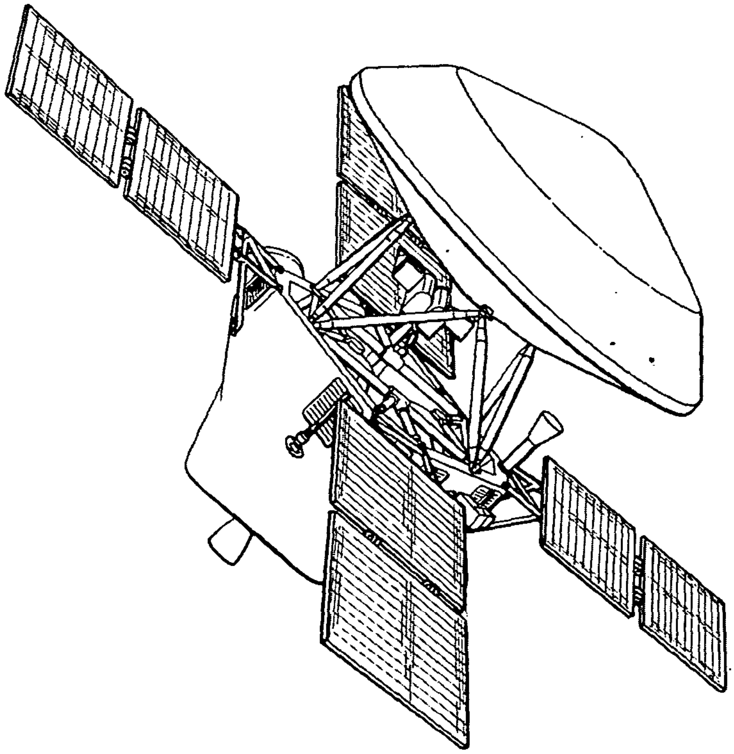
VIKING



PRESS KIT

National
Aeronautics and
Space
Administration

RELEASE NO: 75-183

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FOREWORD

By

President Gerald R. Ford

In only a few short years, we have learned more about the planets than in all the time that has gone before. We have taken the first closeup look at Jupiter. We have started to solve the great mysteries of Venus and only last year we photographed the surface of Mercury for the first time.

Through this closeup study of our planetary neighbors, we are gaining a better understanding of the planet on which we live and of its place and role in the universe -- and, most importantly, of its future.

The launch of Viking represents another bold step toward the betterment of all mankind. The scientific experiments to be conducted in the Martian atmosphere and on the planet's surface are expected to add still another significant dimension to our knowledge as we continue to probe the frontiers of space.

If all goes well, Viking will land on Mars about July 4, 1976, erect its antenna and "speak" to us here on Earth 200 million miles away. It is symbolic that this event will take place during America's Bicentennial anniversary. The hard work, skill and ingenuity that have gone into this most significant of technological tasks are in keeping with the pioneering spirit of America.

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For Release:
IMMEDIATE

Nicholas Panagakos
Headquarters, Washington, D.C.
(Phone: 202/755-3680)

Maurice Parker
Langley Research Center, Hampton, Va.
(Phone: 804/827-3966)

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VIKING MARS LAUNCH SET FOR AUGUST 11

America's most ambitious unmanned space venture will get under way next month with the launch of two Viking spacecraft to Mars.

The year-long, 815-million-kilometer (505-million-mile) journey will culminate with the landing of an automated laboratory on the surface of the planet in the summer of 1976.

The instrument-laden craft will take pictures and conduct a detailed scientific examination of Mars, including a search for life.

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The surface exploration of Mars--the planet most like Earth--should yield new knowledge on the origin and evolution of our solar system, and provide insights into the processes that have shaped our Earth.

The scientific venture begins about August 11, when Viking A is scheduled for launch from Cape Canaveral, Fla., aboard a Titan 3/Centaur rocket. Viking B is set to follow 10 days later.

The designations of Vikings A and B will be changed to Vikings 1 and 2 once each spacecraft has been successfully launched.

After a long, looping chase through space to overtake Mars, Viking 1 will arrive in Martian orbit about June 18, 1976, and may remain in orbit for as little as two weeks or as much as 50 days.

The most critical part of the mission begins when the four-ton Viking divides into an Orbiter and a Lander. The Orbiter, circling the planet at distances ranging from 1500 km (930 mi.) to 32,600 km (20,200 mi.), will map the surface and take Mars' atmospheric pulse, looking for signs of life.

The Lander will survive the flashing heat of entry through the planet's atmosphere, land gently on the surface, and conduct an intricate scientific examination.

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If all goes as planned, Lander 1 may touch down on Mars July 4, 1976, the 200th anniversary of the United States.

Viking 2 will arrive at Mars seven weeks after Viking 1, about August 7. Lander 2 will touch down about September 9.

Each Viking is packed with instruments that will be used to conduct 13 separate but related scientific investigations. Some instruments will do experiments, some will take measurements, others will observe, and a few will be combined into a single investigation that observes, measures and experiments.

Three investigations will be conducted from each Orbiter, eight from each Lander, and two more will use equipment aboard both spacecraft.

The Orbiter's three investigations will photograph the planet and map its atmospheric water vapor and thermal properties. Its instruments are two high-resolution television cameras, an infrared spectrometer and an infrared radiometer. They are mounted on a scan platform that is bore-sighted along a common axis to look at the same area of Mars.

The instruments will seek suitable landing sites and provide information on Mars' atmospheric water concentration, its surface temperature, any clouds or dust storms, and terrain topography and color.

The Orbiter instruments will continue to operate during the Lander portion of each mission.

During the Lander entry to Mars, several instruments and sensors will measure the atmosphere's structure and chemical composition. In the upper atmosphere, a mass spectrometer, a retarding potential analyzer and several sensors -- all mounted on the Lander's protective aeroshell -- will measure atmospheric composition, temperature, pressure and density.

Continued pressure, temperature and density variations will be measured in the lower atmosphere by sensors mounted on the Lander.

The Lander's cameras will take pictures of Mars from the surface, and Lander instruments will study the planet's biology, molecular structure, inorganic chemistry, meteorology and seismology, and physical and magnetic properties.

The Lander's surface sampler, attached to a furlable boom, will be extended to dig up soil samples for incubation and analysis inside the biology instrument's three metabolism and growth experiment chambers, in a gas chromatograph-mass spectrometer (GCMS) and an X-ray fluorescence spectrometer (XRFS).

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These three investigations are particularly important for understanding the biological makeup of Mars. They will also supply knowledge to chemists, planetologists and other scientists.

The meteorology instrument, located on a folding boom attached to the Lander, will periodically measure temperature, pressure, wind speed and direction during the mission.

A three-axis seismometer will measure any seismic activity that takes place during the mission, which should establish whether or not Mars is a very active planet.

The physical and magnetic properties of Mars will be studied with several small instruments and pieces of equipment located on the Lander.

The radio science investigations will make use of Orbiter and Lander communications equipment to measure Mars' gravitational field, determine its axis of rotation, measure surface properties, conduct certain relativity experiments, and pinpoint the locations of both Landers on Mars. A special radio link, the X-band, will be used to study charged ion and electron particles.

The Viking launch vehicle, the Titan III solid-and-liquid-fueled rocket and the liquid-fueled Centaur, is a relatively new combination, although both vehicles have been used separately for many space launches.

About 10 minutes after launch, the vehicle takes its Viking payload into an Earth parking orbit of 167 km (104 mi.). A second firing of the Centaur engine puts Viking into Trans-Mars Injection (TMI), starting the spacecraft on its long voyage to Mars.

As the cruise begins, the Orbiter adjusts its antennas toward Earth, spreads its solar panels, seeks the Sun, and acquires the bright star Canopus for guidance.

Tracked by the Deep Space Network on Earth, Viking quietly cruises toward Mars, powered by sunlight (and batteries when required). The Orbiter is the operating spacecraft during cruise, taking periodic pulse of the Lander stored in its aeroshell like a pupa inside its cocoon.

Both craft become very active once Mars orbit is achieved. The Orbiter begins its science investigations about 10 days before that time, then powers up the Lander in preparation for separation.

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Four landing sites have been selected for the Landers, two primary and two secondary spots, but mission controllers do not have to commit themselves to a site until they have had a chance to observe the planet for several days.

Prime target for Lander 1 is a region known as Chryse, located at the northeast end of a 4,800 km (3,000 mi.)-long rift canyon discovered by Mariner 9. The Chryse site is 19.5 degrees north and 34 degrees west.

Lander 2's primary landing site is Cydonia, in the Mare Acidalium region at the edge of the southernmost reaches of the north polar hood, a hazy veil that shrouds the region during winter and that some scientists think may carry moisture. Cydonia is 44.3 degrees north and 10 degrees west.

Lander 1's backup site is Tritonis Lacus, located at 20.5 degrees north and 252 degrees west. The Lander 2 backup is Alba, called the white region, lying 44.2 degrees north and 110 degrees west.

If any of these selected sites proves unpromising after Orbiter investigations, scientists on Earth will select other sites before committing the Landers.

Once separated from its Orbiter, the Lander will be aligned for Mars entry. Its aeroshell will then bear the heat of peak acceleration. Once slowed, the Lander's parachute will pop out to gently lower the craft almost to the surface. Retro engines will finally settle the Lander to its operating base.

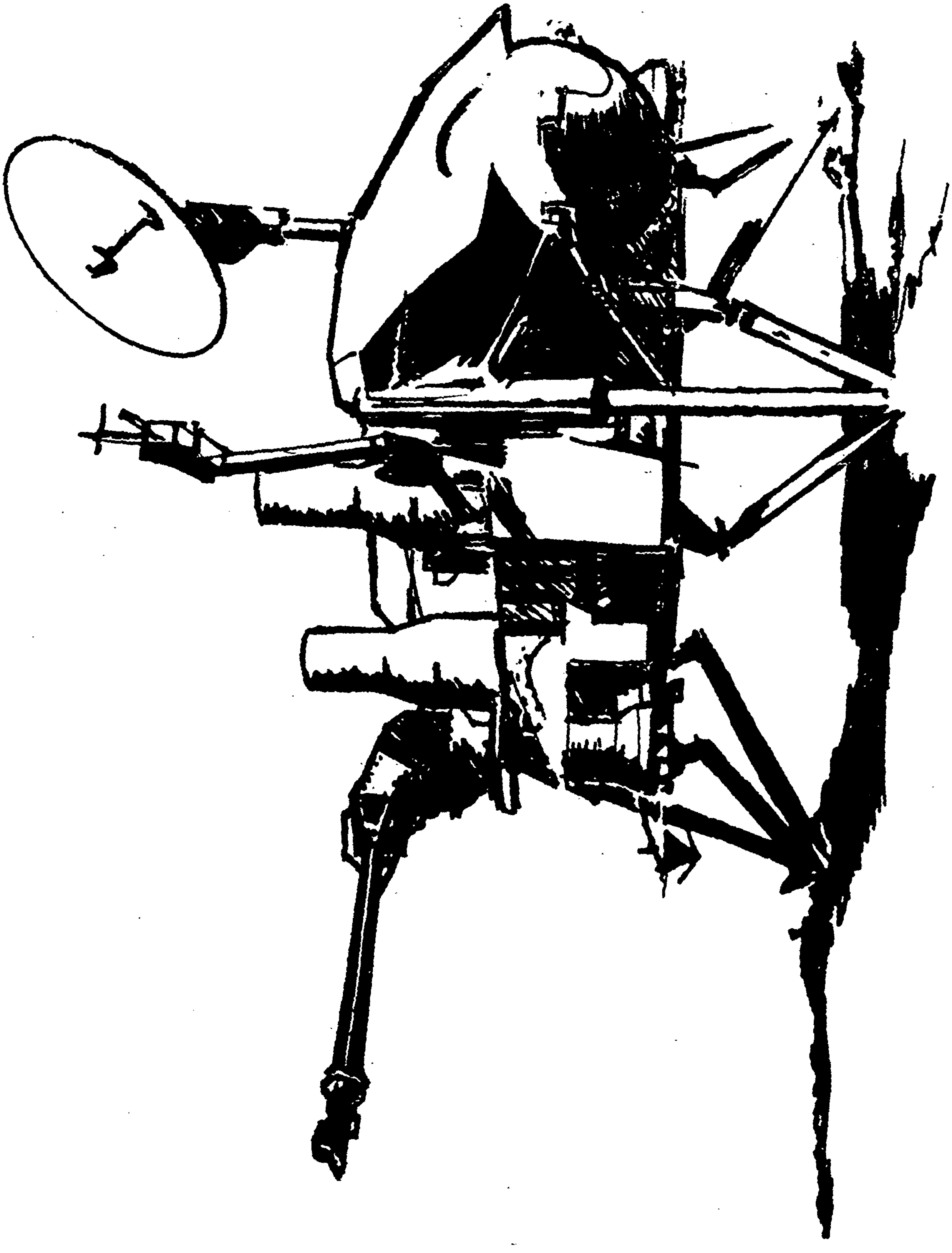
The Viking Project is managed by NASA's Langley Research Center, Hampton, Va. The Landers were built by Martin Marietta Aerospace of Denver, Colo., which also has integration responsibility for Viking. The Orbiters were built by NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

The Titan III/Centaur launch vehicle is managed by NASA's Lewis Research Center, Cleveland, Ohio, and was built by Martin Marietta Aerospace and the General Dynamics Corp.

Viking will be controlled from NASA's Kennedy Space Center, Fla., until completion of the launch phase. Control then shifts to JPL in Pasadena for the remainder of the missions.

Nerve center of the JPL operations is the Viking Mission Control and Computing Center (VMCCC), where the 700-member Viking Flight Team of engineers, scientists and technicians will maintain constant control of the four Viking spacecraft.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)



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THE SCIENTIFIC GOALS OF THE VIKING MISSION

Mars has excited man's imagination more than any other celestial body except the Sun and the Moon. Its unusual reddish color, which the ancients associated with fire and blood, gave rise to its being named for the Roman God of War.

The invention of the astronomical telescope by Galileo in 1608 opened a new era in the observation of the planet. Instead of appearing merely as a tiny disc, Mars' surface features could be resolved.

Christian Huygens made the first sketch in 1659 of the dark region, Syrtis Major ("giant quicksands"). Able to observe a distinguishable feature, Huygens could show that Mars rotated on a north-south axis like Earth, producing a day that was about half an hour longer than Earth's.

In 1666, the Italian astronomer Giovanni D. Cassini observed and sketched the Martian polar caps. Observers in the early 1700's noted changes in the surface appearance in a matter of hours, probably caused by dust storms, now known to rage periodically. In 1783, William Herschel observed that Mars' axis of rotation is inclined to its orbital plane at about the same extent as Earth's, revealing that long-term changes were often associated with seasons that would result from such inclination.

In the 17th and 18th centuries, it was commonly accepted that Mars and the other planets were inhabited, but the real excitement was created by Giovanni Schiaparelli and Percival Lowell between 1877 and 1920. As a result of extensive observations, beginning with the favorable apparition of 1877, Schiaparelli constructed detailed maps with many features, including a number of dark, almost straight lines, some of them hundreds of kilometers long. He referred to them as "canali" or channels. Through mistranslation, they became "canals" and the idea of civilized societies was propagated.

Lowell's firm opinion that the canals were not natural features but the work of "intelligent creatures, alike to us in spirit but not in form" contributed to the colorful literature. To pursue his interest in the canals and Mars, he founded the Lowell Observatory near Flagstaff, Ariz., in 1894, and his writings about the canals and possible life on Mars created great public excitement near the turn of the 20th Century.

- more -

Speculation about intelligent life on Mars continued through the first part of the century, with no possibility of an unequivocal resolution, but a gradual tendency developed among scientists to be very skeptical of the likelihood.

The skepticism was reinforced by the results of two Mariner flyby missions in 1965 and 1969. The limited coverage of only about 10 per cent of the Martian surface by flyby photography indicated that Mars was a lunar-like planet with a uniformly cratered surface.

In 1971-72 the Mariner 9 orbiter revealed a completely new and different face of Mars. Whereas the flyby coverage had seen only a single geologic regime in the cratered highlands of the southern hemisphere, Mariner 9 revealed gigantic volcanoes, a rift valley that extends a fifth of the way around the planet's circumference, and possible evidence of flowing liquid water sometime in the past. Also revealed were layered terrain in the polar regions, and the effects of dust moved by winds of several hundred kilometers an hour.

In short, Mariner 9's 7,000 detailed pictures revealed a dynamic, evolving Mars completely different from the lunar-like planet suggested by the flyby evidence. That eminently successful Orbiter mission showed a fascinating subject for scientific study and also provided the maps from which the Viking sites have been selected.

The scientific goal of the Viking missions is to "increase our knowledge of the planet Mars with special emphasis on the search for evidence of extra-terrestrial life." The scientific questions deal with the atmosphere, the surface, the planetary body, and the question of bio-organic evolution. This goal ultimately means understanding the history of the planet.

The physical and chemical composition of the atmosphere and its dynamics are of considerable interest, not only because they will extend our understanding of planetary atmospheric sciences, but because of the intense focus of interest in contemporary terrestrial atmospheric problems.

We want to understand how to model our own atmosphere more accurately, and we want to know how the solar wind interacts with the upper atmosphere; to do this we must know more about its chemistry, the composition of neutral gases and charged particles.

We want to reconstruct the physics of the atmosphere and determine its density profile. We want to measure the atmosphere down to the surface and follow its changes, daily and seasonally. From these data may come clues to the atmospheric processes that have been taking place and determining the planet's character.

Of special interest is the question of water on Mars. Scientific literature is sparse in data and rich in speculation. It is known that there is water in the Mars atmosphere, but the total pressure of the atmosphere (about one per cent of Earth's) will not sustain any large bodies of liquid water. Nevertheless, the presence of braided channels suggests to many geologists that they are the result of previous periods of flowing water. This idea of episodic water suggests a very dynamic planet.

The geology of Mars has attracted great interest among planetologists because of the wide variety of features seen in the Mariner photos.

Volcanologists are intrigued by the high concentration of volcanoes near the Tharsis ridge. Scientists who study erosion are fascinated with the great rift valley (Valles Marineris) that is 100 kilometers (62 miles) wide, 3,000 km (1,800 mi.) long and 6 km (4 mi.) deep. Some geologists have focused on the polar region, which appears to be stratified terrain. The pole resembles a rosette; it has been suggested that this is evidence of precession (wobbling) of the poles. One important question that Viking is not likely to answer, due to payload limitation, is the age of the planet.

One mystery that Viking may solve is the fate of nitrogen. So far there has been no report of nitrogen on Mars. Has it been lost by outgassing? Is it locked up in the surface as nitrates or in some organic form? Chemists and biologists both look upon nitrogen, among the most cosmically abundant of the elements, as vitally important because of the clues it provides to the evolution of the atmosphere and of the planet itself.

There is the final question of life on Mars. This may be one of the most important scientific questions of our time. It is also one of the most difficult to answer.

A negative answer does not prove there is no life on Mars. The landing site may have been in the wrong place, during the wrong season, or we may have conducted the wrong experiments. Many scientists still think there is a low probability of life on Mars.

How can this extensive effort to perform the search be justified? First, it must be aknowledged that there is no evidence at present, pro or con, of the existence of life on Mars. And what we seek is evidence. The remarkable thing is that we live at a time in which we can make this first test for life, and also assemble a great store of knowledge of the planet.

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As has been so well stated of the importance of this goal: "The discovery of life on another planet would be one of the momentous events of human history."

(Dr. N. H. Horowitz, Professor
of Biology, Cal Tech)

Finally, we regard as of utmost importance a knowledge of the organic character of the planet. Whether life has begun or not, it is critical to our concept of chemical evolution to determine the path of carbon chemistry. Mars offers the first opportunity to gain another perspective in the cosmic history of planetary chemistry.

The scientific investigations of Viking were intentionally selected to complement one another. The Orbiter science instruments are used to help select landing sites for the Lander investigations. The Lander cameras help select soil samples for the chemical and biological analyses. The meteorology data are used to determine periods of quiet for the seismology experiment. The atmospheric data are used in determining the chemistry, which in turn is used in understanding the biological result.

But Viking's greatest asset is its flexibility. The scientist-engineer teams will be interacting, hour by hour, during the several months that Viking will be returning data. Every day will bring new discoveries and fresh ideas for improving the mission to extract the maximum benefit from this effort.

G. A. Soffen, Project Scientist
G. D. Sands, Associate Project Scientist
C. Snyder, Orbiter Scientist

-more-

VIKING SCIENCE INVESTIGATIONS

Three science investigations use instruments located on the Orbiter: orbiter imaging, atmospheric water vapor mapping and thermal mapping. One investigation, located on the Lander, is conducted while the Lander is descending to the surface of Mars: entry science.

Eight other investigations are conducted from the Lander: lander imaging, biology, molecular analysis, inorganic chemical analysis, meteorology, seismology, physical properties and magnetic properties. One investigation, radio science, has no specific instrument, but uses the Viking telecommunications system to obtain data and do certain experiments.

Orbiter Imaging

The orbiter imaging investigation has four objectives:

- Add to the geologic knowledge of Mars by providing high-resolution photographic coverage of scientifically interesting areas of the Martian surface.
- Add to the knowledge of dynamic processes on Mars by observing the planet during seasons never before seen.
- Provide high-resolution imaging data of the Viking landing sites before landing so site safety and scientific desirability can be assessed.
- Monitor the region around each landing site after landing so the dynamic environment in which Lander experiments are done is better understood.

The Visual Imaging Subsystem (VIS) consists of two identical cameras, mounted side by side on the Orbiter's scan platform.

The cameras will be used in different ways as the mission progresses. As Viking 1 approaches Mars, the planet will be photographed in three colors. The planet's atmosphere is expected to be clear, in contrast to the 1971 Mariner 9's approach to Mars, allowing the first useful approach pictures since 1969.

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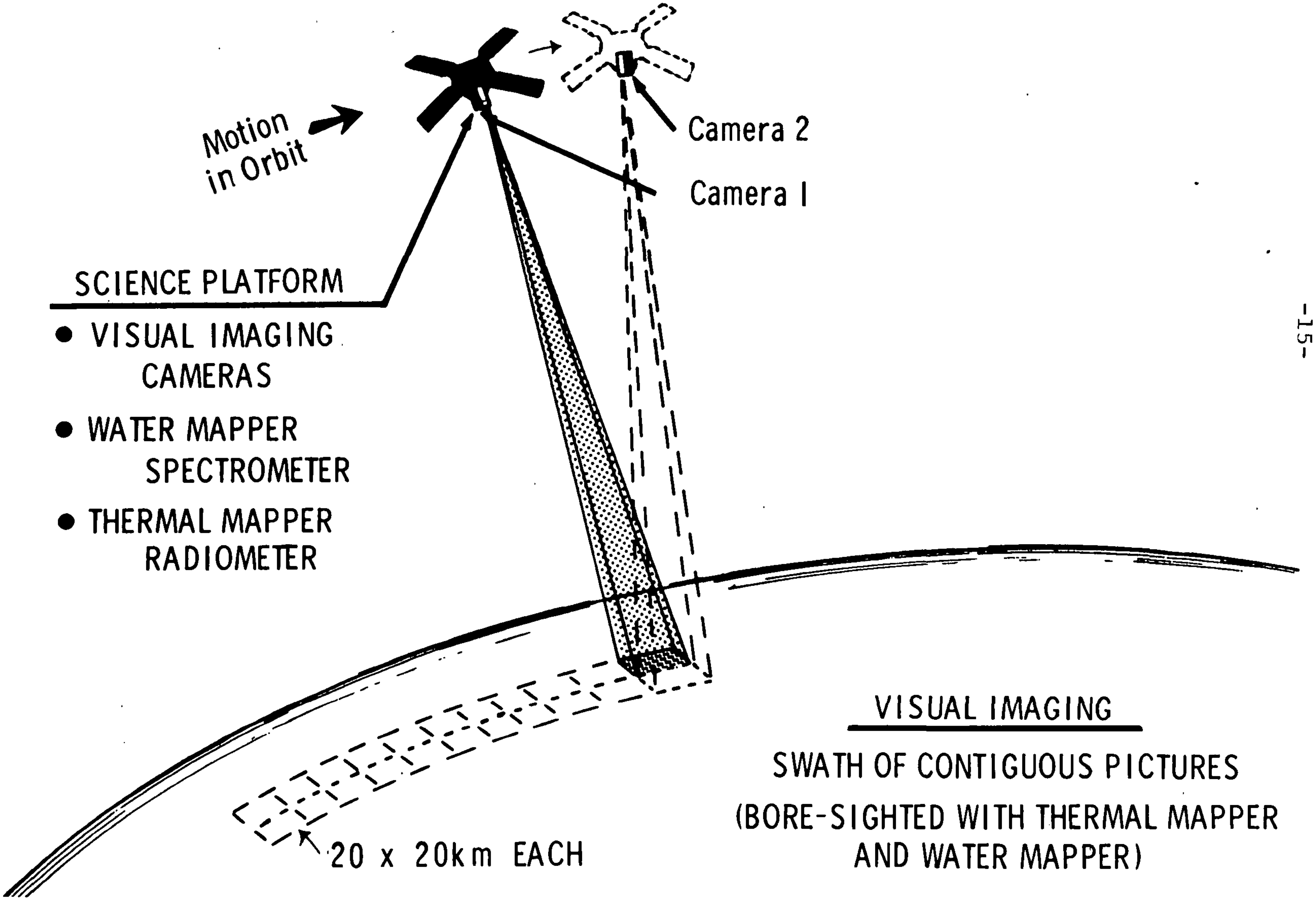
ORBITER IMAGERY COVERAGE



Between Mars orbit insertion and landing, the cameras will be used almost exclusively for examining the landing site. The intent is to characterize in detail terrain at the site and make estimates of slopes at the Lander scale; examine the region of the site for both long- and short-term changes that might indicate wind action; and monitor any atmospheric activity.

For most of the period after landing, the Orbiter will be a communications relay link for the Lander and its orbit will remain synchronized with the Lander; i.e., it will pass over the Lander at the same time each day. Areas visible from the synchronous orbit will be systematically photographed during this time. Areas covered will include the large channel system upstream from the primary landing site, chaotic terrain from which many of the channels seem to originate, and areas of greatest canyon development.

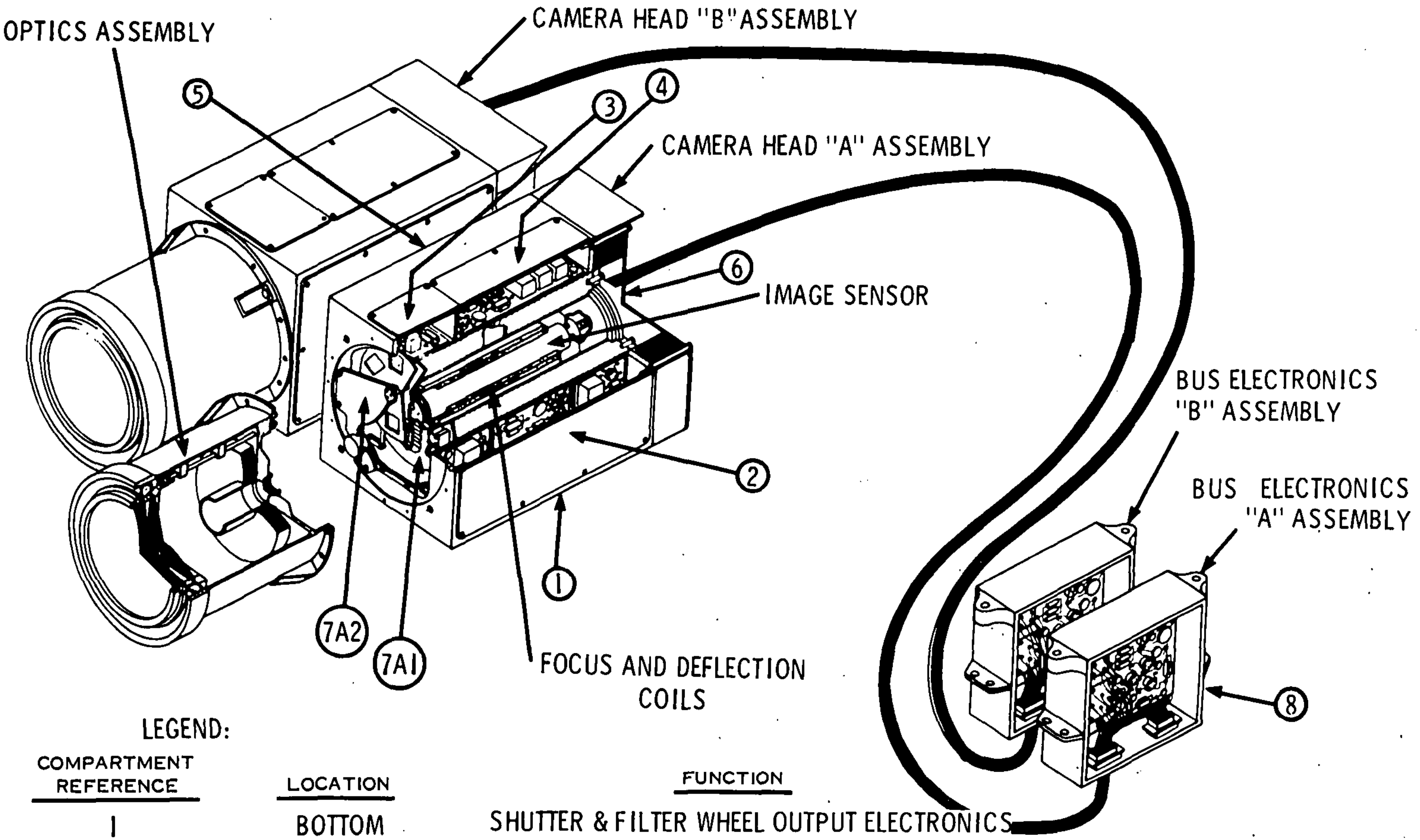
The detailed observations are expected to lead to a better understanding of the origin of these features, and aid in interpreting Lander data. At the same time, activity will be monitored over all the planet that is visible from apoapsis. Any areas of unusual activity will also be examined in detail. The orbital period will be changed for short periods of time to allow the rest of the planet to be seen. During these periods, observations will be made of large volcanoes, channels and other features.

Viking 2 will follow a similar plan, except for one major difference: shortly after Lander 2 lands, the orbital inclination of Orbiter 2 will be increased to perform polar observations. After the inclination change, a period of systematic mapping of the North Polar region is anticipated, similar to that undertaken in the canyon lands by Orbiter 1.

The succession of deposits in the polar regions, their thicknesses and relative ages, will be determined with these observations. This portion of the mission is particularly important because of its potential for unraveling past climatic changes and assessing the volatile inventory (primarily carbon dioxide and water) of the planet.

Each visual imaging subsystem consists of a telescope, a camera head and supporting electronics. The telescope focuses an image of the scene being viewed on the faceplate of a vidicon within the camera head. When a shutter between telescope and vidicon is activated, an imprint of the scene is left on the vidicon faceplate as a variable electrostatic charge. The faceplate is then scanned with an electronic beam and variations in charge are read in parallel onto a seven-track tape recorder.

ORBITER VISUAL IMAGING SYSTEM (VIS) DIAGRAM



LEGEND:

COMPARTMENT REFERENCE	LOCATION	FUNCTION
1	BOTTOM	SHUTTER & FILTER WHEEL OUTPUT ELECTRONICS
2	LEFT SIDE	DIGITAL SEQUENCING LOGIC
3	TOP FRONT	VIDEO AMPLIFIER CHAIN
4	TOP REAR	ANALOG TO DIGITAL CONVERTER
5	RIGHT SIDE	VIDICON ANALOG CONTROLS
6	REAR	VIDICON POWER SUPPLY
7	FRONT (A1)	SHUTTER ASSEMBLY
	FRONT (A2)	FILTER WHEEL ASSEMBLY
8	BUS ELECTRONICS	LOW VOLTAGE POWER SUPPLY

Data are later relayed to Earth one track at a time. A picture is assembled on Earth as an array of pixels (picture elements), each pixel representing the charge at a point on the faceplate (i.e., the brightness at a point in the image). As data are read back, the pixel array is slowly assembled, complete only when all seven tracks have been read. The image is then displayed on a video screen and film copies are made.

The telescope has an all-spherical, catadioptric cassegrain lens with a 475-millimeter (18.7-inch) focal length. The sensor is a 38 mm (1.5-in.) selenium vidicon. A mechanical focal plane tape allows exposure times from 0.003 to 2.7 seconds. Between the vidicon and telescope is a filter wheel that provides color images. Each frame has 8.7 million bits (binary digits).

The cameras are mounted on the Orbiter with a slight offset and the timing of each shutter is offset by one-half-frame time so the cameras view slightly different fields and shutter alternately. The combined effect is to produce a swath of adjacent pictures as the motion of the spacecraft moves the fields of view across the surface of Mars. The resolution at the lowest part in the orbit (1,500 km or 810 mi.) is 37.5 meters (124 ft.) per pixel. This would allow an object the size of a football field to be resolved.

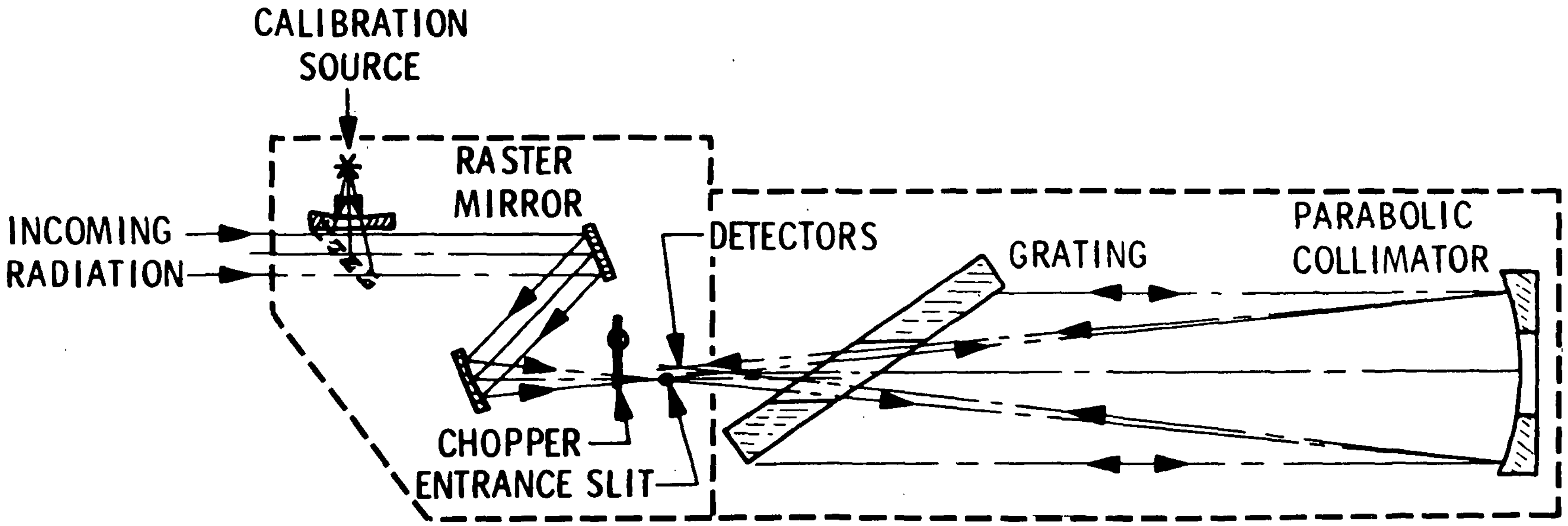
The Orbiter Imaging investigation team leader is Dr. Michael H. Carr of the U.S. Geological Survey, Menlo Park, Calif.

Water Vapor Mapping

Water vapor is a minor constituent of the Martian atmosphere. Its presence was discovered about 10 years ago from Earth-based telescopic observations. They indicated that the vapor varies seasonally, appearing and disappearing with the recession and growth of the polar cap in each hemisphere, and diurnally (daily), with its maximum close to local (Mars) noon (Mars time). Some evidence was found that water vapor is contained in the lowest layers of the atmosphere, perhaps within the first 1,000 m (3,300 ft.) above the surface.

The abundance of atmospheric water vapor is usually given in units of "precipitable microns," a measure of the thickness of the ice layer or liquid that would be formed if all the vapor in the atmospheric column above the surface were condensed out.

OPTICAL CONFIGURATION DIAGRAM
(MAWD)



Compared with Earth, Mars' atmosphere contains very little water. The atmosphere on Earth typically holds the equivalent of one or two centimeters (0.4 to 0.8 inches) of water, but the most water observed on Mars is only a fraction of one per cent of Earth's or 50 precipitable microns (0.002 inches).

The Mars atmosphere is a hundred times thinner than Earth's, however, and its mean or average temperature is considerably lower. The relative water concentrations, therefore, are not very different (about one part per thousand) and the relative humidity on Mars can be significant at times. It is misleading to refer to Mars as a "dry" planet.

Yet in terms of total planetary abundance, evidence suggests that there is very little water on or above the planet's surface in the form of atmospheric vapor or surface ice. Since water is cosmically one of the more abundant molecules, the question arises: Has Mars lost most of its water during its evolution, or is water present beneath the surface, a subsurface shell of ice or permafrost, or perhaps held deeper in the interior to be released by thermal and seismic activity at some future time?

Mariner spacecraft observations of Mars in 1969 and 1971 showed that while the polar hoods are predominantly frozen carbon dioxide, the visible caps left after the carbon dioxide vaporizes are water crystals.

Mariner results revealed other intriguing facts related to the history of water on Mars: The atmosphere loses hydrogen and oxygen atoms to space at a slow but steady rate, and in the relative proportions with which they make up the water molecule. Surface features exist that appear to have been formed by flowing liquid; the latter are quite different from the river-like features caused by lava flows; they appear to be wide braided channels formed from an earlier period of flooding by a more mobile liquid than volcanic lava.

Again a question: Are we now seeing the last disappearing remnants of water that was once much more plentiful on the planet, or is Mars locked in an ice age that has frozen out most of its water in the polar caps or beneath a layer of surface dust?

Martian water clearly holds many clues to the planet's history. By studying the daily and seasonal appearance and disappearance of water vapor in more detail than is possible from Earth by mapping its global distribution, and by determining the locations and mechanisms of its release into the atmosphere, scientists should understand more clearly the present water regime, and perhaps unravel some of the mystery surrounding past conditions on the planet.

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In the context of Martian biology, such clarification may have great significance in establishing the existence, now or in the past, of an environment favorable to the survival and proliferation of living organisms. This presumes that Martian life is dependent on the availability of water as is life on Earth.

The Viking water vapor-mapping observations will be made with an infrared grating spectrometer mounted on the Orbiter scan platform, boresighted with the television cameras and the Infrared Thermal Mapper (IRTM). The spectrometer, called the Mars Atmospheric Water Detector (MAWD), measures solar infrared radiation reflected from the surface of the planet after it has passed through the atmosphere.

The instrument selects narrow spectral intervals coincident with characteristic water vapor absorptions in the 1.4-micron wavelength region of the spectrum. Variations in the intensity of radiation received by the detectors provide a direct measure of the amount of water vapor in the atmospheric path traversed by the solar rays.

The sensitivity of the instrument enables amounts of water from a minimum of a precipitable micron to a maximum of 1,000 microns to be measured. The precise wavelengths of radiation to which the detectors respond are also selected so instrument data can be used to derive atmospheric pressure at the level where the bulk of the water vapor resides, providing an indication of its height above the surface.

At the lowest point in the orbit, the field of view of the detector is a rectangle 3 by 20 km (1.9 by 12.4 mi.) on the planet's surface. This field is swept back and forth, perpendicular to the ground track of the Orbiter, by an auxiliary mirror at the entrance aperture of the instrument. In this way the water vapor over selected areas of the planet can be mapped.

A small ground-based computer, dedicated to the use of the two orbiting infrared isntruments, directly reduce data to contour plots of the water vapor abundance and pressure.

During the initial orbits, and particularly through the landing site certification phase of the missions before Lander separation, MAWD observations will concentrate on an area within a few hundred kilometers around the landing sites, to help in site certification and to complement landed science measurements.

In later phases of the mission, observations will be extended to obtain global coverage of water vapor distribution and its variation with time-of-day and seasonal progression. The search for regions of unusually high water content will be emphasized during these later stages, and areas of special interest will be studied, including volcanic ridges, the edge of the polar cap and selected topographic features.

The Water Vapor Mapping investigation team leader is Dr. Crofton B. (Barney) Farmer of the Jet Propulsion Laboratory.

Thermal Mapping

The Thermal Mapping investigation is designed to obtain temperature measurements of areas on the surface of Mars. It obtains the temperature radiometrically with an Infrared Thermal Mapper (IRTM) instrument.

Information obtained by the thermal mapper will contribute to the study of the surface and atmosphere of Mars, which is similar to and in some ways simpler to study than Earth. Mars appears to be geologically younger, and clearly is undergoing major changes. Studies of Martian geology and meteorology can have implications in tectonics (the study of crustal forces), volcanology and understanding weathering and mineral deposition.

Just as fine beach sand cools rapidly in the evening while large rocks remain warm, daily temperature variation of the Martian surface indicates the size of individual surface particles, although the thermal mapper necessarily obtains an average value over many square kilometers. Measurements obtained just before sunrise are especially valuable (the detectors can sense the weak heat radiation from the dark part of the planet), since at that time the greatest temperature differences occur between solid and fine-grained material.

One detector is used to measure the upper atmospheric temperature. That information may be combined with surface temperatures to permit construction of meteorological models. An understanding of the important Martian wind circulation depends on such models.

Data received from the thermal mapper are intended to help establish and evaluate the site for the Viking Lander. Martian organisms would probably be affected by local water distribution and temperatures of the soil and air; these factors are either measured by the radiometer or are dependent on the soil particle characteristics determined by the thermal mapper.

ORBITER IRTM DIAGRAM

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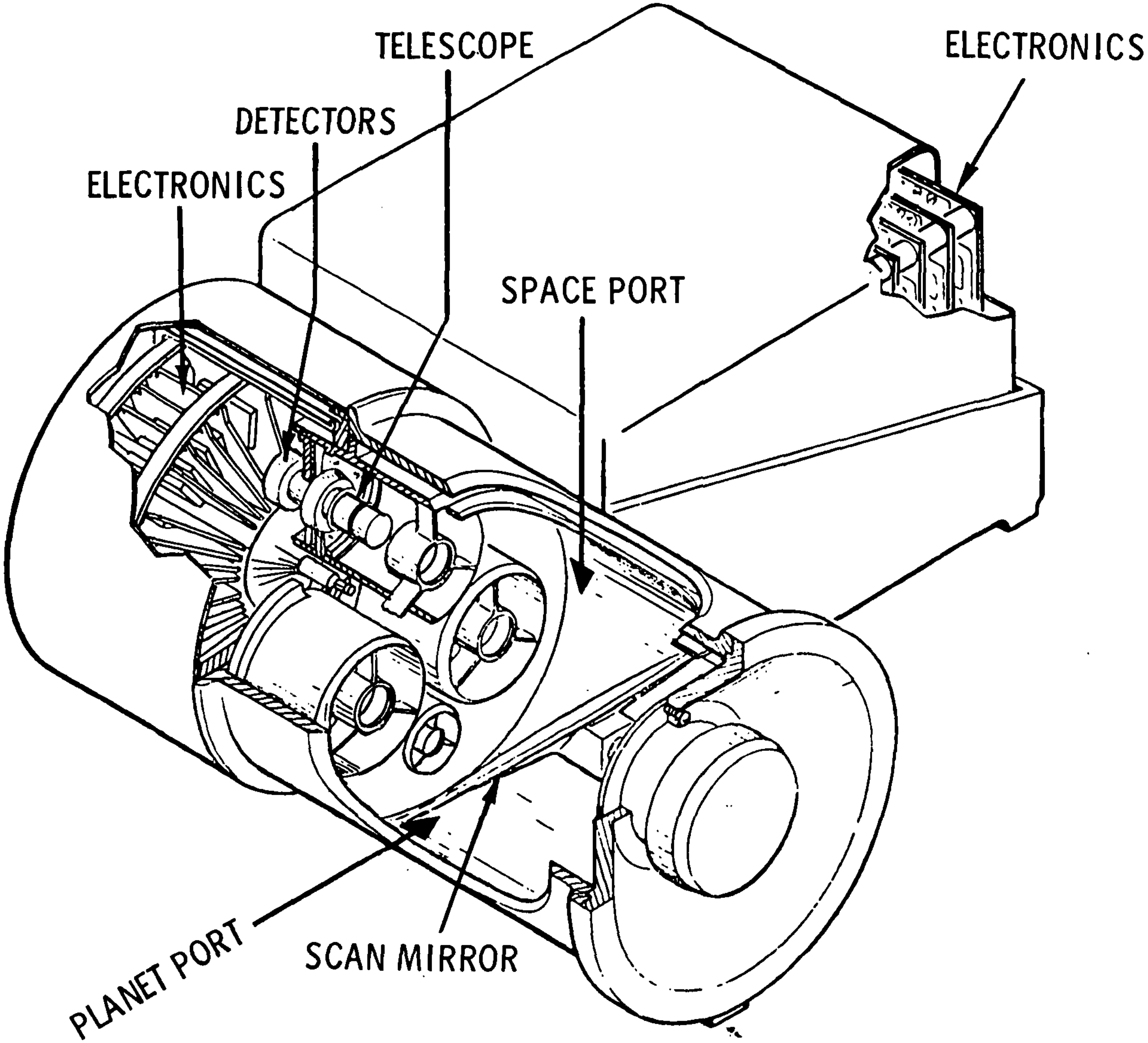


The Infrared Thermal Mapper is a multi-channel radiometer mounted on the Orbiter's scan platform. It accurately measures the temperatures of the Martian surface and upper atmosphere, and also the amount of sunlight reflected by the planet. Four small telescopes, each with seven sensitive infrared detectors, are aimed parallel to the Visual Imaging optical axis. Differences of one degree Celsius (about 1.8 degrees Fahrenheit) can be measured throughout the expected temperature range of minus 130 degrees C to plus 57 degrees C (minus 202 to 135 degrees F). The instrument is 20 by 25 by 30 cn (8x10x12 in.) and has a minimum spatial resolution of 8 km (5 statute miles) on the surface.

The large number of detectors (28) is chosen to provide good coverage of the Martian surface, and to allow several infrared "colors" to be sampled. Differences in the apparent brightness of a spot on the planet in the various colors imply what kinds of rocks (granite, basalt, etc.) are present. The temperatures themselves may indicate the composition of clouds and the presence of dust in the atmosphere.

The spatial resolution available to the thermal mapper will permit reliable determination of the frost composition comprising the polar caps. The close spacing of infrared detectors and the spacecraft scanning mode improves the ability to identify possible local effects such as current volcanic activity or water condensation.

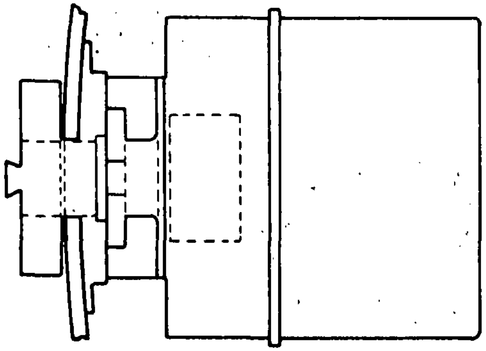
The Thermal Mapping investigation team leader is Dr. Hugh H. Kieffer of the University of California at Los Angeles.

Entry Science

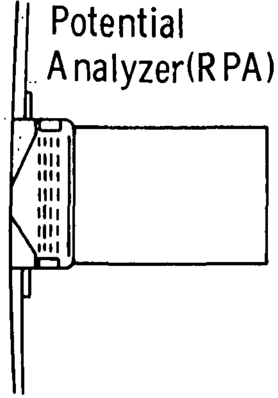
The Entry Science investigation is concerned with direct measurements of the Martian atmosphere from the time the Lander and Orbiter separate until the Lander touches down on the planet's surface. Knowledge of a planet's atmosphere, both neutral and ionized components tells much about the planet's physical and chemical evolution, and it increases understanding of the history of all planets, including that of Earth.

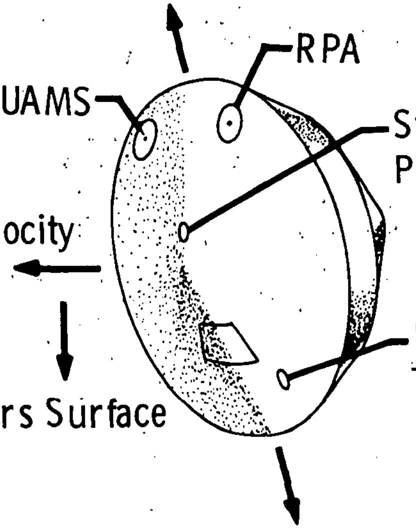
ENTRY SCIENCES AEROSHELL INSTRUMENTATION

Upper Atmospheric Mass Spectrometer (UAMS)

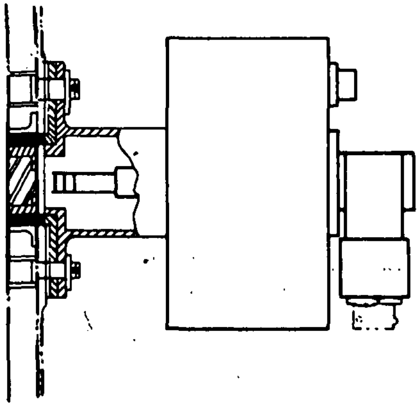


Retarding Potential Analyzer(RPA)



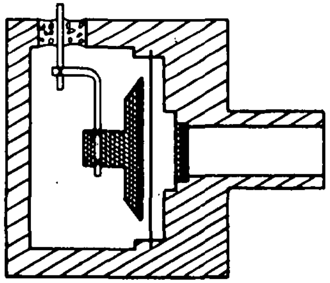


Recovery Temperature Instrument

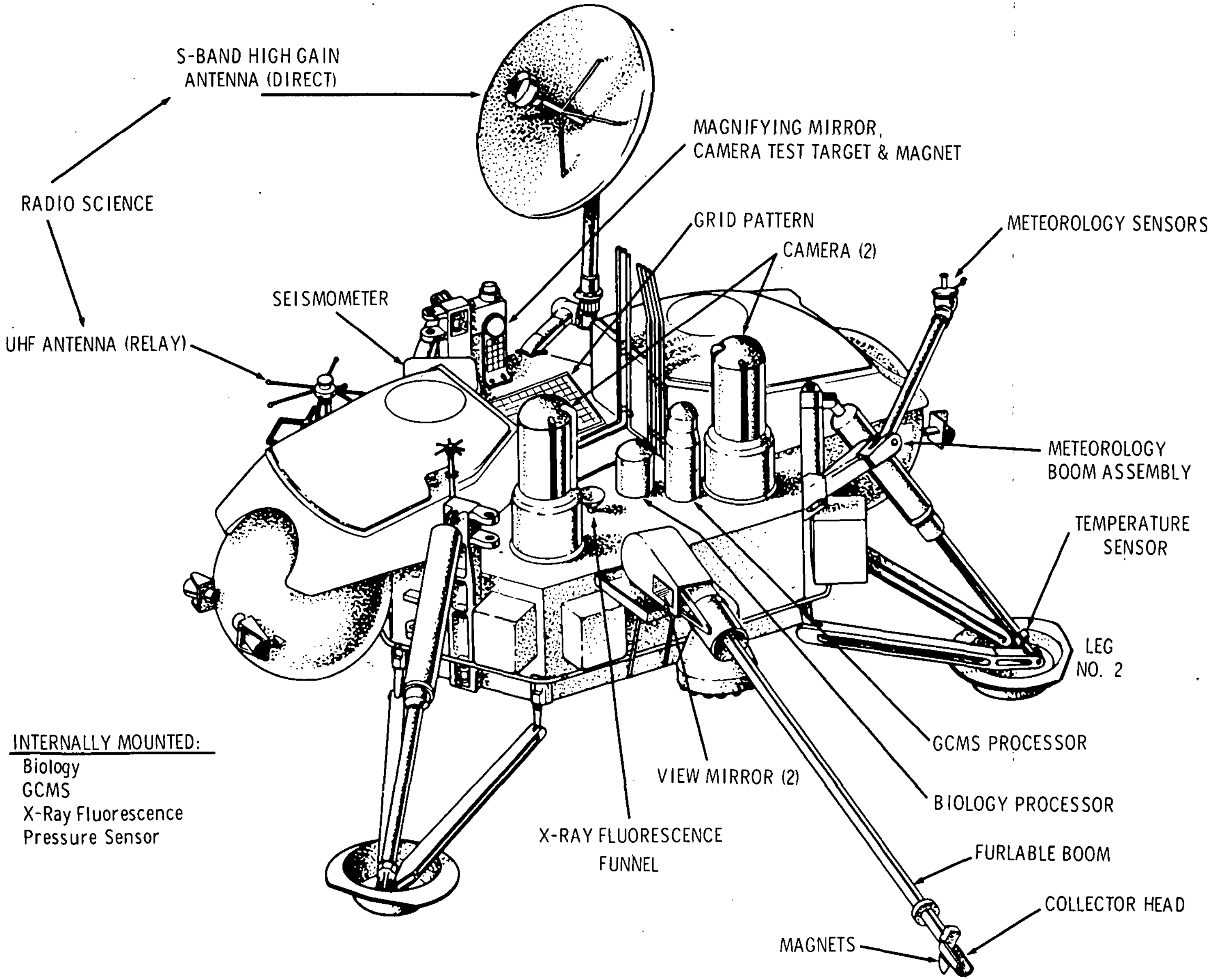


NOTE:
ACCELEROMETERS LOCATED INTERNALLY IN THE INERTIAL REFERENCE UNIT (GUIDANCE & CONTROL S/S)

Stagnation Pressure Sensor Cell



VIKING LANDED SCIENCE CONFIGURATION



INTERNALLY MOUNTED:
Biology
GCMS
X-Ray Fluorescence
Pressure Sensor

The question of the atmospheric composition of Mars is of immediate interest to scientists. Nitrogen, believed essential to the existence of life, has never been detected on Mars by remote sensing methods, either because it is not present or because of the low sensitivity of the measurement methods. Measurements of atmospheric pressure and temperature, plus winds, are important in understanding the meteorology, just as observations made with weather balloons in Earth's atmosphere supplement surface observations.

Upper Atmosphere. Studies of the Martian upper atmosphere composition begin shortly after the Lander leaves the Orbiter. The first measurements are made so high above the surface that only charged particles can be detected. These measurements are made with a Retarding Potential Analyzer (RPA) that will measure electron and ion concentrations and temperatures of these components. Measurements continue down to about 100 km (60 mi.) above the planet's surface, where the pressure becomes too high for the instrument to operate.

On Mars, which has a weak magnetic field compared with that of Earth, charged particles streaming from the Sun (called the solar wind) and interacting with the upper atmosphere may be important in determining the nature of the lower atmosphere and, therefore, the conditions for life.

At the very highest altitudes, the analyzer will study the interaction of the solar wind with the Martian atmosphere. Measurements at lower altitudes will make important contributions to knowledge of the interaction of sunlight with atmospheric gases, a matter of great significance in understanding the photochemical reactions that take place in all planetary atmospheres, including Earth's.

The analyzer will make measurements several thousand kilometers above the Martian surface, but the neutral atmosphere at high altitudes is so thin that measurements will not begin until the Lander drops to an altitude of around 300 km (180 mi.) above the surface. Measurements on the neutral constituents of the atmosphere are made with the Upper Atmosphere Mass Spectrometer (UAMS).

The mass spectrometer will sample and analyze the atmosphere as the Lander passes through. Inside the instrument, the gas to be analyzed is ionized by an electron beam, and the ions formed are sent through an appropriate combination of electric and magnetic fields to determine the amounts of the various molecular weights by which the various gases can be identified.

From remote measurements, carbon dioxide is known to be the principal atmospheric constituent on Mars. The mass spectrometer should be able to detect 0.1 per cent of nitrogen and even a smaller amount of argon. Argon's principal isotope is a radioactive decay product of potassium, an important constituent in many minerals. About one per cent of the Earth's atmosphere has come from the radioactive decay of potassium in the Earth's crust.

The mass spectrometer will also look for molecular and atomic oxygen, carbon monoxide and other common gases that may be present in the Martian atmosphere. It may tell if the isotope composition in elements such as carbon, oxygen and argon is the same as on Earth, thereby providing measurements needed to understand planetary evolution.

Lower Atmosphere. The lower atmosphere begins at about 100 km (60 mi.) altitude, where the analyzer and mass spectrometer become inoperative. The bulk of the atmospheric gases reside below this altitude. On Mars the surface atmospheric pressure is only about 1.5 per cent as great as on Earth.

Measurements of Mars' surface pressure are all based on remote observations, principally alteration by the atmosphere of radio waves from Mariner spacecraft as they flew behind the planet. Viking will obtain direct pressure and temperature measurements in the lower atmosphere and on the surface.

In passing through the atmosphere from 100 km (60 mi.) to the surface, the Landers will obtain profiles of the properties of the atmosphere: pressure, density and temperature. First measurements will be by sensitive determination of the aerodynamic retardation of the Lander, from which atmospheric density can be derived.

The density profile with altitude permits the weight (pressure) of the atmosphere above any given level to be calculated. Given atmospheric composition, pressure and density will define the structure of the atmosphere from roughly 100 to 25 km (60 to 15 mi.) altitude. Below 25 km, sensors can be deployed to directly measure the pressure and temperature, although these measurements have to be done with specially designed sensors because of the low pressure in the atmosphere.

The importance of the profiles is that they are determined by solar energy absorption and vertical heat flow. Heat can be transported either radiatively or convectively (by infrared emission or absorption) or by currents and winds.

The atmosphere of Mars appears to be windy compared to Earth's lower atmosphere. This is a result of the low density of the atmosphere, which permits it to change temperature rapidly, and causes large temperature variations from day to night and seasonally. There are large contrasts in temperature of the atmosphere, precisely the condition to create winds.

One evidence for high winds is the frequently severe dust storms, such as the long-lasting one that greeted Mariner 9. These storms are a puzzle, since it takes even stronger winds than those now calculated by computer models of the atmospheric circulation (18 to 46 m per second; 40 to 100 mi. per hour) to raise dust in this tenuous atmosphere.

The vertical profiles of temperature will provide additional evidence of the thermal balance of the atmosphere and, it is hoped, of forces that drive the winds. Winds also will be measured directly in the parachute phase by tracking the motion of the Lander over the surface as it drifts, carried by local winds. These measurements will extend to an altitude of 6 km (3.7 mi.).

The Entry Science investigation team leader is Dr. Alfred O. C. Nier of the University of Minnesota.

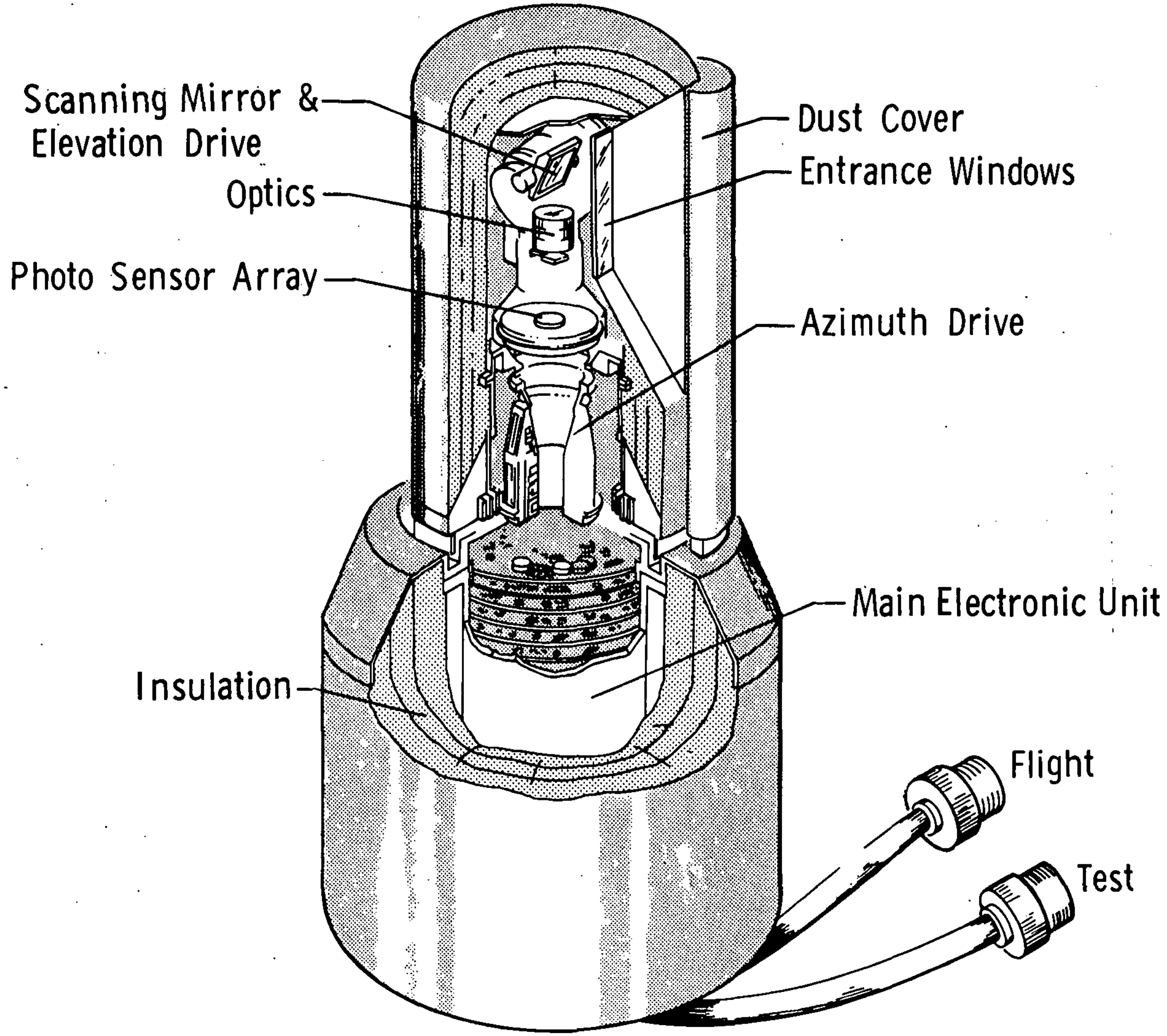
Lander Imaging

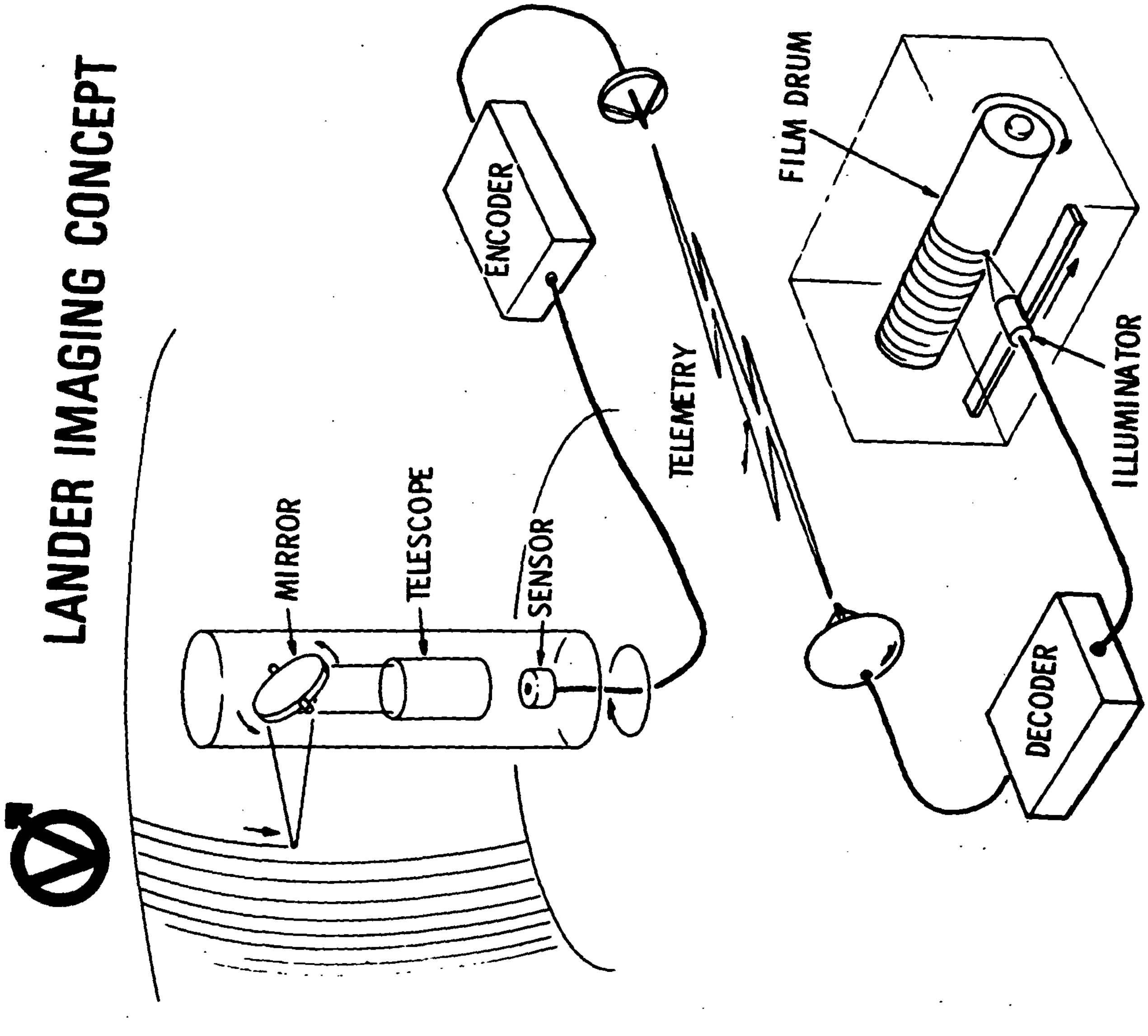
As a person depends on sight for learning about the world, so cameras will serve as the eyes of the Lander and, indirectly, of the Viking scientists.

Pictures of the region near the Lander will be studied to select a suitable site for acquiring samples that will be analyzed by other Lander instruments. The cameras will also record that the samples have been correctly picked up and delivered. From time to time, the cameras will examine diferent parts of the Lander to see that components are operating correctly.

One category of the Lander imaging investigation is the study of general geology or topography. Pictures of the Martian surface visible to the cameras are of the highest scientific priority. The first pictures will be panoramic surveys, and then regions of particular interest will be imaged in high resolution, in color and in infrared.

LANDER CAMERA SYSTEM DIAGRAM




LANDER IMAGING CONCEPT
MIRROR
TELESCOPE
SENSOR
ENCODER
TELEMETRY
FILM DRUM
ILLUMINATOR
DECODER

Stereoscopic views are obtained by photographing the same object with two cameras, providing photos in which three-dimensional shapes can be distinctly resolved. Putting together this information, scientists can tell much about the character of the Martian surface and the processes that have shaped it.

One can imagine finding shock-lithified rocks (as on the Moon), igneous boulders, wind-shaped boulders (ventifacts), sand ripples, or a lag gravel deposit. Each of these possible objects could be resolved in pictures; each would bespeak a particular kind of surface modification.

The advantage of operational flexibility is important. Scientists will study the first pictures and, on the basis of what they reveal, select particular areas for more detailed examination. This method will require sending new picture commands to the Lander every few days.

Used as photometers, the cameras will yield data that permit inferences about the chemical and physical properties of Martian surface materials. Color and IR diodes will collect data in six different spectral bands. Reflectance curves constructed from these six points have diagnostic shapes for particular minerals and rocks. For example, differing degrees of iron oxidation cause varying absorption in the range from 0.9 to 1.1 micron wavelengths.

Another goal will be to spot variable features. Changes in features can be determined by taking pictures of the same region at successive times. The most probable change will be caused by the movement of sand and silt by the wind. Mariner pictures have revealed large-scale sediment movement; similar Lander observations are anticipated.

A grid target has been painted atop the Lander; one aim of the variable features investigation is to see if the target is being covered by sediment. The cameras' single-line scan will be used each day to detect any sand grains saltating (hopping) along the surface.

The most spectacular variable feature would be one of biological origin. Many scientists are skeptical about the probability of life on Mars; very few expect to see large forms that can be recognized in a picture. The possibility will not be discounted, however. If there are organic forms, they might be difficult to identify in a conventional "snapshot." Their most recognizable attribute might be motion, and this motion might be uniquely characterized by the single-line-scan mode of operation.

Another area of camera investigation is atmospheric properties. Pictures taken close the horizon at sunset or sunrise will be used to determine the aerosol content of the atmosphere. Some pictures will also be taken of celestial objects: Venus, perhaps Jupiter, and the two Mars satellites, Phobos and Deimos. The brightness of these objects will be affected by the interference of the atmosphere, and the cameras can provide a way to measure aerosol content.

The cameras can also be used in the same way as more conventional surveying instruments. Pictures of the Sun and planets can be geometrically analyzed to determine the latitudinal and longitudinal position of the Lander on Mars.

Each Lander is equipped with two identical cameras, positioned about 1 m (39 in.) apart. They have a relatively unobstructed view across the area that is accessible to the surface sampler. The cameras are on stubby masts that extend 1.3 m (51 in.) above the surface.

The imaging instruments are called facsimile cameras. Their design is fundamentally different from that of the television cameras that have been used on most unmanned orbital and flyby spacecraft. Facsimile cameras use mechanical instead of electronic scanning.

In a television camera the entire object is simultaneously recorded as an image on the face of a vidicon tube in the focal plane. Then the image is "read" by the vidicon through the action of an electron beam as it neutralizes the electro static potential produced by photons when the image was recorded. In a facsimile camera, small picture elements (called pixels) that make up the total image are sequentially recorded.

In a facsimile camera an image is produced by observing the object through sequential line scans with a nodding mirror which reflects the light from a small element of the object into a diode sensor. Each time the mirror nods, one vertical line in the field of view is scanned by the diode. The entire camera then moves horizontally by a small interval and the next vertical line is scanned by the nodding mirror. Data that make up the entire picture are slowly accumulated in this way.

Because each element (spot) in the field of view is recorded on the same diode, opposed to different parts of the vidicon tube face the facsimile camera has a photometric stability that exceeds most television systems. Relatively subtle reflectance characteristics of objects in the field of view can be measured.

There are actually 12 diodes in the camera focal plane; each diode is designed to acquire data of particular spectral and spatial quality. One diode acquires a survey black-and-white picture. Three diodes have filters that transmit light in blue, green and red; together these diodes record a color picture. Three more diodes are used in essentially the same way, but have filters that transmit energy in three bands of near-infrared.

Four diodes are placed at different focal positions to get the best possible focus for high-resolution black-and-white pictures. (This results in a spatial resolution of several millimeters for the field of view closest to the camera--objects the size of an aspirin can be resolved.) The twelfth diode is designed with low sensitivity so it can image the Sun.

The survey and color pictures have a fixed elevation dimension of 60 degrees; high-resolution pictures have a fixed dimension of 20 degrees. The pictures can be positioned anywhere in a total elevation range of 60 degrees below to 40 degrees above the nominal horizon. The azimuth of the scene is adjustable; it can vary from less than one degree to almost 360 degrees to obtain a panorama.

The facsimile camera acquires data relatively slowly, line by line. Rapidly moving objects, therefore, will not be accurately recorded. They might appear as a vertical streak, recorded on only one or two lines. This apparent liability can be turned into an asset.

If the camera continues to operate while its motion is inhibited, the same vertical line is repetitively scanned. If the scene is stationary, the reflectance values between successive lines will be identical, but if an object crosses the region scanned by the single line, the reflectance values dramatically change between successive scans. The single-line-scan mode of camera operation, therefore, provides an unusual way of detecting motion.

As the mission proceeds, pictures will be acquired and transmitted three ways: the first Lander pictures will be sent directly to the Orbiter for relay to Earth. On successive days, pictures will be acquired during the day and stored on the Lander's tape recorder for later transmission to the Orbiter. Pictures can also be transmitted directly to Earth at a lower data rate.

The number of pictures that will be sent to Earth each day will vary according to the size of the pictures, amount of data to be transmitted by other instruments, and length of the transmission period. A typical daily picture budget for one Lander might be one picture directly transmitted to Earth at low data rate, two pictures transmitted real time through the Orbiter, and three pictures stored on the tape recorder and later relayed to Earth.

The Lander Imaging investigation team leader is Dr. Thomas A. (Tim) Mutch of Brown University.

Biology

Biology investigations will be performed to search for the presence of Martian organisms by looking for products of their metabolism. Three distinct investigations will incubate samples of the Martian surface under a number of different environmental conditions. Each is based on a different fundamental assumption about the possible requirements of Martian organisms; together they constitute a broad range of ideas on how to search for life on Mars. The three investigations are Pyrolytic Release (PR), Labeled Release (LR) and Gas Exchange (GEX).

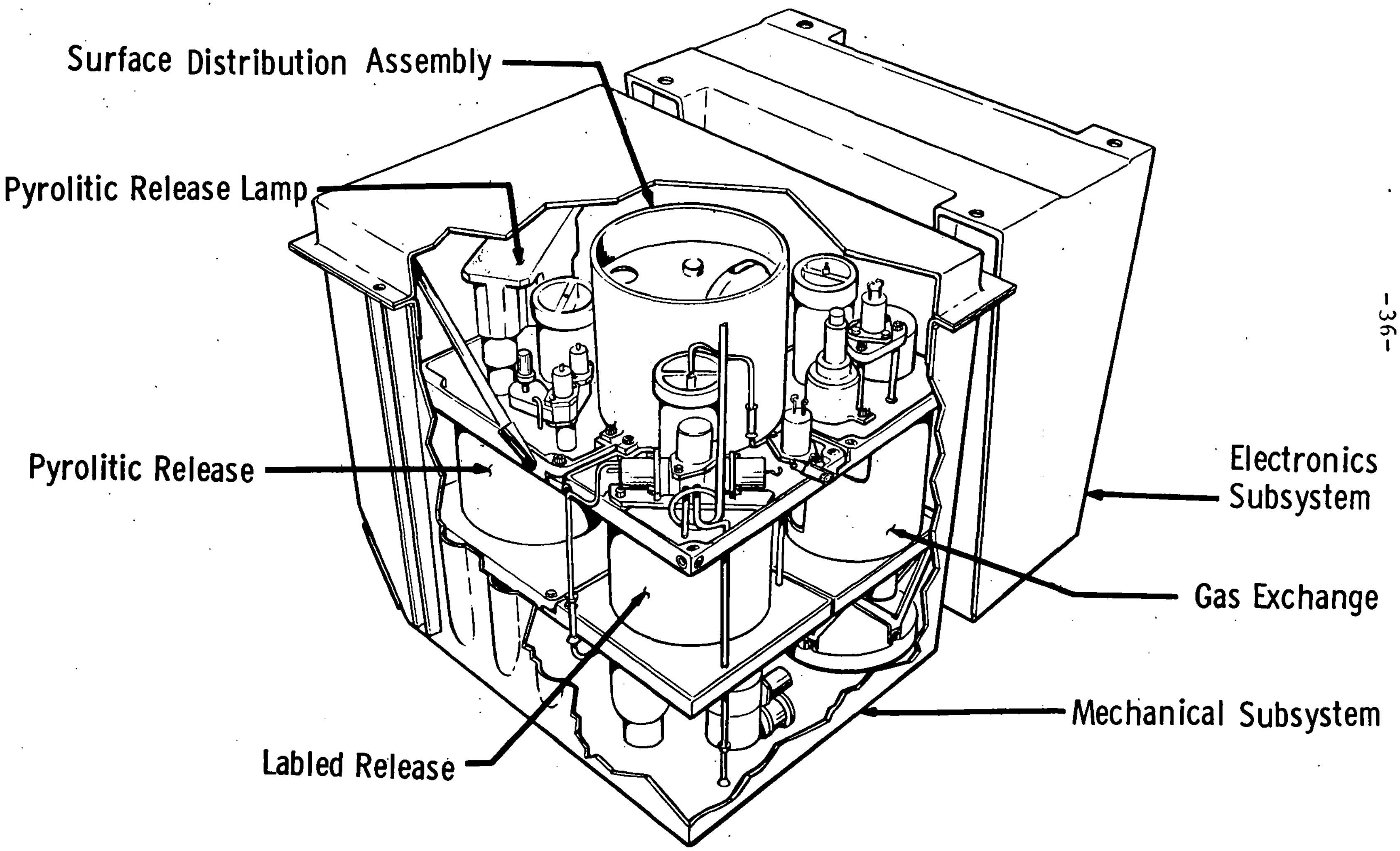
Martian soil samples acquired by the surface sampler, several times during each landing, will be delivered to the Viking Biology Instrument (VBI). There the samples will be automatically distributed, in measured amounts, to the three experiments for incubation and further processing.

Within the biology instrument, a complex system of heaters and thermo-electric coolers will maintain the incubation temperatures between about 8 and 17 degrees C. (46 to 63 degrees F.) in spite of external temperatures that may drop to minus 75 degrees C. (minus 103 degrees F.) or internal Lander temperatures that may rise to 35 degrees C. (95 degrees F.).

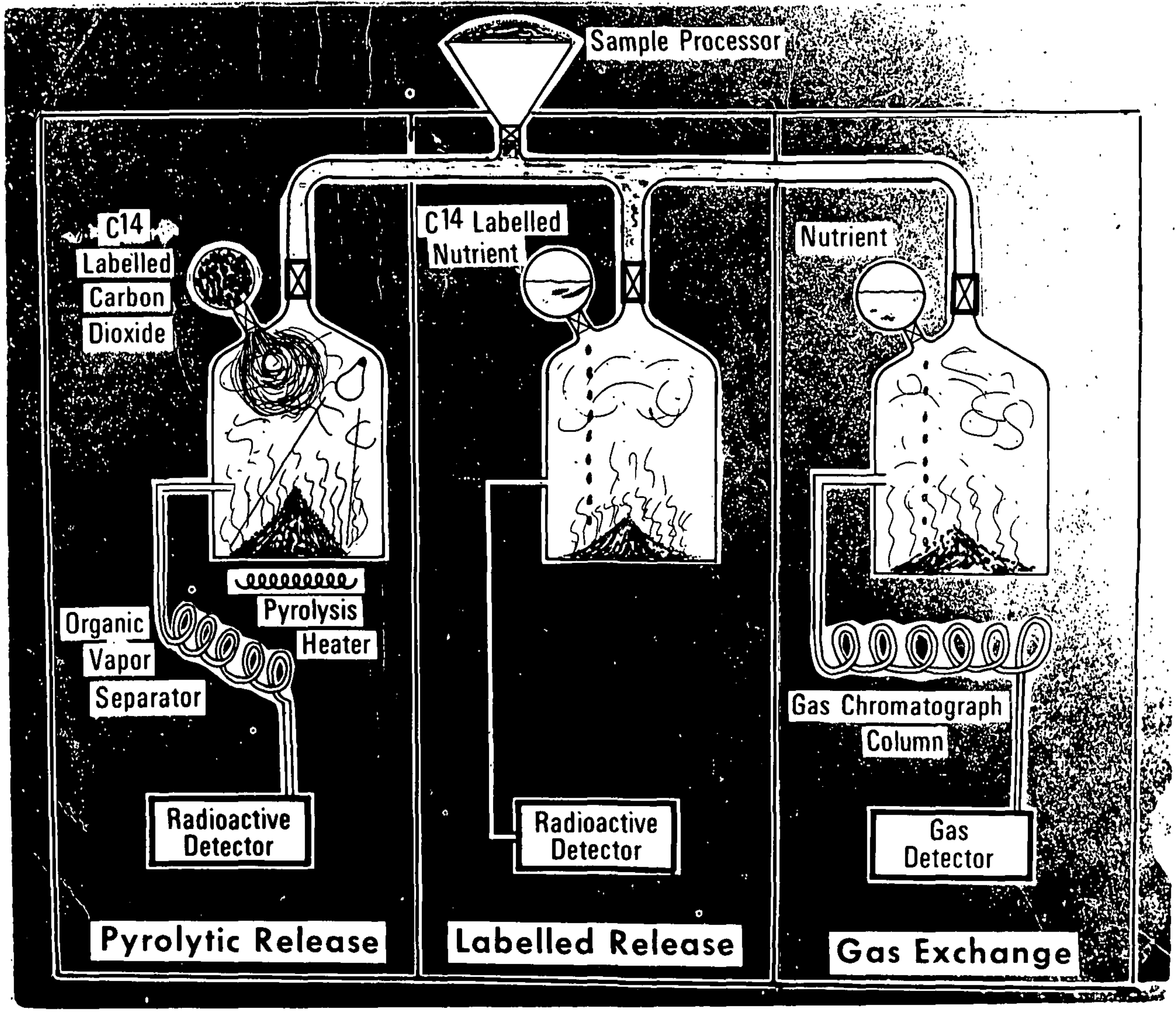
Pyrolytic Release. The Pyrolytic Release (PR) experiment contains three incubation chambers, each of which can be used for one analysis. This experiment is designed to measure either photosynthetic or chemical fixation of carbon dioxide (CO_2) or carbon monoxide (CO). The main rationale for this is that the Martian atmosphere is known to contain CO_2, with CO as a trace component. Any Martian biota (animal or plant life) are expected to include organisms capable of assimilating one or both of these gases. It also seems reasonable that at least some organisms on Mars would take advantage of solar energy, as occurs on Earth, and that Martian soil would include photosynthetic organisms.

- more -

BIOLOGY INSTRUMENT DIAGRAM



INTEGRATED BIOLOGY INSTRUMENT



The experiment incubates soil in a Martian atmosphere with radioactive CO_2 added. Then, by pyrolysis (heating at high temperatures to "crack" organic compounds) and the use of an organic vapor trap (OVT), it determines whether radioactive carbon has been fixed into organic compounds. This experiment can be conducted either in the dark or light.

For an analysis, 0.25 cc of soil is delivered to a test cell, which is then moved to the incubation station and sealed. After establishing the incubation temperature, water vapor can be introduced by ground command if desired. Then the labeled CO_2/CO mixture is added from a gas reservoir and a xenon arc lamp is automatically turned on during the five-day incubation.

After incubation, the test cell is heated to 120 degrees C. (248 degrees F.) to remove residual incubation gases, which are vented to the outside. Background counts are made, after which the test cell is moved from the incubation station to another station.

Here pyrolysis is done by heating the test cell to 625 degrees C. (1,160 degrees F.), while purging the test cell with helium gas. The purged gases pass through the OVT, designed to retain organic compounds and fragments, but not CO_2 or CO. The radioactivity detector at this stage will sense a "first peak" consisting mainly of unreacted CO2/CO. This first peak is regarded as non-biological in origin.

After this operation, the test cell is moved away from the pyrolysis station, the detector is heated and purged with helium, and background counts are taken once more to verify that the background radiation is down to pre-pyrolysis levels. The trapped organic compounds are then released from the OVT by heating it to 700 degrees C. (1,290 degrees F.), which simultaneously oxidizes them to CO_2. These are flushed into the detector. A second radioactive peak at this point would indicate biological activity in the original sample.

Labeled Release. The Labeled Release (LR) experiment is designed to test metabolic activity in a soil sample moistened with a dilute aqueous solution of very simple organic compounds. The rationale for this experiment is that some Martian organisms, in contact with an atmosphere containing CO_2, should be able to break down organic compounds to CO_2. The experiment depends on the biological release of radioactive gases from a mixture of simple radioactive compounds supplied during incubation.

The test cell is provided 0.5 cc of soil sample and is moved to the incubation station and sealed. The Martian atmosphere is established in the test cell in this process. Before the radioactively-labeled nutrients (a mixture of formate, glycine, lactate, alanine, and glycolic acid; all compounds are uniformally labeled with radioactive carbon) are added, a background count is taken. Then approximately 0.15 cc of nutrients are added, and incubation proceeds in the dark for 11 days.

The atmosphere above the soil sample is continuously monitored by a separate radioactivity detector throughout the incubation, after which the test cell and detector are purged with helium. The accumulation of radioactive CO_2 (or other radioactive gases) indicates the presence of life metabolizing the nutrient. Data are collected for 12 days. These data will produce a metabolic curve as a function of time. The shape of the curve can be used to determine if growth is taking place in the test cell.

Gas Exchange. The Gas Exchange (GEX) experiment measures the production or uptake of CO_2, nitrogen, methane, hydrogen and oxygen during the incubation of a Martian soil sample. The GEX experiment can be conducted in one of two modes: in the presence of water vapor, without added nutrients, or in the presence of a complex source of nutrients.

The first mode is based on the assumption that substrates (foodstuffs) may not be limiting in the Martian soil and that biological activity may be stimulated when only water vapor becomes available. The second mode assumes that Martian soil contains organisms metabolically similar to those found in most terrestrial soils and that these will require organic nutrients for growth.

A single test cell is used for the experiment. After receiving 1 cc of soil from the distribution assembly, the test cell is moved to its incubation station and sealed. After a helium purge, a mixture of helium, krypton and CO_2 is introduced into the incubation cell and this becomes the initial incubation atmosphere. (Krypton is used as an internal standard; helium is used to bring the test chamber pressure to approximately one-fifth of an Earth atmosphere.)

At this point either 0.5 or 2.5 cc of a rich nutrient solution can be introduced. Using the lesser quantity, the soil does not come into contact with the solution, and incubation proceeds in a "humid" mode. An additional two cc allows contact between the soil and the nutrient solution, which consists of a concentrated aqueous mixture of nineteen amino acids, vitamins, other organic compounds, and inorganic salts. Incubation initially is planned to be in the humid mode for seven days, after which additional nutrient solution will added. For gas analyses, samples (100 microliters) of the atmosphere above the incubating soil are removed through a gas sampling tube. This occurs at the beginning of each incubation and after 1, 2, 4, 8 and 12 days.

The sample gas is placed in a stream of helium flowing through a coiled, 0.7 m (23 ft.) long, chromatograph column into a thermal conductivity detector. The system used in the GEX experiment is very sensitive and will measure changes in concentration down to about one nanomole (one-billionth of a molecule).

After a 12-day incubation cycle, a fresh soil sample can be added to the test cell to begin a new incubation cycle; the medium can be drained and replaced by fresh nutrients; and the original atmosphere is replaced with fresh incubation atmosphere. The latter procedure will be used if significant gas changes are noted in the initial incubation, on the assumption that if these changes are due to biological activity, they should be repeatable and should be enhanced. If of non-biological origin, they should not reappear.

Each incubation station also contains auxiliary heaters that can be used to heat soil samples to approximately 160 degrees C. (320 degrees F.). The heaters will be activated for three hours in case one or more of the experiments indicates a positive biological signal, after which the experiment will then be repeated on the "sterilized" soil samples. This is the control for the experiment. The detection of life would only be acknowledged if there were a significant difference between the "control" and the experiment.

An electronic system within the Viking Biology Instrument, containing tens of thousands of components, will automatically sequence all events within the experiments, but will be subject to commands from Earth. The electronic subsystem will also obtain data from the experiments for transmission to Earth.

- more -

In addition to the electronic subsystem, each biology instrument contains four compartments, or modules, within a volume of just over one cubic foot. The common services module is a reservoir for the three other modules. It contains a tank of pressurized helium gas to move the incubation chambers from one place to another, to purge pneumatic lines used in the experiments, and to carry other gases as required.

The Biology investigation team leader is Dr. Harold P. Klein of NASA's Ames Research Center, Mountain View, Calif.

Molecular Analysis

The Molecular Analysis investigation will search for and identify organic (and some inorganic) compounds in the surface layer (the first few centimeters) of Mars. It will also determine the composition of the atmosphere near the surface and monitor composition changes during part of a Martian season.

Organic compounds on Earth are substances that contain carbon, hydrogen (almost always) and often oxygen, nitrogen and other elements; all are attached to one another. All but the most simple ones contain a series of carbon atoms attached to each other. On Earth carbon has the tendency to form a variety of long-chain molecules. This may happen on Mars, although it's possible that the situation may be different on another planet.

The question of whether there are organic compounds in the surface of Mars and, if so, what is their chemical structure, is of interest for several reasons. Organic substances produced by purely non-biological processes (such as thermal, photo-chemical or radiation-induced reactions) would tell something about the occurrence of these processes, and would allow speculation of precursors (carbon dioxide, carbon monoxide, ammonia, water, hydrogen sulfide, etc.) that could produce the substances detected.

The possibility also exists that the planet abounds with chemical compounds produced by living systems. Their chemical nature, distribution and structural uniqueness could be used to argue the presence of living organisms on Mars.

The wide area between these two extremes may represent manifestations of various levels of chemical evolution, or even of a planet that carried living systems that died gradually or through a catastrophic event.

Identification of the relatively small and simple organic molecules in the surface of Mars may enable comparison of the present chemistry of the planet to chemistry we assume existed on Earth a few billion years ago. Conversely, compounds may be encountered that resemble the composition of petroleum. From the distribution of individual structures, speculation can be made whether or not these hydrocarbons represent chemical fossils remaining after the decomposition of living systems of earlier times (a theory favored for the origin of petroleum on Earth).

While the major constituent of the Martian atmosphere is known to be carbon dioxide, there is a conspicuous absence of terrestrially important gases like oxygen and nitrogen, at least at the level of more than about one per cent.

Recent Soviet measurements indicate the possibility of an appreciable amount of argon. The concentration would tell something of the early history of Mars. Information about minor constituents like carbon monoxide, oxygen, nitrogen, and possibly even traces of small hydrocarbons or ammonia is important to an understanding of the chemical and possibly biological processes occurring at the surface of the planet. Periodic measurements during the day and during the entire landed phase of the mission are required for this purpose.

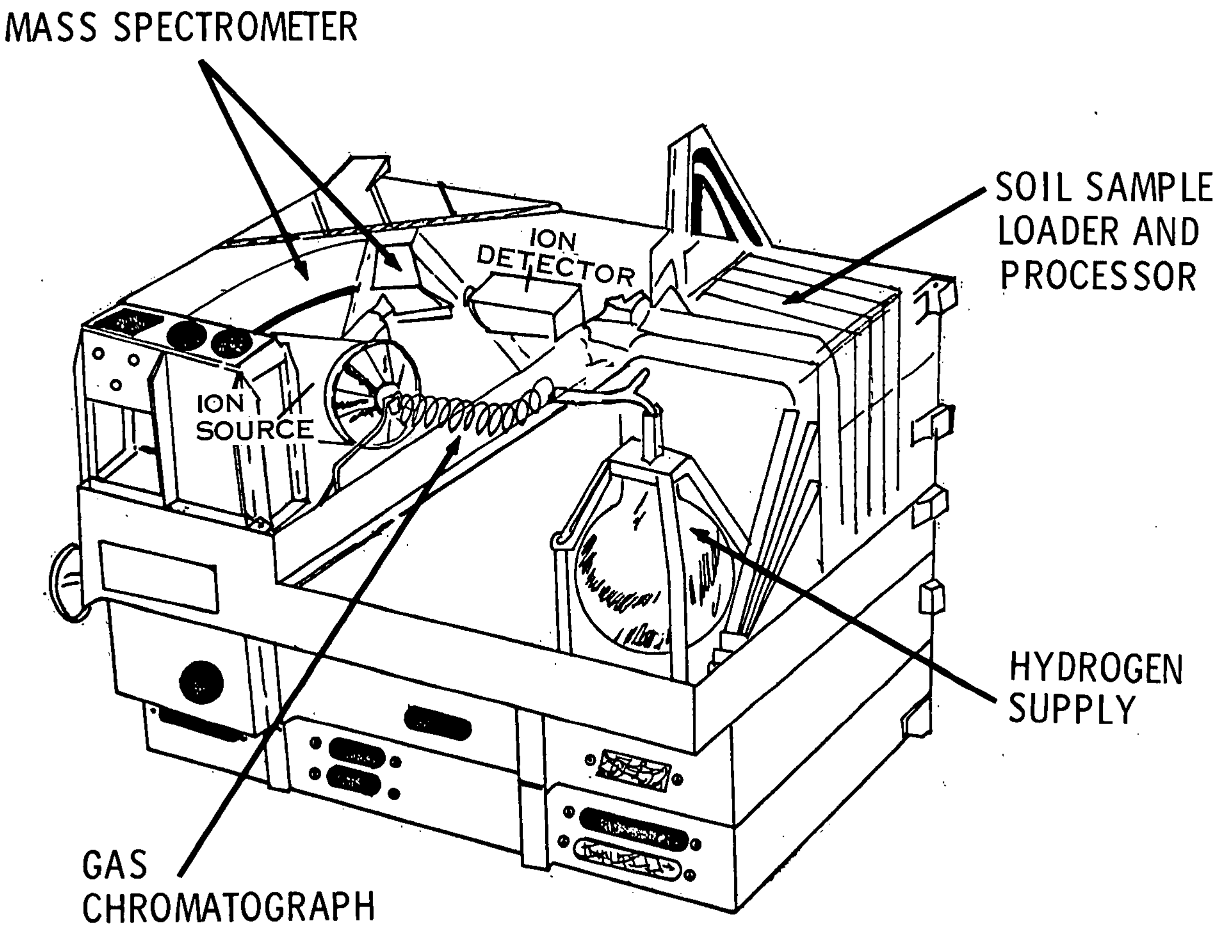
Finally, because of the absence of nitrogen in the atmosphere, it is of interest to search for nitrogen-containing inorganic substances such as nitrates or nitrites in the surface minerals.

A Gas Chromatograph Mass Spectrometer (GCMS) was chosen for these experiments because of its high sensitivity, high structural specificity and broad applicability to a wide range of compounds. Because mass spectra can be interpreted even in the absence of reference spectra, detection is possible of compounds not expected by terrestrial chemists.

The spectrometer will be used directly for analysis of the atmosphere before and after removal of carbon dioxide, which facilitates the identification and quantification of minor constituents.

Identification of organic substances probably present in surface material is a complex task because little is known about their overall abundance (which may be zero), and because any one of thousands of organic substances, or any combination thereof, may be present.

GCMS INSTRUMENT



During the experiment, organic substances will be vaporized from the surface material by heating it to 200 degrees C. (392 degrees F.), while carbon dioxide (labeled with 13 C., a non-radioactive carbon isotope) sweeps through. The emerging material is carried into a gas chromatographic column, which is then swept by a carrier gas (hydrogen). While passing through this column (a thin tube filled with solid particles) substances entering the column are separated from each other by their different degrees of retention on this solid material.

After emerging from the column, excess carrier gas is removed by passing the stream through a palladium separator that is permeable only to hydrogen; the residual stream then moves into the mass spectrometer. This produces a complete mass spectrum (from mass 12 to 200) every 10 seconds for the entire 84 minutes of the gas chromatogram. The data are then stored and sent to Earth.

In this part of the experiment, materials that are volatile at 200 degrees C. (392 degrees F.) will be measured. The same sample is then heated to 500° C. (932° F.) to obtain less volatile materials and to pyrolyze (crack by heating) those substances that are not volatile enough to evaporate.

The results of the organic experiment will consist of three parts: interpretation of the mass spectra to identify compounds evolved from the soil sample; reconstruction of the molecular structures of those substances that were pyrolyzed and gave only mass spectra of their pyrolysis products; and correlation of the compounds detected in the surface material with hypotheses of their generation on the Martian surface.

The detection of inorganic gaseous materials such as water, carbon dioxide or nitrogen oxides, produced upon heating the soil sample, may permit conclusions on the composition of minerals that comprise the inorganic surface material. Results of the inorganic experiment are expected to help in this correlation and vice versa.

Atmospheric analyses are relatively simple and don't require much time, power or expendable supplies, but organic analyses are more involved. They consume a considerable amount of power, produce a large amount of data that must be sent to Earth, and involve materials that are limited (labeled carbon dioxide and hydrogen). For these reasons only three soil samples will be analyzed during each of the two missions. Considering the limited source (the area accessible to the surface sampler), this should be an adequate number of tests.

The Molecular Analysis investigation team leader is Dr. Klaus Biemann of the Massachusetts Institute of Technology.

Inorganic Chemistry

Scientific questions, ranging from the origin of the solar system to the metabolism of microbes, depend largely on knowledge of the elemental chemical composition of surface material. The Inorganic Chemical investigation will greatly expand present knowledge of the chemistry of Mars, and it is likely to provide a few clues to help answer some of these questions.

The conditions under which a planet condenses are thought to be reflected in its overall chemical composition. The most generally recognized relationship is that planetary bodies forming closer to the Sun should be enriched in refractory elements such as calcium, aluminum and zirconium, relative to more volatile elements such as potassium, sodium and rubidium.

To be truly diagnostic, ratios of volatile/refractory elemental pairs must represent planet-wide abundances, which will certainly be distorted by local differentiative geochemical processes (core/mantle formation, igneous and metamorphic differentiation, weathering and erosion, etc.). On the other hand, gross variations should be apparent. More detailed information on local processes (from other experiments as well as this one) will help reduce the effects of distortion.

Weathering in a watery environment (especially one highly charged with carbon dioxide, as is Mars' atmosphere) leads to fairly distinctive residual products, whose nature should be inferable from the inorganic chemistry data. This is especially so in concert with data from the Gas Chromatograph-Mass Spectrometer (GCMS) (on the presence and perhaps the identity of hydrate and carbonate minerals) and the Magnetic Properties experiment (on oxidation states of iron). We hope, therefore, to obtain data of at least a corroborative sort bearing on the question of the possible former existence of abundant liquid water on Mars.

The experiment, reduced to essentials, consists of exposing samples of Martian surface materials to x-rays from radioisotope sources, which stimulate the atoms of the sample to emit "fluorescent" x-rays. Each chemical element emits x-rays at a very few, extremely well-defined energies. This effect is analogous to the emission of visible light by certain fluorescent minerals when illuminated with "black light." By analyzing the energy of the fluorescent x-rays, the elements in the sample and their relative abundances can be ascertained.

Because of characteristics inherent in the technique, elements lighter (i.e., earlier in the Periodic Table) than magnesium are not individually measured. While several of these elements (e.g., nitrogen, carbon, oxygen) may be abundant and very important for biological processes, their precise abundance in surface materials is of relatively minor interpretative value. Gross abundances should be deducible from x-ray data combined with data from other experiments, notably the GCMS and Magnetic Properties investigations.

The sample delivered to the x-ray Fluorescence Spectrometer (XRFS) by the surface sampler may be coarse-grained material up to 1.3 cm (0.5 in.) in diameter (the opening of a screen in the funnel head) or fine-grined material that has been passed by vibratory sieving through 2 mm (0.08 in.) circular openings in the surface sampler head.

The spectrometer contains a sample analysis chamber, x-ray sources, detectors, electronics, and a dump cavity. The unit weighs two kilograms (4.5 pounds). Facing each window of the chamber are two sealed, gas-filled proportional counter (PC) detectors flanking a radioactive source.

These sources (radioactive iron and cadmium) produce x-rays of sufficient energy to excite fluorescent x-rays from the elements between magnesium and uranium in the Periodic Table. Elements before magnesium in the table can be determined only as a group, although useful estimates of their individual abundances may be indirectly achieved.

The output of the detectors is a series of electrical pulses with voltages proportional to the energy of the x-ray photons of the elements that produced them. A determination of the energy level identifies the presence of that element and the intensity (count rate) of the signal is related to its concentration.

A single-channel analyzer circuit divides the output of each detector into 128 energy levels and steps through each level, recording the accumulated count for a fixed period of time. A continuous plot of the count rate in each level produces a spectral signature of the material.

Mounted on the walls opposite the windows of the sample chamber are two calibration plaques ("A" is metallic aluminum; "B" is silver with a vertical, wedge-shaped central strip of zinc oxide). Signals from these plaques, with the chamber empty, monitor possible electronic drift, gas leakage from the detectors, radiation from the Lander's nuclear generators and/or cosmic rays, cross contamination of the windows between samples and, after sample delivery, the level of filling within the chamber. A calibration flag can be interposed on command in front of the radioactive iron source to provide additional calibration.

Spectral signatures obtained from spectrometer response to a variety of rock types are a part of an extensive library of reference spectra being accumulated, to which spectra of Martian material will be compared. Computer analysis of the spectra, to derive concentrations of the elements, is based on a semi-empirical model of the instrument response, including corrections for absorption and enhancement, PC tube response and backscatter intensity. By matching spectra to a mathematical model of the instrument's response, it is possible to calculate element concentrations.

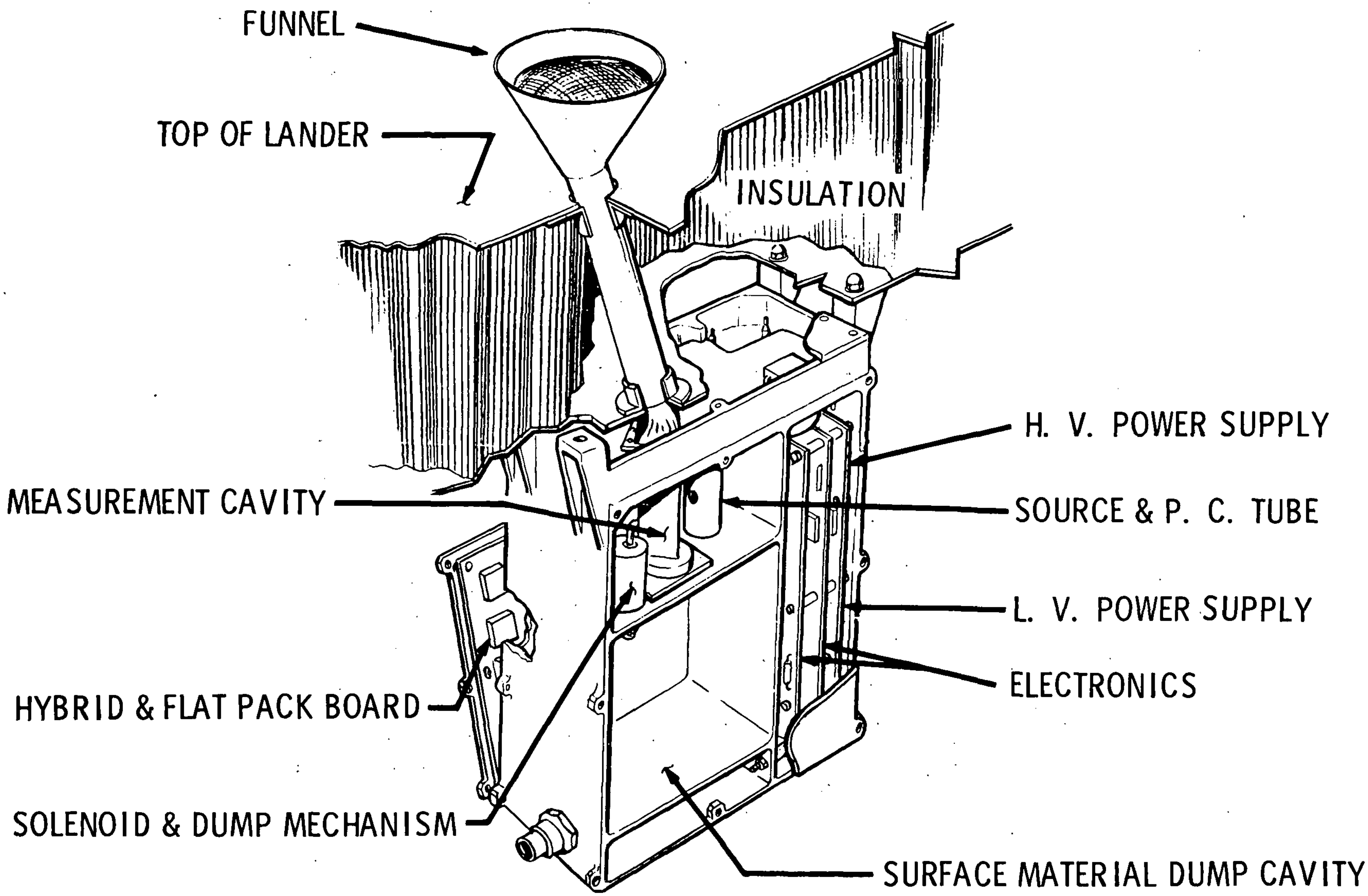
All spectra are normalized by reference to the backscattered primary radiation to make comparisons uniform between spectra. The integrated intensity of the backscatter peak also provides data on the bulk density of the sample and the amounts of elements lighter than magnesium.

Toward the end of the Lander 1 mission, the x-ray Fluorescence Spectrometer will repeatedly analyze a single sample, to achieve a higher order of precision than will be possible in the earlier part of the mission.

The inorganic Chemistry investigation team leader is Dr. Priestley Toulmin III of the U.S. Geological Survey, Reston, Va.

- more -

X-RAY FLUORESCENCE SPECTROMETER DIAGRAM



Meteorology

Meteorology science measurements on Mars will be obtained primarily from sensors mounted on a boom attached to the Lander. Measurements will include wind speed, wind direction and temperature. Atmospheric pressure will be measured by a sensor located inside the Lander and vented by a tube to the outside. Readings will be obtained during approximately 20 periods every Sol*(Mars day), each period consisting of several instantaneous measurements.

The Meteorology investigation is designed to increase understanding of how the Martian atmosphere works. It will be man's first opportunity to directly observe the meteorology of another planet that obeys the same physical laws as does Earth's atmosphere. The opportunity to extend and refine comprehension of how an atmosphere works, driven by the Sun's radiation and subject to rotation of the planet, should give better understanding of Earth's atmosphere.

Scientific goals of the experiment are to:

- Obtain the first direct measurements of Martian meteorology with instruments placed in the atmosphere. Until now all information on wind speeds, for example, has come from theoretical calculations of the circulation of the atmosphere, or from calculations of the wind speed needed to raise dust.

- Measure and define meteorological variations during the day (Sol). The validity of existing theories that predict these diurnal (daily) variations can be compared with measurements and the theories revised as needed.

- Measure some of the turbulent characteristics of the planetary boundary layer. The boundary layer is the main brake on atmospheric circulation, and this circulation cannot be adequately understood until more is known about the turbulent dissipation of energy in the boundary layer.

- Verify whether such well-known terrestrial phenomena as weather fronts and dust devils occur on Mars by observing the behavior of the atmosphere as these things pass near the Landers.

- Support other Lander science experiments by providing information needed for other experiments. Meteorology results during the first few days, for example, should provide information on the best time of day to deploy the surface sampler boom to avoid damage from high winds.

- more -

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*24 hours, 39 minutes

D6E2
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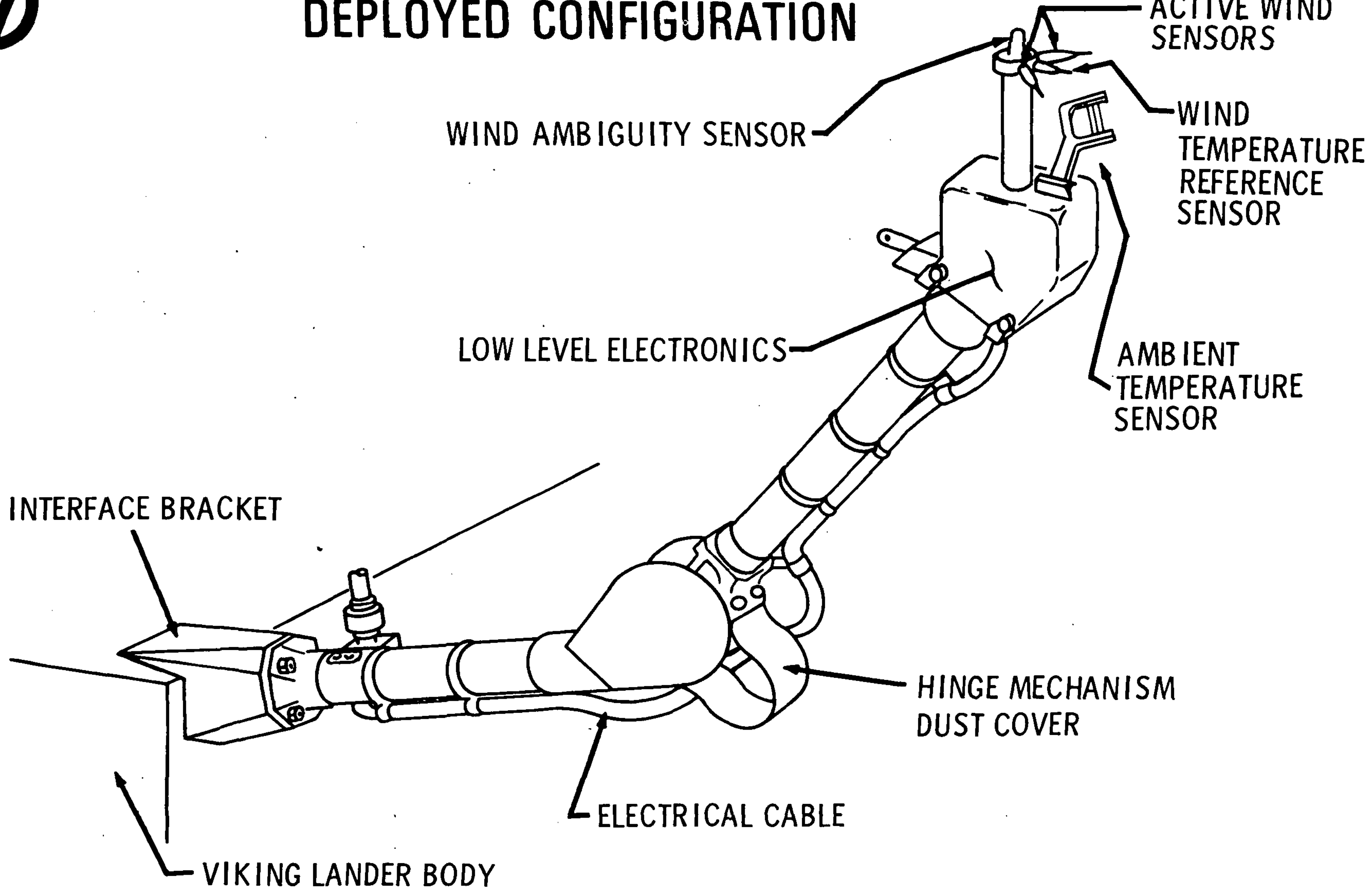
METEOROLOGY BOOM AND SENSORS DEPLOYED CONFIGURATION



The experiment's primary wind sensors are hot-film anemometers, two glass needles coated with platinum and overcoated with a protective layer of aluminum oxide. An electric current is passed through the platinum films to heat the needles, while the wind takes away the heat. Electric power needed to maintain these sensors at a fixed temperature above the surrounding air is the measure of the wind speed.

The device measures wind speed perpendicular to its length, so two devices, mounted 90 degrees apart, are necessary to find the total wind. A third identical sensor is mounted between the two, and it is used to determine air temperature and, through automatic circuitry, control the power applied to the active sensors.

The sensors give the same readings for winds from opposite directions, so an uncertainty remains as to wind direction. This problem is solved by a quadrant sensor, an electrically heated core surrounded by four thermocouples (located every 90 degrees). Heat taken away from the core by the wind affects the thermocouples enough to eliminate uncertainty about wind direction.

The quadrant sensor can also measure wind speed, so readings are combined from the hot-film anemometers and the quadrant sensor. A sophisticated computer program produces the best available determinations of both wind speed and direction.

Air temperature is measured by three fine-wire thermocouples in parallel. They are extremely thin to quickly respond to temperature fluctuations, but this makes them more subject to being broken by blowing sand. Each of the three thermocouples can operate independently, so breakage of one or two will not be catastrophic.

The pressure sensor consists of a thin metal diaphragm mounted in a case. A vacuum is maintained on one side of the diaphragm while the other side is exposed to the atmosphere. As air pressure varies, the diaphragm moves slightly in response to the fluctuating force upon it. This movement is detected by an electrical sensor and its output is converted to a pressure reading.

The Meteorology investigation team leader is Dr. Seymour L. Hess of Florida State University.

Seismology

The Seismology investigation will determine the level of seismic or tectonic (crustal forces) activity on Mars and its internal structure. Waves from naturally occurring Marsquakes spread throughout the planet and will be detected by seismometers on the surface.

Each Lander has miniature seismometers that will measure motion in three perpendicular directions. Two instruments, and the three-axis nature of each, allows a crude triangulation to be made to locate a seismic event. Regions of active tectonism can be identified and associated with surface manifestations of faulting.

The basic question: Is Mars a tectonically active planet or are the various surface features remnants of an earlier active period? The Earth is a tectonically active planet, primarily due to the motions of large crustal plates on its surface. Mars may be starting a phase of continental breakup or it may be a seismically dead planet. Either way, studying Mars will help scientists understand better the processes that cause quakes and plate motions in Earth.

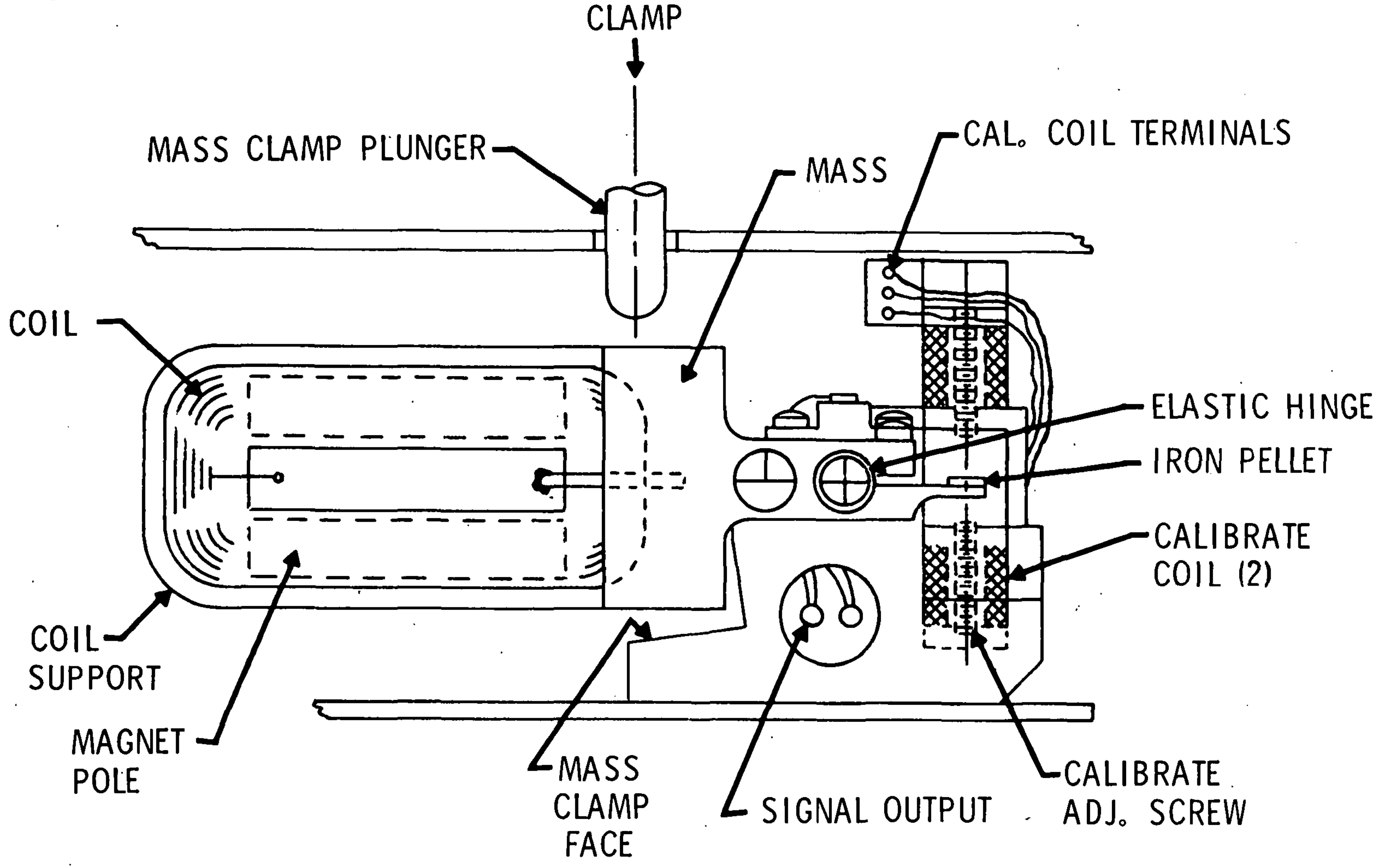
If there are abundant Marsquakes, scientists can begin to unravel the internal structure of the planet. Seismic waves are used to map deep discontinuities and to determine seismic velocities as a function of depth, and would help determine if Mars has a crust and a core like Earth. This knowledge is important in understanding Earth's early evolution and the evolution of the atmosphere.

The seismology instrument consists of an approximately cubical package, about 15 cm (6 in.) on a side that weighs about 2.3 kg (5 lbs.). In the package are three miniaturized seismometers for sensing ground motion, and electronic circuitry for amplifying, conditioning and compressing data.

The seismometers are arranged in a mutually perpendicular manner to sense the components of motion in three directions. They consist of a 20-gram (0.7-ounce) mass with an attached coil, elastically pivoted from the instrument frame on a short boom, so the coil projects into a magnet mounted on the frame. Relative motion of the coil and magnet, induced by the mass's reaction to ground motion, generates a varying voltage that is applied to the input of an amplifier.

Modes of operation may be changed by command from Earth to accommodate whatever seismic environment might be found on Mars; the modes may also be automatically cycled by internal controls.

SEISMOMETER SENSOR SCHEMATIC



Modes include selection of various filters to determine frequency content of seismic data, or to adjust for the best possible reception of specific types of data; a low sampling rate for reading the general level of activity; a high data rate for more detailed examination of events; and a compressed, medium rate for continuous monitoring of Marsquakes. This last mode normally will be dormant, with the system operating at low rate until activated by a quake event.

Since the amount of raw data produced by the seismometer is much greater than the capacity of telemetry, data must be compressed to reduce quantity without seriously degrading quality. Normally, many samples are required for high-frequency data.

Data compression is done in two ways. First, normal ground noise (microseisms) is observed by averaging its amplitude over a 15-second period as it is passed through selectable filters. Its average amplitude and frequency content can be indicated by one sample every 15 seconds.

Second, when a Marsquake event occurs, a trigger activates a higher data rate mode that samples, not oscillations in the data, but amplitude of the overall event envelope. This varies at a much lower rate than individual oscillations and requires only one amplitude sample per second to indicate its shape.

At the same time, crossing of the zero axis by the oscillations (change in polarity of the data signal) is counted and sampled once per second. The shape of the envelope and its incremental frequency content can be transmitted to Earth with relatively few data samples and reconstructed to approximate the original event.

The Seismology investigation team leader is Dr. Don L. Anderson of the California Institute of Technology.

Physical Properties

The Physical Properties investigation group frequently has been called "the team without an instrument." While the statement is not quite true, the investigation mainly will use available engineering data. Hardware for the investigation includes two mirrors (mounted on the surface sampler boom), stroke gauges on each Lander leg, a grid on the Lander's top, ultraviolet degradable coatings, and current-measuring circuits in the surface sampler.

Besides engineering data, selected images will be taken by the Lander cameras to determine properties of the Mars surface such as grain size, bearing strength, cohesion, and eolian transportability (how easily surface material is moved by the wind). Other properties to be examined include thermal inertia (how quickly surface temperature changes) and the ultraviolet flux levels.

The bearing strength of the Mars surface will be one of the first characteristics determined. Immediately after landing, a panoramic picture will be taken that will include the Lander's number 3 footpad and its impression in the surface. This picture, data on Lander velocity and attitude at landing, and the amount of leg stroke (compression) will be used to calculate the surface bearing strength, an important fundamental parameter. The footpad impression will also give preliminary data on the cohesion of the surface material.

Early in the landed mission, the surface sampler collector head will eject its protective shroud. Following the ejection, the camera will image the spot where the shroud hits the surface, using the boom-mounted mirror (the area under the retro-engine), and again photograph the footpad and its impression on the surface. This image will be analyzed like the one taken after landing to better define critical surface properties of bearing strength, cohesion and eolian transportability.

While the surface sampler is acquiring samples for the analytical instruments, the physical properties investigation will automatically be acquiring data by measuring the sampler motor currents and taking pictures of the surface markings generated by the sampler. Even the pile of excess sample dumped by the sampler after giving the instruments all they need will be of interest to the Physical Properties scientists.

When the sample for the Gas Chromatograph-Mass Spectrometer (GCMS) is comminuted (ground) the comminutor motor current will be recorded for analysis by the scientists to determine grain size, porosity and hardness.

The team has defined several unique experiments to better understand surface properties. These include digging trenches, examining material in the collector head jaw with the magnifying mirror, piling material on the grid atop the Lander, picking up and dropping a rock or clod on the surface, pressing the collector head firmly into the surface and using the collector head thermal sensor to measure surface temperatures.

Another very simple experiment for the Physical Properties investigation is the addition of ultraviolet degradable coatings on the camera reference test charts. These coatings darken in the presence of ultraviolet and the amount of darkening, to a certain limit, is proportional to the total amount of ultraviolet received.

The investigation will provide valuable information to complement the results of other studies, such as geology and mineralogy. Knowledge concerning the structure of the surface can be very helpful in understanding apparently conflicting data and grasping the significance of otherwise unexplainable findings.

The Physical Properties investigation team leader is Dr. Richard W. Shorthill of the University of Utah.

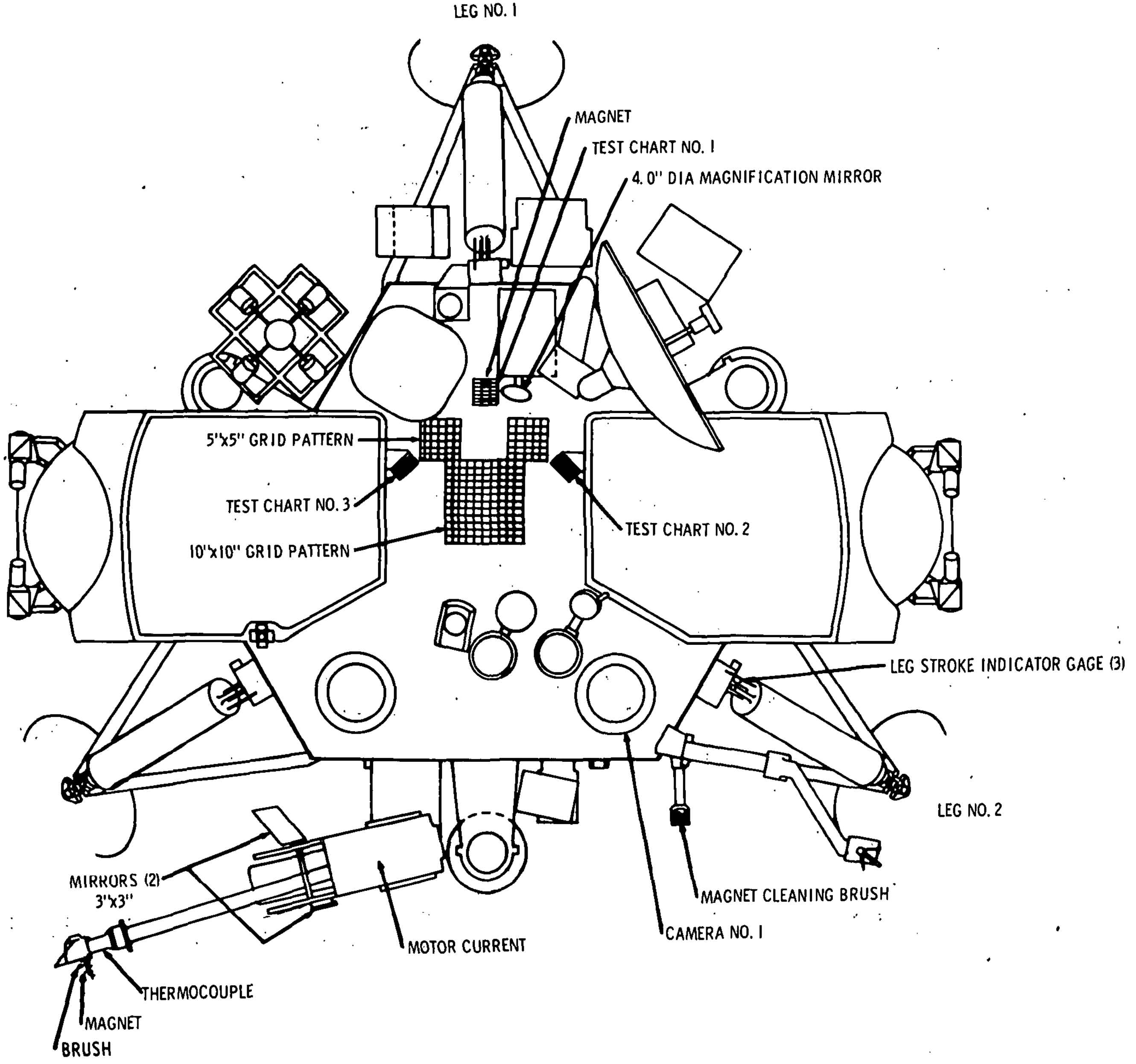
Magnetic Properties

The Magnetic Properties investigation will attempt to detect the presence of magnetic particles in the Mars surface material, and determine the identity and quantity of these particles.

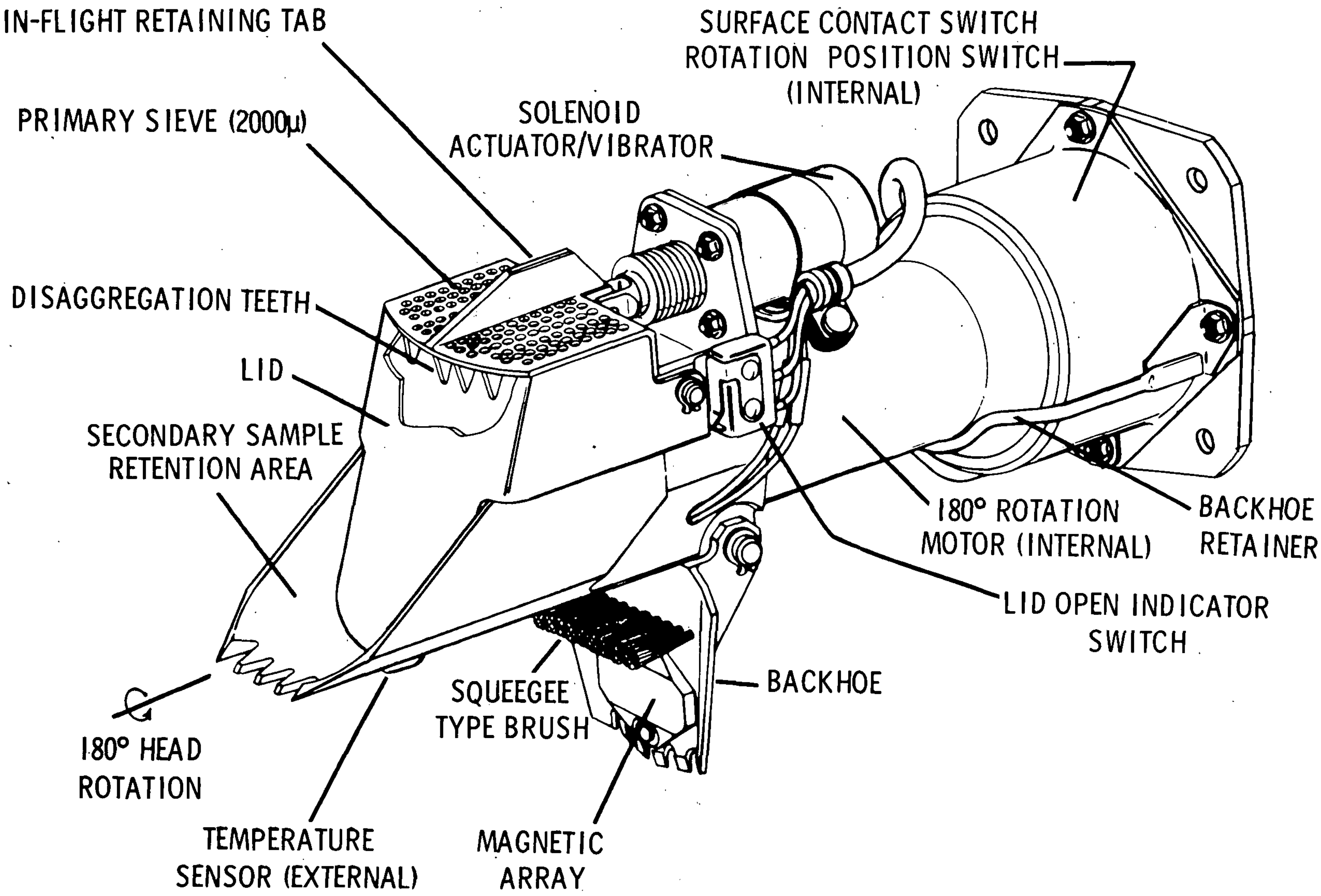
Iron in magnetic minerals is usually an accessory phase in naturally occurring rocks and surface materials on Earth, on the Moon and in meteorites. The chemical form in which this magnetic iron occurs on a planetary surface may vary from elemental metal to more complex iron compounds (i.e., ferrous oxide magnetite, highly oxidized hematite, the hydrates goethite and lepidocrocite). The abundance and chemistry of the accessory iron minerals on the surface have bearing on the degree of differentiation and oxidation of the planet, the composition of its atmosphere, and the extent of interaction between the solid surface materials and the atmosphere.

This investigation uses a set of two permanent, samarium-cobalt magnet pairs, mounted on the back of the surface sampler collector head. Each pair consists of an outer ring magnet, about the size of a quarter, with an inner core-magnet of opposite polarity. These are relatively strong magnets. (The maximum field obtained is approximately 2,500 guass. A guass is a unit of magnetic field intensity.)

PHYSICAL PROPERTIES OF MARTIAN SURFACE USING ENGINEERING MEASUREMENTS



SURFACE SAMPLER COLLECTOR HEAD DIAGRAM



The magnets are mounted at different depths from the outer surface of the backhoe to ensure a gradient in magnetic field strength.

In addition, a similar magnet pair is mounted on the photometric target atop the lander, where it will be automatically photographed when the camera system is calibrated. The magnets in this location should attract any magnetic particles that might be present in windblown dust.

In acquiring samples, the collector head will dig into the surface; and any magnetic particles will tend to adhere to the magnets. The collector head can be directly imaged with the camera system. A five-power magnifying mirror can also be used for maximum resolution in black-and-white or color. These images will be the scientific data return on which the conclusions will be based.

The Magnetic Properties principal investigator is Dr. Robert B. Hargraves of Princeton University.

Radio Science

The objectives of the Radio Science investigation are to conduct scientific studies of Mars using the Orbiter and Lander tracking and communications systems that are required for spacecraft operations and data transmission.

Scientific uses of the systems evolved from recognition of the potential applications of the data, and developments in data analysis to extract scientific results from information contained in the radio signals.

The science investigations will provide new and improved determinations of the gravity field, figure, spin axis orientation, and surface density of Mars; pressure, temperature and electron profiles in the planet's atmosphere; and properties of the solar system.

Radio science applies the principles of celestial mechanics and electromagnetic wave propagation to relate tracking and communications systems signals to physical parameters.

The investigation has no specifically dedicated instruments except the Orbiter's X-band transmitter, which provides a dual-frequency capability on the downlink. This is unique to Viking, compared with previous Mars missions, and is especially important for the Radio Science investigations.

Radio science characteristically deals with small perterbations or changes in spacecraft orbits, deduced from tracking data analysis, and with small variations in frequency, phase or amplitude of received signals. The investigations are intimately involved with data analysis, using complicated analytical procedures and associated computer programs to determine the physical effects that produce the observed variations. Data must sometimes be collected for an extended period to produce results.

The basic tracking data consist of very precise measurements of distance (range) and line-of-sight velocity (range rate) between the spacecraft and Earth tracking stations. Range and range rate measurements are the primary data used to determine global Mars gravity field and local gravity anomalies, precise Lander locations and radii of Mars at the landing sites, spin axis (pole) orientation and motion, and the ephemerides (assigned places) of Mars and Earth. Variations in the signal and other characteristics determine Mars atmospheric and ionospheric properties during occultation experiments.

During Viking's cruise phase, properties of the interplanetary medium, particularly the total electron content and its variations, can be determined by analyses of differences in signal properties on the two downlink frequencies. From such measurements intensity, size and distribution of electron streams from the Sun and from solar storms can be studied to increase understanding of the Earth-Mars region of interplanetary space.

While the Orbiters are being gradually maneuvered to pass over the landing sites, large local gravity anomalies might be detectable in the tracking data. If such anomalies appear near the landing sites or elsewhere they will be of considerable interest with respect to the geology and internal structure of the planet.

After landing, tracking data will be used to define precise Lander locations, including the radius of Mars at these sites. Tracking is also used to define the spin axis (pole) direction, and possibly variations in the spin axis related to the global internal density distribution of Mars.

As the Orbiters rise and set with respect to the Landers, the signal amplitude received at the Orbiter on the Lander-to-Orbiter communication link is expected to vary. An attempt will be made to analyze these variations to determine dielectric properties of the regions near the Landers; these properties can be related to surface density.

After Orbiter 1 has been in Mars orbit for about 80 days, it will be placed in a non-synchronous orbit to make a global survey of the planet. Tracking data taken near periapsis will be used to determine the global gravity field and local gravity anomalies.

Several times during the missions, Mars passes near the line-of-sight between Earth and a quasar (an intense extra-galactic radio source). Radio signals from an Orbiter and the quasar will then be alternately recorded at two tracking stations at the same time. This is a very long baseline interferometry (VLBI) experiment that yields a precise measurement of the angular separation of the two sources.

With suitable data analysis, the results give the precise location of the spacecraft, Mars and Earth with respect to the fixed, inertial frame defined by the very distant quasar. By making such observations over a period of years, in various spacecraft missions, the precise orbits of Mars and Earth with respect to the inertial frame can be determined. One application of such information is to determine the relativistic advance of the perihelion of Mars, providing a test of the general theory of relativity.

In October 1976 Orbiter 1 passes behind Mars, as viewed from Earth, during a portion of its orbit. The spacecraft signals are gradually cut off or occulted, by the planet. Variations in signal properties (frequency, phase and amplitude) as the spacecraft enters or emerges from occultation are used to infer atmospheric and ionospheric properties. Occultations for Orbiter 2 start in January 1977.

Mars and Earth will be in conjunction on Nov. 25, 1976. As the planets approach conjunction radio signals from Viking spacecraft pass closer and closer to the Sun and are gradually more affected by the solar corona, particularly the electron content.

Signal variations, again measured with the dual frequency downlinks, will yield new information on the properties of regions close to the Sun, including the characteristics of any timely solar storms (Sun spots) or high activity events. Spacecraft signals are also affected by the intense gravitational field of the Sun, so a precise solar gravitational time-delay test of general relativity theory will be done in the conjunction time period.

Tests to resolve small differences in the Einstein formulation of general relativity, as compared with more recently proposed formulations, can have an important impact on fundamental physical laws and on studies of the Universe's evolution.

The Radio Science investigation team leader is Dr. William H. Michael, Jr. of Langley Research Center, Va.

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VIKING SCIENTISTS

The Viking scientists represent an outstanding cross-section of the scientific community. They were selected from universities, research institutes, NASA centers and other government agencies.

The scientists are divided into investigation teams, each headed by a team leader or principal investigator. The teams are led by a Science Steering Group, consisting of a chairman, vice chairman, the leaders of each team and two other members.

The scientists have worked closely with Viking engineers in designing the science instruments. Considerations of weight, power, data constraints and the necessary flexibility of the investigations were developed through cooperation between the two groups.

Team leaders are listed first in each group.

Science Steering Group

Dr. Gerald A. Soffen, Chairman, Langley Research center, Hampton, Va.
Dr. Richard S. Young, Vice Chairman, NASA Headquarters, Washington, D.C.
A. Thomas Young, Langley Research Center
Dr. Conway W. Snyder, Jet Propulsion Laboratory, Pasadena, Calif.

Orbiter Imaging

Dr. Michael H. Carr, U.S. Geological Survey, Menlo Park, Calif.
Dr. William A. Baum, Lowell Observatory, Flagstaff, Ariz.
Dr. Geoffrey A. Briggs, Jet Propulsion Laboratory
Dr. James A. Cutts, Science Applications, Inc., Pasadena
Harold Masursky, U.S. Geological Survey, Flagstaff, Ariz.

Orbiter Water Vapor Mapping

Dr. Crofton B. Farmer, Jet Propulsion Laboratory
Dr. Donald W. Davies, Jet Propulsion Laboratory
Daniel D. La Porte, Santa Barbara Research Center, Goleta, Calif.

Orbiter Thermal Mapping

Dr. Hugh H. Kieffer, University of California, Los Angeles
Dr. Stillman Chase, Santa Barbara Research Center
Dr. Ellis D. Miner, Jet Propulsion Laboratory
Dr. Guido Munch, California Institute of Technology, Pasadena
Dr. Gerald Neugebauer, California Institute of Technology

Entry Science

Dr. Alfred O. C. Nier, University of Minnesota, Minneapolis
Dr. William B. Hanson, University of Texas, Dallas
Dr. Michael B. McElroy, Harvard University, Cambridge, Mass.
Alvin Seiff, Ames Research Center, Mountain View, Calif.
Nelson W. Spencer, Goddard Space Flight Center, Greenbelt, Md.

Lander Imaging

Dr. Thomas A. Mutch, Brown University, Providence, R.I.
Dr. Alan B. Binder, Science Applications, Inc., Tucson, Ariz.
Friedrich O. Huck, Langley Research Center
Dr. Elliott C. Levinthal, Stanford University, Palo Alto, Calif.
*Dr. Sidney Liebes, Stanford University
Dr. Elliott C. Morris, U.S. Geological Survey, Flagstaff, Ariz.
Dr. James A. Pollock, Ames Research Center
Dr. Carl Sagan, Cornell University, Ithaca, N.Y.

Biology

Dr. Harold P. Klein, Ames Research Center
Dr. Norman H. Horowitz, California Institute of Technology
Dr. Joshua Lederberg, Stanford University
Dr. Gilbert V. Levin, Biospherics, Inc., Rockville, Md.
Vance I. Oyama, Ames Research Center
Dr. Alexander Rich, Massachusetts Institute of Technology,
  Cambridge, Mass.

Molecular Analysis

Dr. Klaus Biemann, Massachusetts Institute of Technology
Dr. DuWayne M. Anderson, U.S. Army Cold Regions Research
  Engineering Laboratory, Hanover, N.H.
Dr. Alfred O. C. Nier, University of Minnesota, Minneapolis
Dr. Leslie E. Orgel, Salk Institute, San Diego, Calif.
Dr. John Oró, University of Houston, Tex.
Dr. Tobias Owen, State University of New York, Stony Brook
Dr. Priestley Toulmin III, U.S. Geological Survey, Reston, Va.
Dr. Harold C. Urey, University of California at San Diego,
  La Jolla, Calif.

* Associate

-more-

Meteorology

Dr. Seymour L. Hess, Florida State University, Tallahassee
Robert M. Henry, Langley Research Center
Dr. Conway Leovy, University of Washington, Seattle
Dr. Jack A. Ryan, McDonnell Douglas Corp., Huntington Beach, Calif.
James E. Tillman, University of Washington, Seattle

Inorganic Chemistry

Dr. Priestley Toulmin III, U.S. Geological Survey, Reston, Va.
Dr. Alex K. Baird, Pomona College, Claremont, Calif.
Dr. Benton C. Clark, Martin Marietta Aerospace, Denver, Colo.
Dr. Klaus Keil, University of New Mexico, Albuquerque
Harry J. Rose, Jr., U.S. Geological Survey, Reston, Va.

Seismology

Dr. Don L. Anderson, California Institute of Technology
Dr. Robert A. Kovach, Stanford University
Dr. Gary V. Latham, University of Texas, Galveston
Dr. George Sutton, University of Hawaii, Honolulu
Dr. M. Nafi Toksöz, Massachusetts Institute of Technology

Physical Properties

Dr. Richard W. Shorthill, University of Utah, Salt Lake City
Dr. Robert E. Hutton, TRW Applied Mechanics Laboratory, Redondo Beach, Calif.
Dr. Henry J. Moore II, U.S. Geological Survey, Menlo Park
Dr. Ronald F. Scott, California Institute of Technology

Magnetic Properties

Dr. Robert B. Hargraves, Princeton University, Princeton, N.J.

Radio Science

Dr. William H. Michael, Jr., Langley Research Center
Dan L. Cain, Jet Propulsion Laboratory
Dr. John G. Davies, Jodrell Bank, MacClesfield, Cheshire, England
Dr. Gunnar Fjeldbo, Jet Propulsion Laboratory
Dr. Mario D. Grossi, Raytheon Co., Sudbury, Mass.
Dr. Irwin I. Shapiro, Massachusetts Institute of Technology
Dr. Charles T. Stelzried, Jet Propulsion Laboratory
Dr. G. Leonard Tyler, Stanford University
*Joseph Brenkle, Jet Propulsion Laboratory
*Robert H. Tolson, Langley Research Center

* Associates

MISSION DESCRIPTION

Each Viking mission is divided into five phases: launch, cruise, orbit, entry and landed operations.

(Note: Viking 1 and Viking 2 missions will be described in the singular except when there are differences between the two missions.)

Launch Phase

The Viking launch phase begins with liftoff and lasts until the Deep Space Network (DSN) antennas acquire Viking's radio signal.

Liftoff occurs two-tenths of a second after ignition of the Titan launch vehicle's solid rocket motors. The solid motors begin to shut down 109 seconds after launch, and one second after the liquid-fueled Titan first stage engine is ignited. First stage engines fire for 148 seconds and shut down 258 seconds after launch.

The Titan's second stage engine then ignites to provide thrust for 203 seconds. Ten seconds after second stage ignition, the protective shroud is jettisoned from around the Centaur and the Viking spacecraft.

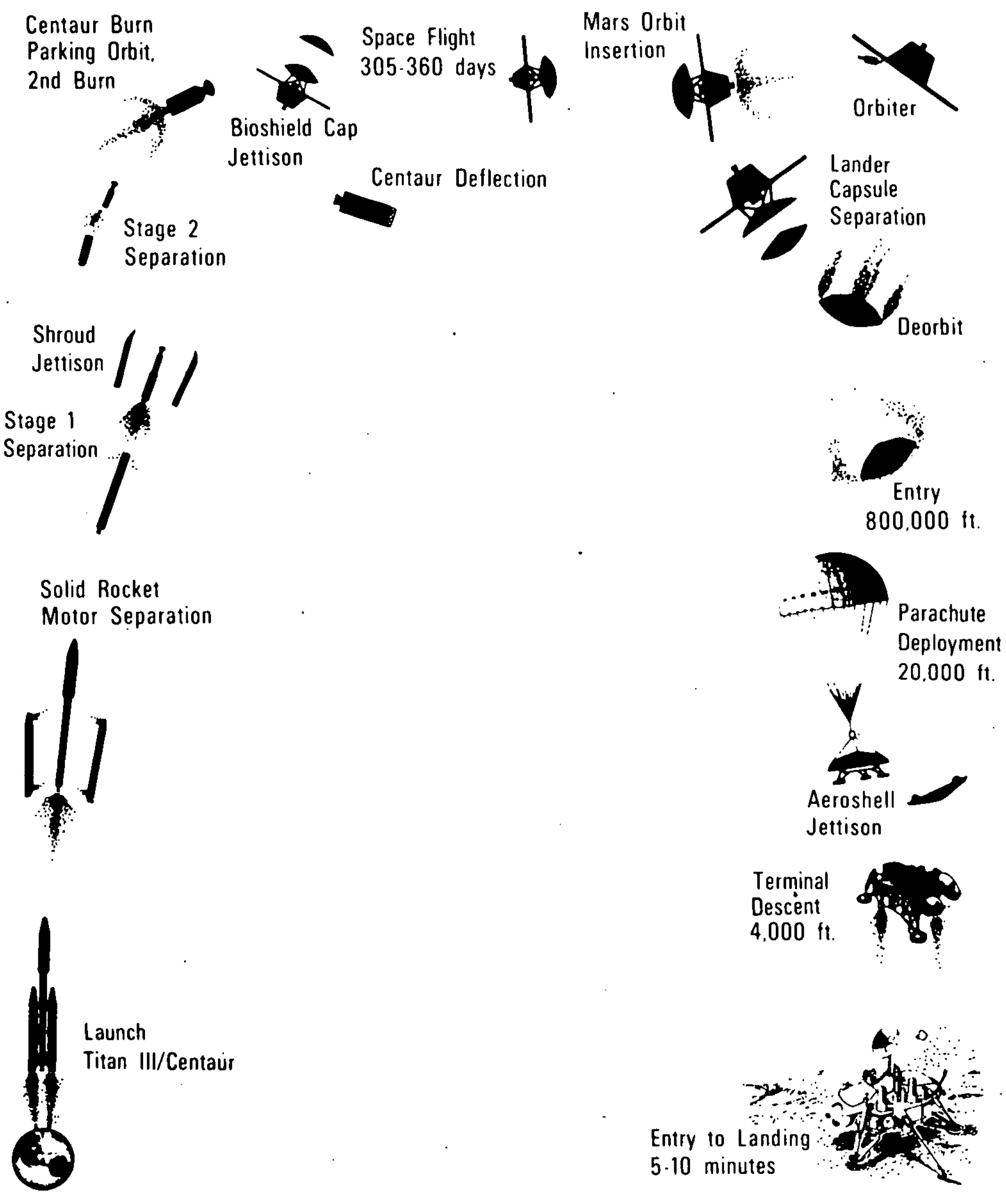
The Centaur's main engine fires for two minutes (126 seconds), placing the spacecraft in an Earth parking orbit at an altitude of 167 km (104 mi.) for from 11 to 30 minutes. The parking orbit will be used to correctly position Viking for Trans-Mars Injection (TMI). TMI is achieved by re-igniting the Centaur's engine for about 310 seconds.

Cruise Phase

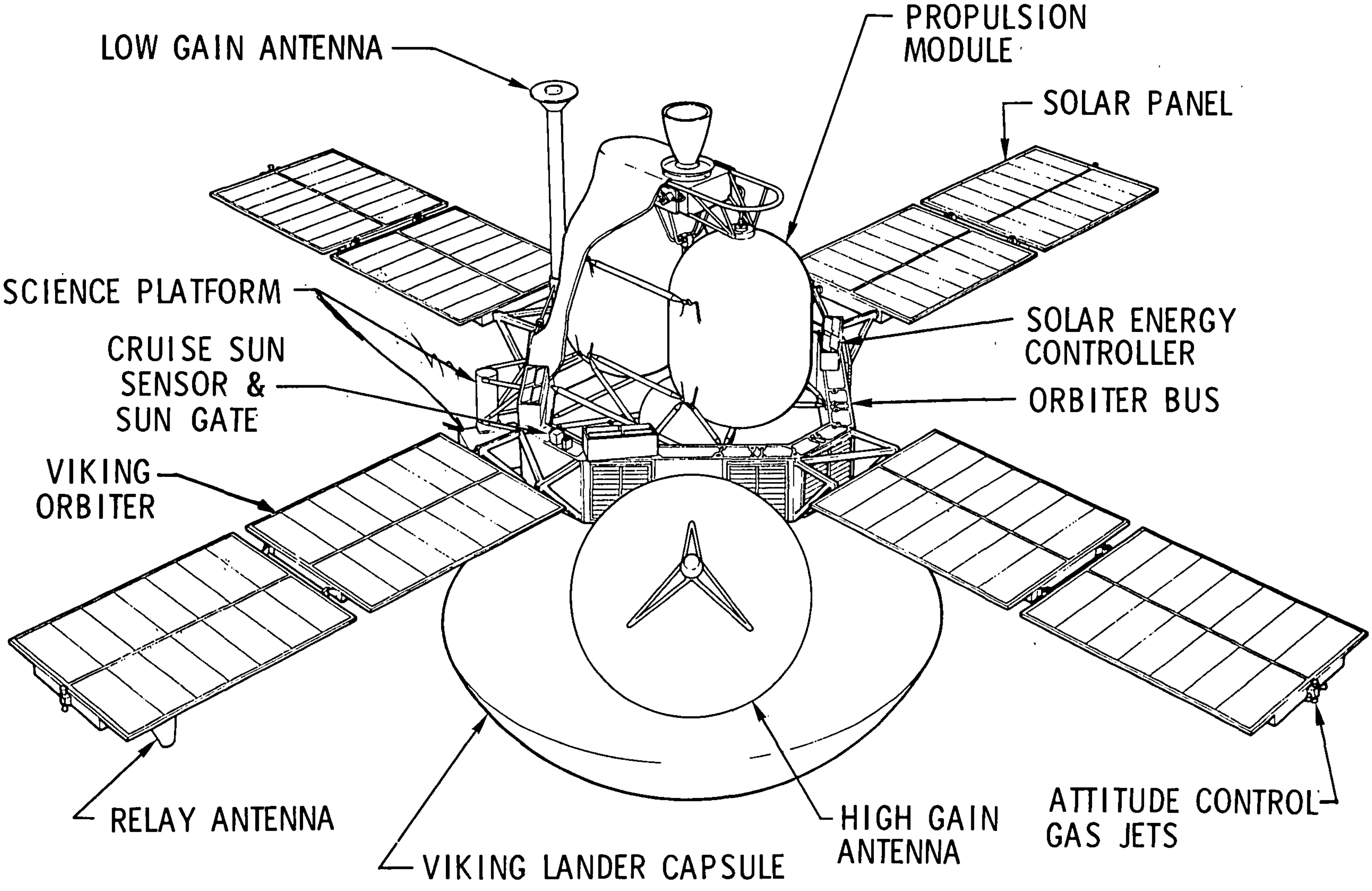
Viking's interplanetary cruise phase from Earth to Mars will last from 305 days to 360 days, with arrival occurring during maximum Earth-to-Mars distances. The Orbiter is the operating portion of the spacecraft during this phase, but both Orbiter and Lander remain relatively inactive.

Viking will follow what is called a Type II trajectory to reach Mars, circling more than 180 degrees around the Sun as it chases the planet. Viking will travel about 815 million km (505 million mi.) in its cruise, reaching Mars during summer 1976, which is also the summer season in Mars' northern hemisphere. At that time Earth and Mars will be about 380 million km (236 million mi.) apart.

Viking Mission Sequence



SPACECRAFT CONFIGURATION IN CRUISE MODE
(sunlit view)



One to four mid-course maneuvers are planned during cruise to correct the launch aim bias, possible trajectory errors and to insure Viking's arrival at the proper location and at the right time for its Mars Orbit Insertion (MOI) maneuver.

After the spacecraft is aligned to send and receive telemetry, it is separated from the Centaur (220 seconds after TMI). The Orbiter's four solar panels will be unfolded and the spacecraft will begin searching for the Sun. Once found, sunlight will provide power to Viking through the Orbiter's windmill-like solar panels.

At TMI plus 18 minutes, the Centaur will be deflected from a Mars flight path to one that bypasses the planet.

Soon after spacecraft separation, the DSN will acquire Viking's radio signal. DSN antennas will collect enough tracking information to determine the first mid-course maneuver, which will be done by a short firing of the Orbiter's engine.

The Lander's bioshield cap will be jettisoned shortly after the Orbiter's star sensor has acquired the star Canopus. With the acquisition of both the Sun and Canopus, the spacecraft is in a stable cruise attitude.

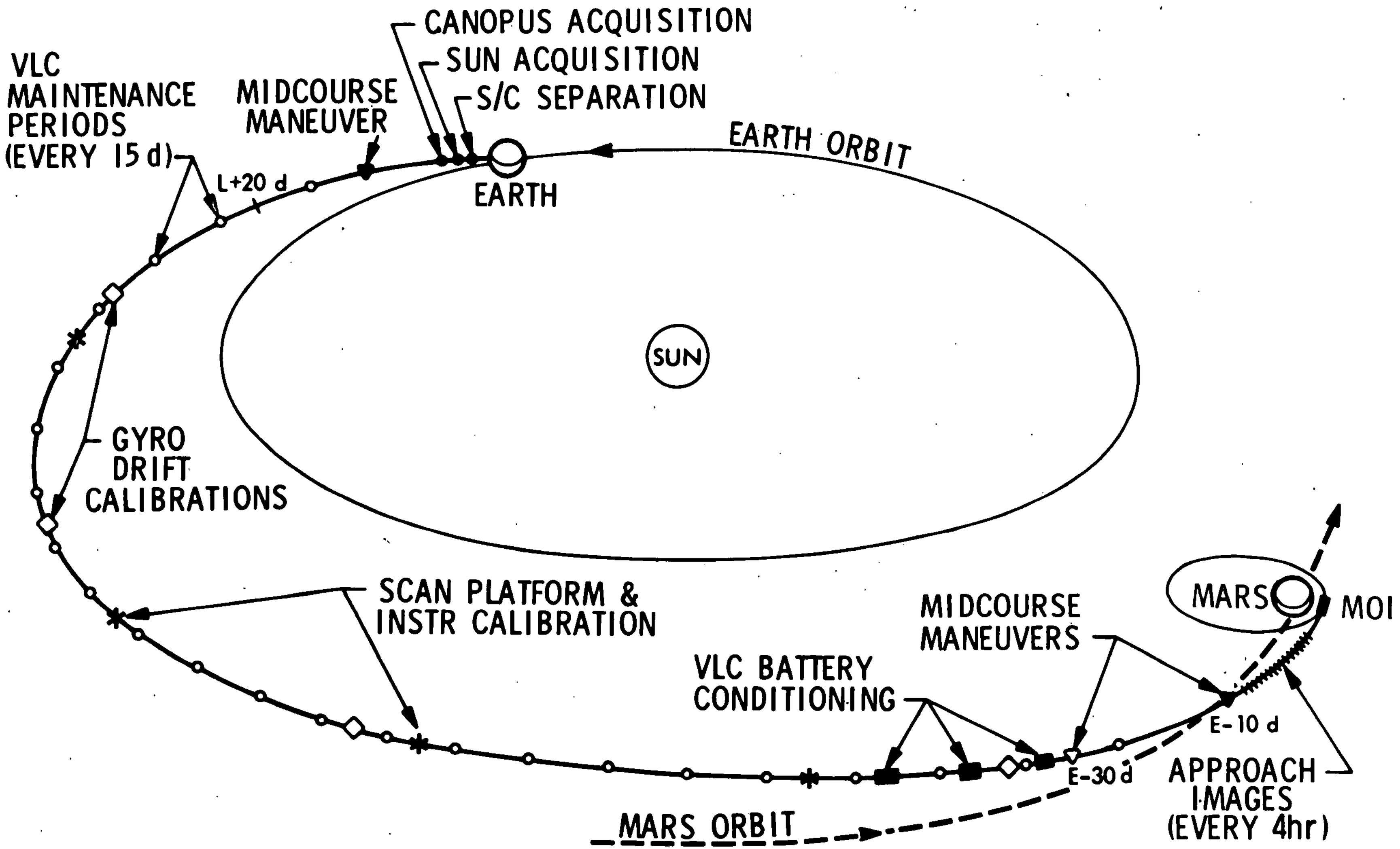
The DSN will track Viking, determining its position and velocity, and check the condition of both Orbiter and Lander. The combination of DSN metric data, star tracking and Sun sensing will enable Earth controllers to keep Viking on its trajectory.

Beginning about 30 days after launch, the Orbiter's scientific instruments will be periodically checked, and the Orbiter will contact the Lander about every 15 days. Instrument calibrations, battery charges, and other maintenance will be made during the cruise. A third mid-course maneuver is planned about 30 days before Mars Orbital Insertion (MOI).

About 10 days before Mars encounter, the Orbiter's scan platform will be unlatched and pointed toward Mars. Although still many thousands of kilometers away, the Orbiter will observe the planet with its cameras for calibration. Approach science observations will be made, including color photography and global infrared observations.

During the last three days before MOI, pictures will be taken of the Martian moon Deimos against the star background. The pictures will provide final optical navigation information to help calculate the MOI maneuver.

SPACECRAFT INTERPLANETARY ACTIVITY



Orbital Phase

The initial orbital phase is the period from MOI to separation of the Lander from the Orbiter. The orbital phase will continue after landed operations begin.

The first Viking is scheduled to encounter Mars June 18, 1976. Encounter may be made on or before that date if launch occurs during the first four days after Aug. 11, 1975. Launch delay beyond Aug. 18 will delay MOI beyond June 18, 1976. Delays beyond Aug. 22 will affect the second Viking and the mission profile strategy.

Viking 2 is scheduled for Mars encounter Aug. 7, 1976. This seven-week period between encounters will allow time to get Lander 1 onto the surface and complete the first cycle of landed operations before Viking 2 attains orbit.

The second Viking can be retargeted for a different landing site than its primary site up to 10 days before its MOI. Once Viking 2 is in orbit, however, its landings are restricted to a latitude band about 3 degrees wide.

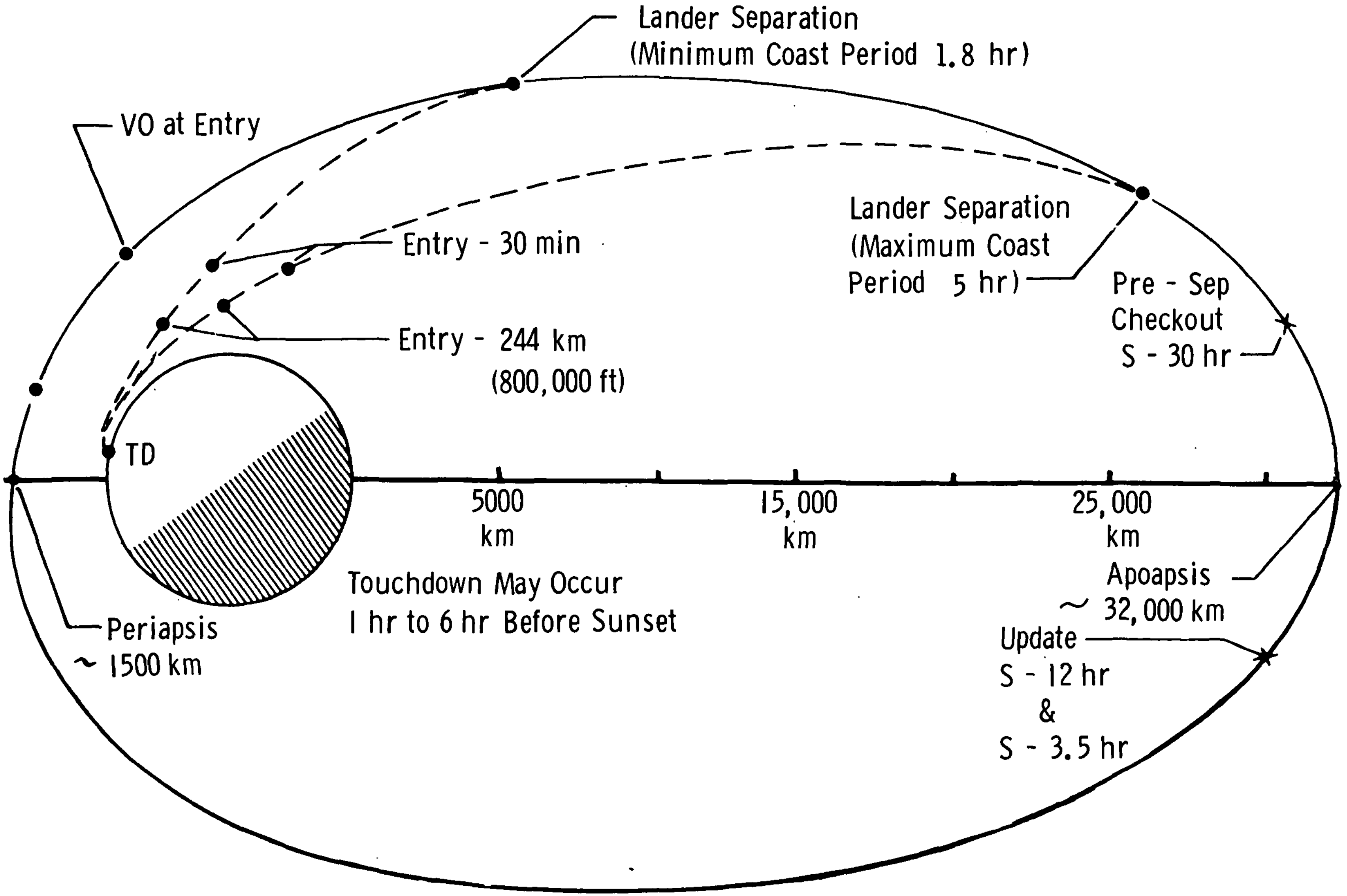
If the second Viking is not launched during the first 20 days of the normal launch range (Aug. 21 through Sept. 9, 1975), its MOI will be delayed and will affect the relationship between the two missions at Mars.

As Viking nears MOI, gas jets on the Orbiter will maneuver the spacecraft to point the Orbiter's engine in the general direction of flight. The engine will fire for 40 to 50 minutes, depending on approach velocity. The spacecraft and its high-gain antenna will be aligned so communications are maintained during engine firing.

The firing will reduce Viking's velocity by as much as 4,320 km per hour (2,678 mph), and insert it into a highly elliptical orbit about Mars.

Once in orbit, site acquisition will be done by trim maneuvers to establish a synchronous orbit in which Viking 1 will pass daily near the site with a periapsis of 1,500 km (930 mi.), an apoapsis of 32,600 km (20,200 mi.) and a period of 24.6 hours, which is the Martian rotation period. Viking 1 will have a 33.4-degree inclination that will result in a 30-degree Sun elevation angle at Lander touchdown.

SPACECRAFT ORBIT DESCRIPTION



Viking 2 will be inserted into a super-synchronous initial orbit with a period of about 28.7 hours. This strategy will provide several opportunities for low-altitude observations of the landing sites under excellent viewing conditions. Orbiter 2's planned orbit will have a 48.9-degree inclination and a 130-degree Sun elevation angle at landing.

Viking 1 will make extensive observations of the prime landing site (A-1), with particular emphasis on low-altitude coverage near periapsis, plus two or three picture pentads (groups of five) to monitor the site on most revolutions.

The A-1 site will be studied with the Orbiter's water vapor detector and thermal mapping instrument. Viking 1 will also observe Viking 2's prime landing site (B-1) from low-altitude with two picture swaths, and from high altitude with a pentad.

If the A-1 site is certified, Lander 1 will be committed. If the site is unacceptable, the backup (A-2) site will be examined. Once a site is picked, Orbiter trim maneuvers will fix periapsis near that site.

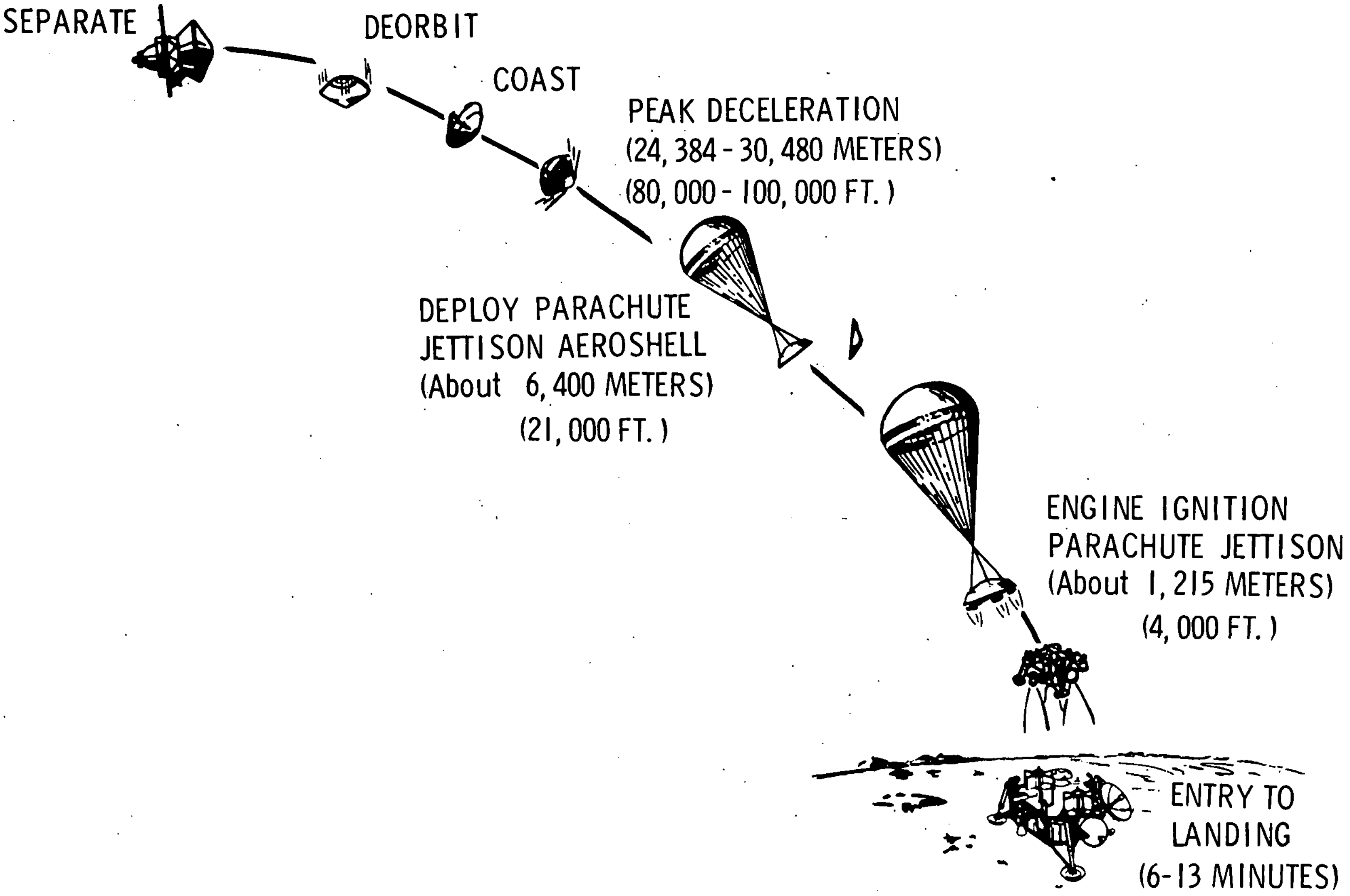
The first task of Viking 2, after its MOI, will be to certify landing site B-1. With Lander 1 already on the surface, 28 days have been planned for site selection. After Lander 2 touches down, an Orbiter 2 support period will be required, similar to that described for Viking 1. Alternatives for Orbiter 2 after this period will be similar to those for Viking 1.

Viking 2 will make a plane change maneuver Sept. 18, 1976, and begin a "resynchronous walk." The combined plane change/period change maneuver will increase the orbital inclination from 49 degrees to about 75 degrees and provide a super-synchronous period of approximately 26.8 hours.

The short walk will cover about 140 degrees longitude in 3.75 revolutions. Orbiter 2 will complete the walk by resynchronizing the descending leg of the orbit approximately over the B-1 site Sept. 23, 1976. This plane change maneuver is made to allow the Orbiter instruments to view the North polar cap.

Landing Sites. Viking landing sites must be both safe and scientifically interesting. They must have low surface elevations, winds, surface slopes and protuberances, adequate bearing strength, and radar properties.

LANDER DESCENT PROFILE



A site must have an elevation low enough for adequate atmospheric drag on the Lander's parachute during entry. Winds less than about 234 kmph (126 mph) will not pose a landing hazard. The Lander is designed to be stable on 19-degree slopes and has a clearance above the surface of 22 cm (8.7 in.). The surface bearing strength must be enough to safely support the Lander and reduce the shock of landing.

An area with a large amount of windblown dust will be a poor landing site, and bare rock is unacceptable because of the difficulty in getting surface samples for the science instruments. Entry is also strongly dependent on the radar altimeter and terminal descent landing radars, so the surface must have properties that allow proper radar return.

Areas with the highest probability of water are of maximum scientific interest because of the biolological emphasis of Viking. Although the chance of finding liquid water is extremely low, this criterion suggests areas of low elevation. Other scientifically interesting features are the geologic nature of the site and a reasonably unobstructed area that won't interfere with meteorological measurements.

Entry Phase

The entry phase is the period between separation of the Orbiter and Lander and the Lander's touchdown on Mars. The de-orbit to landing sequence is completely automated, controlled by the Lander's computer. The time required for a radio signal to travel from Earth to Mars is 20 minutes, making real-time control of the descent impossible from Earth.

Once the landing site is certified and landing is approved, the Orbiter will contact the cocooned Lander 30 hours before planned separation, activate its electrical system, and initiate pre-separation checkout of all Lander systems.

Earth controllers will then put descent instructions into the Lander's Guidance and Control Sequencing Computer (GCSC). After a "go" command from Earth, a GCSC command will sever mechanical and electrical ties between the two spacecraft by energizing explosive nuts and allowing springs to separate the vehicles.

After separation the Lander will align itself for the de-orbit maneuver. Several hours later the bioshield base and Lander adapter are jettisoned from the Orbiter; they will remain in Mars orbit.

A few minutes after separation, the aeroshell's small reaction control engines will fire for 24 minutes to give the Lander a 576 pmph (357 mph) velocity change (Delta V) to begin de-orbit coast.

Although the Martian atmosphere is 100 times less dense than Earth's, the Lander will be initially traveling about 16,000 kmph (9,920 mph), and must be protected from the intense heat and pressure of entry.

The small aeroshell attitude control jets align the Lander for entry and provide roll control during entry to hold the Lander in the correct attitude, which produces a small amount of lift during entry. A lifting entry will be used instead of a ballistic entry because it provides several significant advantages, including increased terrain height and landed weight.

Three to five hours after separation, the Lander will enter the Mars atmosphere at an altitude of 244 km (151 mi.). The first deceleration will come from aerodynamic drag on the aeroshell. Peak deceleration occurs at between 24.4 and 30.5 km (15 and 19 mi.).

At about 5.8 km (19,000 ft.) a parachute will be deployed by a mortar in the base cover. The aeroshell will be separated by spring devices seven seconds after parachute deployment. Aerodynamic lift will cause the aeroshell to drift away from the landing site. Just after aeroshell jettison, the Lander's legs will be extended.

The parachute can be deployed within the Mach 0.5 to 1.9 range, with a velocity of 1,598 kmph (991 mph). Maximum dynamic pressures range from 239 to 383 newtons per square meter (5 to 8 pounds psf).

The parachute will take the Lander to an altitude of about 1.4 km (4,600 ft.) in one minute. The three terminal descent engines (TDE) will then be ignited and the parachute and base cover will be jettisoned.

The TDEs will fire for about 30 seconds and reduce the Lander's velocity from 207 kmph (128 mph) at parachute separation to 8.8 kmph (5.5 mph) at touchdown. From about 16.8 m (55 ft.) the Lander will be on a vertical flight path and descend to the surface at a constant velocity.

Sensors on the Lander footpads automatically shut off the TDEs when one landing leg touches the surface. Shock absorbers in the legs will cushion the impact of landing.

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Two entry events will be initiated from information provided by the Lander's radar altimeter: parachute deployment and TDE ignition. The terminal descent landing radar is a critical element of the guidance and control subsystem during the landing's final phase.

During the 10-minute descent through the atmosphere, the Lander will obtain data on atmospheric structure and composition. These data, plus engineering information, will be relayed to the Orbiter for immediate transmission to Earth, and storage for later transmission.

Landed Phase

Just 25 seconds after the Lander touches down, Camera 2 will take a high-resolution picture of the near field terrain and footpad 3. While this five-minute imaging is underway, the Lander begins to activate itself.

The high-gain antenna is aimed to establish contact with DSN antennas on Earth. The meteorology boom is deployed, other instruments are activated, and the Lander science platform begins its laboratory investigations.

From this time until end-of-mission, the Lander's primary functions are to be a communication relay station for scientific data on their way to Earth, directly or through the Orbiter, and to provide electrical power and a safe thermal environment for science instruments and subsystems.

The communication window that governs the Lander's direct link with Earth is open for about 12 hours a day. Lander electrical power and thermal limits will effectively restrict radio communication to about 70 minutes a day of this available window, however. This will allow a daily data volume direct to Earth of about two million bits (computer binary digits) of information early in the mission and one million bits a day later in the mission when the greatest communication distances exist. The Lander will receive all of its commands over the direct S-band link.

At least 10 million bits a day will be transmitted by ultra-high frequency (UHF) link to the Orbiter, but the transmission period can only occur when the Lander can see the Orbiter 25 degrees or more above the horizon and within 5,000 km (3,100 mi.). This window will be open anywhere from 10 to 40 minutes a day. The UHF link can send 16,000 bits per second, compared with 250 to 500 bits per second directly to Earth by the HGA.

Orbiter 1 will remain in synchronous orbit through the entire Lander 1 mission (Sol 58). It will be a communication relay station for the Lander, gather its own science data and acquire data for use in making final landing decisions for the second mission.

Flexibility will be invaluable if trouble develops with any of the spacecraft. Cross communications between Orbiters and Landers, plus redundancy in many components, yield a high probability of success for Viking.

A scientific bonus also comes from joint Orbiter-Lander operations: the Orbiter provides landing site environmental information to aid landing decisions, then observe phenomena from orbit while the Lander takes surface measurements.

End of Mission. At the end of its planned 58-day landed phase, Lander 1 will go into a reduced mode, although some of its experiments will continue. Near the end of the 120-day mission, the Landers will be powered down to a safe condition to heighten their chances of surviving the conjunction period, when the Sun is exactly between Earth and Mars and the Landers will be out of contact with Earth.

Both Landers will be placed in a safe condition before Nov. 8 to survive the conjunction communications blackout period.

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VIKING ORBITER

The Viking Orbiter is a follow-on design to the Mariner class of planetary spacecraft with specific design changes for the Viking mission. Operational lifetime requirements for the Orbiter are 120 days in orbit and 90 days after the landing.

Orbiter Design

The design of the Orbiter was greatly influenced by the size of the Lander, which dictated a larger spacecraft structure than Mariner, increased propellant storage for a longer burn time for orbit insertion, and upgrading of the attitude control system with additional gas storage and larger impulse capacity.

The combined weight of the Orbiter and Lander was one factor that contributed to an 11-month transit time to Mars, instead of five months for Mariner missions. The longer flight time then dictated an increased design life for the spacecraft, larger solar panels to allow for longer degradation from solar radiation and additional attitude control gas.

Structure

The basic structure of the Orbiter is an octagon approximately 2.4 m across (8 ft.). The eight sides of the ring-like structure are 45.7 cm (18 in.) high and are alternately 1.4 by 0.6 m (55 by 22 in.).

Electronic bays are mounted to the faces of the structure and the propulsion module is attached at four points. There are 16 bays, or compartments, three on each of the long sides and one on each short side.

The Orbiter is 3.3 m (10.8 ft.) high and 9.7 m (32 ft.) across the extended solar panels. Its fueled weight is 2,325 kg (5,125 lbs.).

Combined area of the four panels is 15 square m (161 square ft.), and they provide both regulated and unregulated direct current power; unregulated power is provided to the radio transmitter and the Lander.

Two 30-ampere-hour, nickel-cadmium, rechargeable batteries provide power when the spacecraft is not facing the Sun during launch, correction maneuvers and Mars occultation.

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Guidance and Control

The Orbiter is stabilized in flight by locking onto the Sun for pitch and yaw reference and onto the star Canopus for roll reference. The attitude control subsystem (ACS) keeps this attitude with nitrogen gas jets located at the solar panel tips. The jets fire to correct any drift. A cruise Sun sensor and the Canopus sensor provide error signals. Before Sun acquisition four acquisition Sun sensors are used and then turned off.

The ACS also operates in an all-inertial mode or in roll-inertial with pitch and yaw control, still using the Sun sensors. During correction maneuvers the ACS aligns the vehicle to a specified attitude in response to commands from the on-board computer. Attitude control during engine burns is provided in roll by the ACS and in pitch and yaw by an autopilot that commands engine gimballing.

If Sun lock is lost the ACS automatically realigns the spacecraft. In loss of Canopus lock, the ACS switches to roll-inertial and waits for commands from the spacecraft computer. The nitrogen gas supply for the ACS can be augmented by diverting excess helium gas from the propulsion module, if necessary.

Two on-board general-purpose computers in the computer command subsystem (CCS) decode commands and either order the desired function at once or store the commands in a 4,096-word, plated-wire memory. All Orbiter events are controlled by the CCS, including correction maneuvers, engine burns, science sequences, and high-gain antenna pointing.

Communications

The main Orbiter communications system is a two-way, S-band, high-rate radio link providing Earth command, radio tracking and science and engineering data return. This link uses either a steerable 1.5 m (59 in.) dish high-gain antenna (HGA) or an omni-directional low-gain antenna (LGA), both of them on the Orbiter. The LGA is used to send and receive near Earth, the HGA as distances increase. An X-band link is used for radio science through the HGA.

S-band transmission rates vary from 8.3 or 33.3 bits per second (bps) for engineering data to 2,000 to 16,000 bps for Lander and Orbiter science data.

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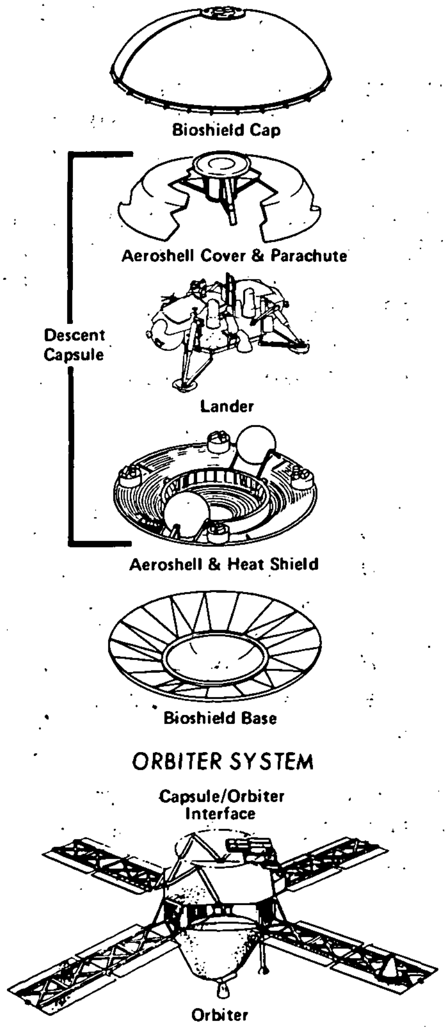
Relay from the Lander is through an antenna mounted on the outer edge of a solar panel. It will be activated before separation and will receive from the Lander through separation, entry, landing, and surface operations. The bit rate during entry and landing is 4,000 bps; landed rate is 16,000 bps.

Data Storage

Data are stored aboard the Orbiter on two eight-track digital tape recorders. Seven tracks are used for picture data and the eighth track for infrared data or relayed Lander data. Each recorder can store 640 million bits.

Data collected by the Orbiter, including Lander data are converted into digital form by the flight data subsystem (FDS) and routed to the communications subsystem for transmission or to the tape recorders for storage. This subsystem also provides timing signals for the three Orbiter science experiments.



VIKING LANDER

The Lander spacecraft is composed of five basic systems: the Lander body, the bioshield cap and base, the aeroshell, the base cover and parachute system, and Lander subsystems. Operational lifetime for the Lander is 90 days after landing.

The completely outfitted Lander measures approximately 3 m (10 ft.) across and is about 2 m (7 ft.) tall. It weighs approximately 576 kg (1,270 lbs.) without fuel.

The Lander and all exterior assemblies are painted light gray to reflect solar heat and to protect equipment from abrasion. The paint is made of rubber-based silicone.

Lander Body

The body is a basic platform for science instruments and operational subsystems. It is a hexagon-shaped box with three 109-cm (43-in.) sidebeams and three 56-cm (22-in.) short sides. It looks like a triangle with blunted corners.

The box is built of aluminum and titanium alloys, and is insulated with spun fiberglass and dacron cloth to protect equipment and to lessen heat loss. The hollow container is 1.5 m (59 in.) wide and 46 cm (18 in.) deep, with cover plates top and bottom.

The Lander body is supported by three landing legs, 1.3 m (51 in.) long, attached to the short-side bottom corners of the body. The legs give the Lander a ground clearance of 22 cm (8.7 in.).

Each leg has a main strut assembly and an A-frame assembly, to which is attached a circular footpad 30.5 cm (12 in.) in diameter. The main struts contain bonded, crushed aluminum honeycomb to reduce the shock of landing.

Bioshield Cap and Base

The two-piece bioshield is a pressurized cocoon that completely seals the Lander from any possibility of biological contamination until Viking leaves Earth's atmosphere.

The two bioshield halves generally resemble an egg, and the shield's white thermal paint heightens the resemblance. It measures 3.7 m (12 ft.) in diameter and is 1.9 m (6.4 ft.) deep. It's made of coated, woven fiberglass, 0.13 mm (0.005-in.) thin, bonded to an aluminum support structure.

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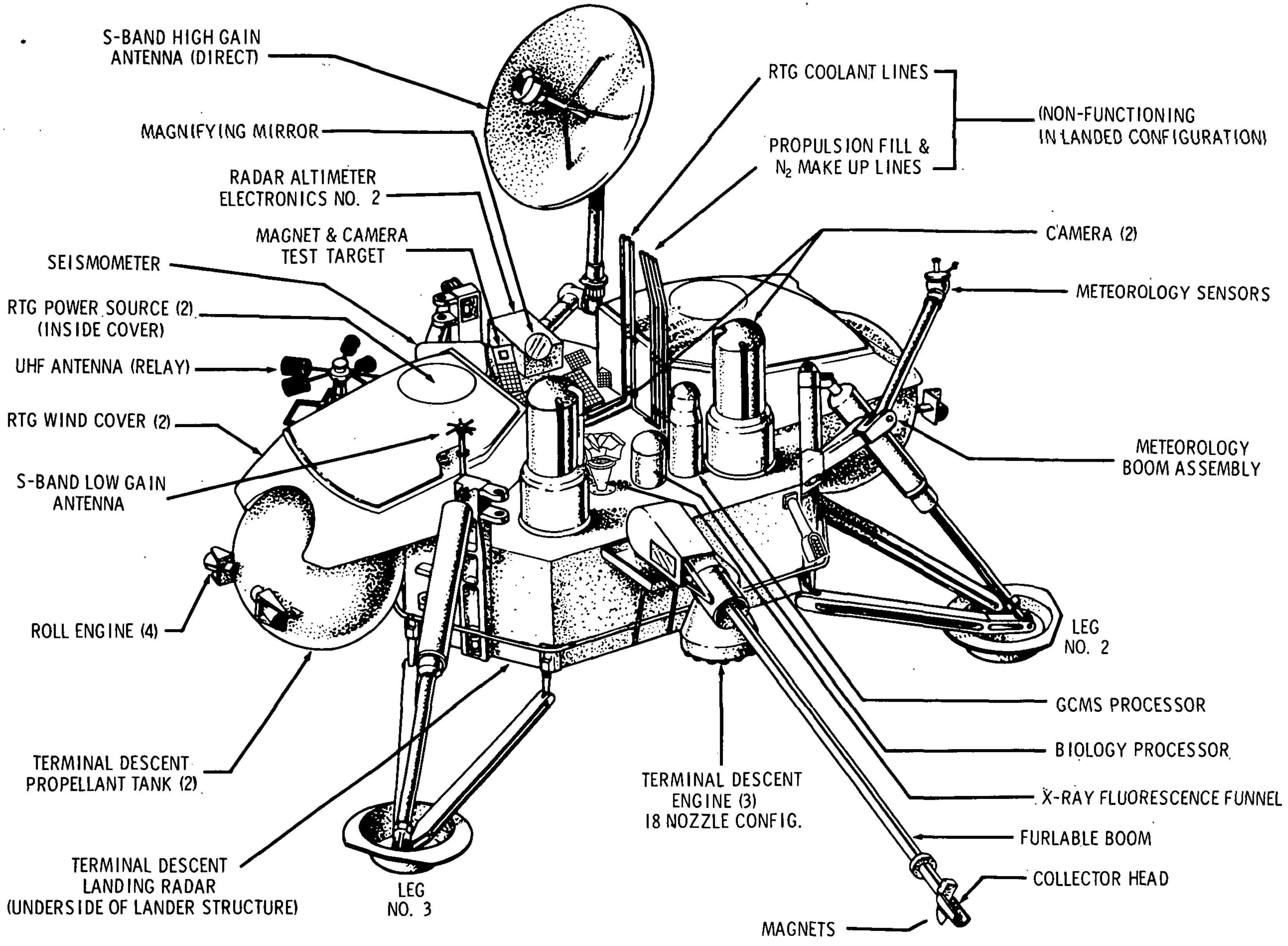
VIKING LANDED CONFIGURATION



The bioshield is vented to prevent over-pressurization and possible rupture of its sterile seal.

Aeroshell

The aeroshell is an aerodynamic heat shield made of aluminum alloy in a 140-degree, flat cone shape and stiffened with concentric rings. It fits between the Lander and the bioshield base. It is 3.5 m (11.5 ft.) in diameter and its aluminum skin is 0.86 mm (0.034-in.) thin.

Bonded to its exterior is a lightweight, cork-like ablative material that burns away to protect the Lander from aerodynamic heating at entry temperatures which may reach 1,500 degrees C. (2,730 degrees F.).

The interior of the aeroshell contains twelve small reaction control engines, in four clusters of three around the aeroshell's edge, and two spherical titanium tanks that contain 85 kg (188 lbs.) of hydrazine mono-propellant.

The engines control pitch and yaw to align the Lander for entry, help slow the craft during early entry and maintain roll control.

During the long cruise phase, an umbilical connection through the aeroshell provides power from the Orbiter to the Lander; housekeeping data also flow through this connection.

The aeroshell also contains two science instruments -- the Upper Atmosphere Mass Spectrometer (UAMS) and the Retarding Potential Analyzer (RPA) -- plus pressure and temperature sensors.

Base Cover and Parachute System

The base cover fits between the bioshield cap and the Lander. It is made of aluminum and fiberglass; the fiberglass allows transmission of telemetry data to the Orbiter during entry. It covers the parachute and its ejection mortar, and protects the Lander's top during part of the entry phase.

The parachute is made of lightweight dacron polyester 16 m (53 ft.) in diameter. It weighs 50 kg (110 lbs.).

The parachute is packed inside a mortar 38 cm (15 in.) in diameter, mounted into the base cover. The mortar is fired to eject the parachute at about 139 km per hour (75 mph). The chute has extra-long suspension lines that trail the capsule by about 30 m (100 ft.).

Lander Subsystems

Lander subsystems are divided into six major categories: descent engines, communications equipment, power sources, landing radars, data storage, and guidance and control.

Descent Engines

Three terminal descent engines (TDE) provide attitude control and reduce the Lander's velocity after parachute separation. The 2,600-newton (600-lb.) throttleable engines are located 120 degrees apart on the Lander's sidebeams. They burn hydrazine mono-propellant.

The engines use an advanced exhaust design that won't alter the landing site environment. An unusual grouping of 18 small nozzles on each engine will spread engine exhaust over a wide angle that won't alter the surface or unduly disturb the chemical and biological experiments.

Two spherical titanium tanks, attached to opposite sides of the Lander body beneath the RTG wind covers, feed the TDEs from an 85-kg (188 lb.) hydrazine propellant supply.

Four small reaction control engines use hydrazine mono-propellant thrusters to control Lander roll attitude during terminal descent. The engines are mounted in pairs on the TDE propellant tanks and are identical to those used on the aeroshell.

Communication Equipment

The Lander is equipped to transmit information directly to Earth with an S-band communications system, or through the Orbiter with an ultra-high frequency (UHF) relay system. The Lander also receives Earth commands through the S-band system.

Two S-band receivers provide total redundancy in both command receiving and data transmission. One receiver uses the high-gain antenna (HGA), a 76-cm (30-in.) diameter parabolic reflector dish that can be pointed to Earth by computer control. The second receiver uses a fixed low-gain antenna (LGA) to receive Earth commands.

The UHF relay system transmits data to the Orbiter with a radio transmitter that uses a fixed antenna. The UHF system will operate during entry and for the first three days of landed operations. After that it will only operate during specific periods.

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Landing Radars

The radar altimeter (RA) measures the Lander's altitude during the early entry phase, alerting the Lander computer to execute the proper entry commands. The RA is a solid-state pulse radar with two specially designed antennas: one is mounted beneath the Lander and one is mounted through the aeroshell. Altitude data are received from 1,370 km down to 30.5 m (740 mi. to 100 ft.).

The aeroshell antenna provides high-altitude data for entry science, vehicle control and parachute deployment. The Lander antenna is switched into operation at aeroshell separation and provides altitude data for guidance and control, and for terminal descent engine ignition.

The terminal descent landing radar (TDLR) measures the horizontal velocity of the Lander during the final landing phase. It is located directly beneath the Lander and is turned on at about 12 km (4,000 ft.). It consists of four continuous-wave Doppler radar beams that can measure velocity to an accuracy of plus or minus one meter per second.

Both radars are essential for mission success, so the terminal descent landing radar can work with any three of its four beams, and identical sets of radar altimeter electronics can be switched to either of the RA antennas.

Guidance and Control

The "brain" of the Lander is its guidance control and sequencing computer (GCSC). It commands everything the Lander does through software (computer programs) stored in advance or relayed by Earth controllers.

The computer is one of the greatest technical challenges of Viking. It consists of two general-purpose computer channels with plated-wire memories, each with an 18,000-word storage capacity. One channel will be operational while the other is in reserve.

Among other programs, the computer has instructions stored in its memory that can control the Lander's first 22 days on Mars without any contact from Earth. These instructions will be updated and modified by Earth command once communication has been established.

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Power Sources

Basic power for the Lander is provided by two SNAP 19-style 35-watt radioisotope thermoelectric generators (RTGs) developed by the U. S. Energy Research and Development Administration (ERDA). They are located atop the Lander, and are connected in series to double their voltage and reduce power loss.

The SNAP 19 Viking generator is 147 cm (23 in.) across the housing fin tips, 96 cm (15 in.) in length and weighs 15.3 kg (34 lbs.).

The first isotopic space generator was put into service in June 1961, on a Navy navigational satellite. Advances in SNAP systems were made with the the development and flight of SNAP 19 aboard Nimbus III, launched in April 1969. This use of SNAP 19 represented a major milestone in the development of long-lived, highly reliable isotope power systems for space use by NASA. The SNAP 27 generator was developed to power 5 science stations left on the Moon by the Apollo 12, 14, 15, 16 and 17 astronauts. The continuing operation of these generators is providing new dimensions of data about the Moon and the universe. Four SNAP 19 nuclear generators are providing the electrical power for each of the two NASA pioneer Jupiter fly by missions (Pioneers 10 and 11) currently in space.

The generators will provide a long-lived source of electricity and heat on Mars, where sunlight is half as strong as on Earth, and is non-existent during the Martian night, when temperatures can drop as low as minus 120 degrees C. (minus 184 degrees F.).

The generators use thermoelectric elements to convert heat from decaying plutonium-238 into 70 watts of electrical power.

"Waste" or unconverted heat is conveyed by thermal switches to the Lander's interior instrument compartment, when required. Covers over the RTGs prevent excess heat dissipation into the environment.

Four nickel-cadmium, rechargeable batteries help supply Lander power requirements in peak activity periods. The batteries, mounted in pairs inside the Lander, are charged by the RTGs with power available when other Lander power requirements are less than RTG output.

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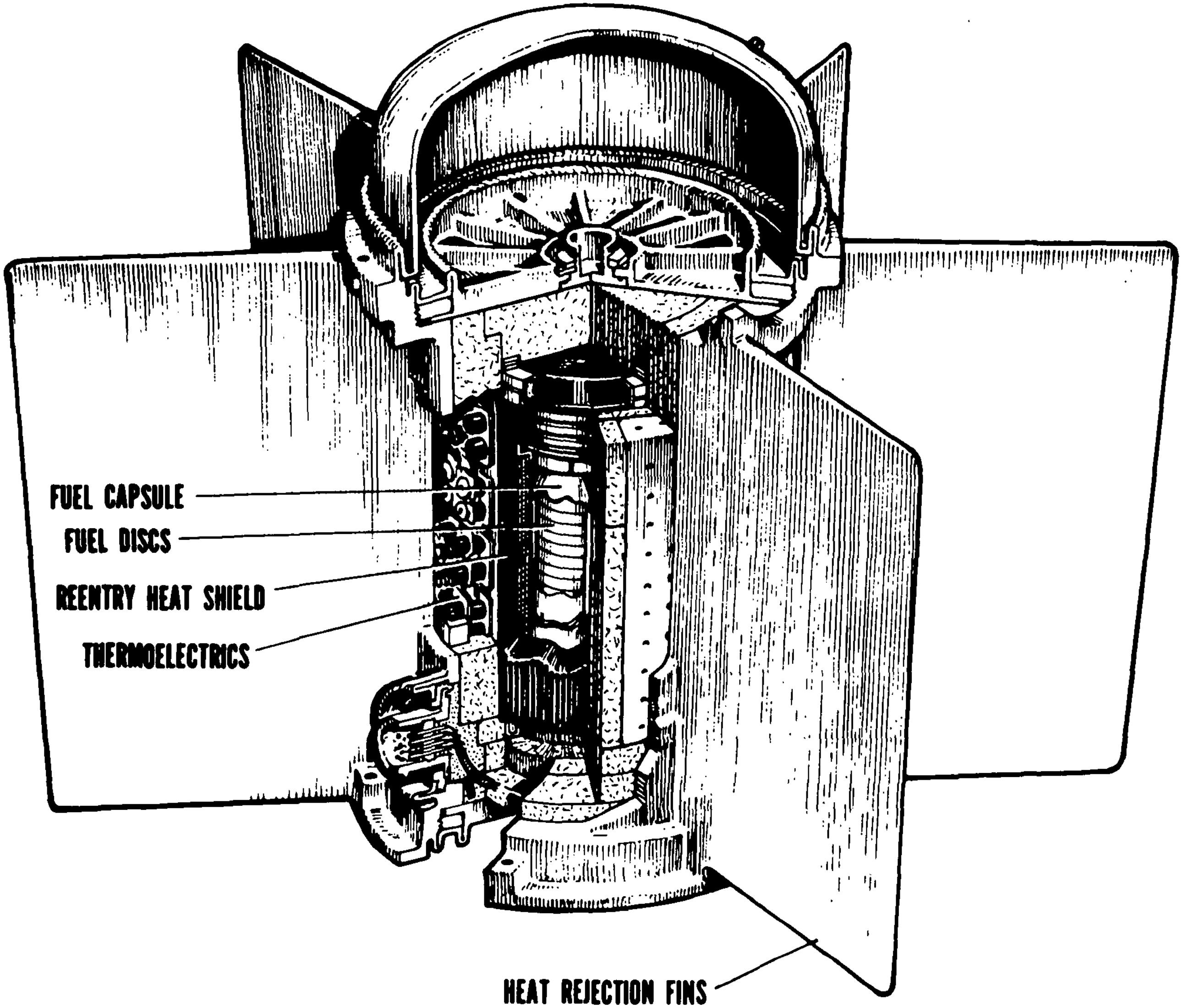
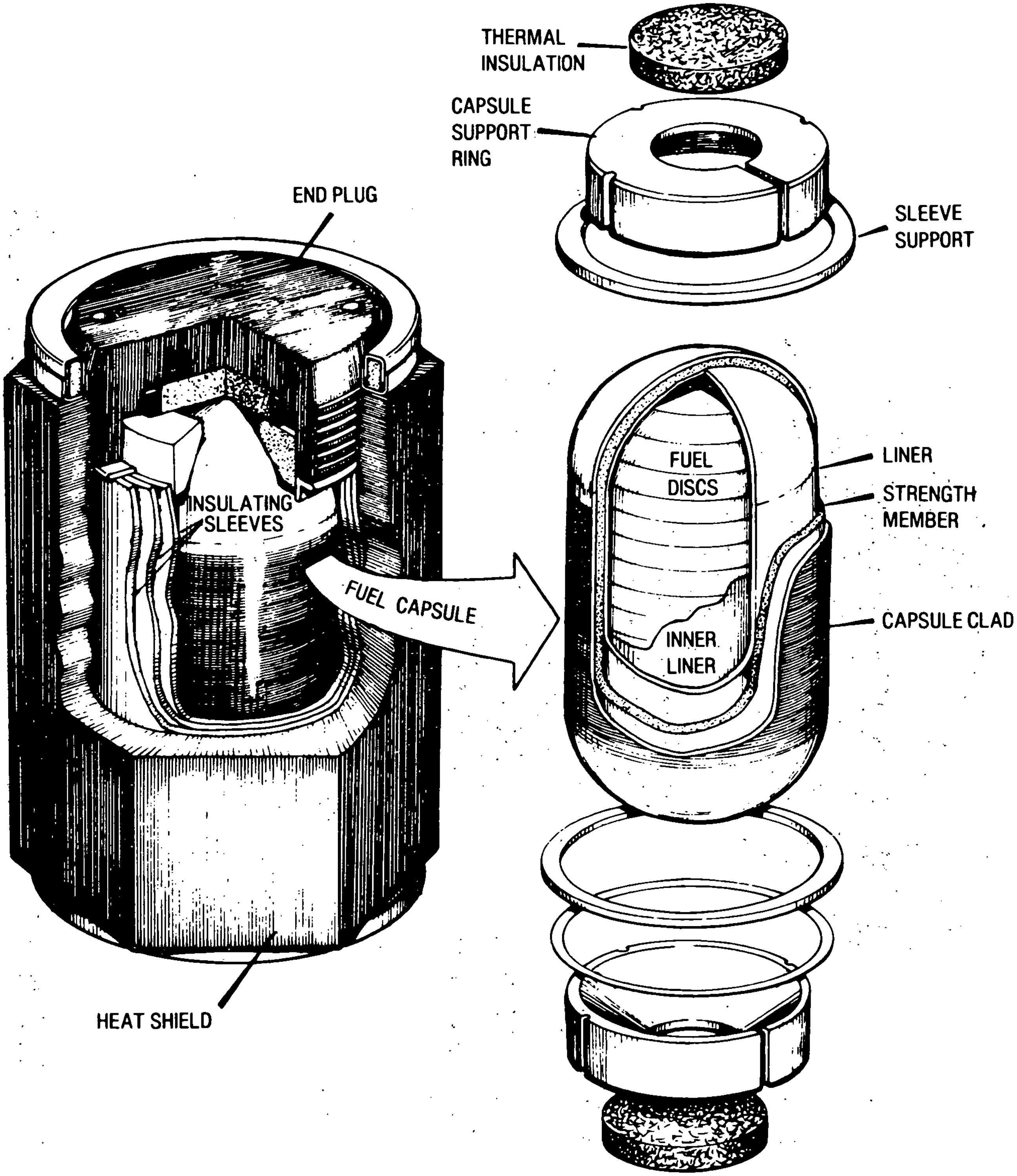


SNAP 19/VIKING RADIOISOTOPE THERMOELECTRIC GENERATOR



SNAP 19/VIKING HEAT SOURCE

Data Storage

This equipment collects and controls the flow of Lander scientific and engineering data. It consists of a data acquisition and processing unit (DAPU), a data storage memory and a tape recorder.

The DAPU actually collects the science and engineering information and routes it to one of three places: to Earth through the S-band HGA, to the data storage memory or to the tape recorder.

Information will be stored in the data storage memory for short periods. Several times a day the memory will transfer data to the tape recorder or back to the DAPU for further transmission. The memory has a storage capacity of 8,200 words.

Data are stored on the tape recorder for long periods. The recorder can transmit at high speed back through the DAPU and the UHF link to an Orbiter passing overhead. It can store as many as 40 million bits of information, and it can record at two speeds and play back at five.

LAUNCH VEHICLE

The two Viking missions are the second and third operational launches for the Titan Centaur vehicle (TC-3 and TC-4). Its first operational launch of a Helios spacecraft last December 10 was an unqualified success. In addition to launching Helios into a solar orbit, the Titan Centaur successfully performed several experiments to demonstrate its readiness to perform future missions. The first experiment demonstrated the Centaur restart capability after a one hour zero-gravity coast for application to the Mariner Jupiter Saturn mission scheduled for 1977. Subsequent experiments demonstrated its ability to directly insert spacecraft into Earth synchronous orbits.

The Titan Centaur launch vehicle combines a Titan III-E booster and Centaur D-1T third stage. It has an over all height of 48.8 m (160 ft.) and a total liftoff weight of 64,000 kg (1.4 million lbs.).

The entire Centaur third stage vehicle and its payload is covered by the Centaur Standard Shroud (CSS). The CSS measures 17.6 m (58 ft.) long and is 4.2 m (14 ft.) in diameter, and will accommodate a spacecraft nearly 8.5 m (28 ft.) in length.

Titan III-E

The Titan III-E booster consists of a two-stage liquid propellant core vehicle and two strap-on solid rocket motors, each 3 m (10 ft.) in diameter and 25.9 m (85 ft.) long. The two solids, which are made up of five segments each, provide a thrust of 10.6 million newtons (2.4 million lbs.) at liftoff.

The 3-m (10-ft.) diameter core stages are primarily constructed of aluminum alloys. They are made with aluminum skins with T-shaped aluminum stringers integrally milled. The length of the first stage is 22.2 m (72.9 ft.) and the second stage 7.1 m (23.3 ft.).

A heat shield assembly protects the Stage I engine from the high temperatures generated by the solid rocket motors. The heat shield encloses a major portion of the engine from the thrust chamber throats upward.

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The two core stages burn a 50-50 blend of hydrazine and unsymmetrical dimethylhydrazine (UDMH) fuel and nitrogen tetroxide oxidizer. The first stage uses an Aerojet YLR87 OAJ-11 engine with two gimballing thrust chambers. It can burn for approximately 148 seconds and provides 2,340,000 N (520,000 lbs.) thrust. The second stage Aerojet YLR91AJ-11 engine has a single thrust chamber and provides 446,000 N (101,000 lbs.) thrust for about 208 seconds. Both the first and the second stage engines are regeneratively cooled and turbopump fed.

Control for Stage I is achieved by gimballing the engines. The gimballed main engine provides pitch and yaw control for Stage II, with the gas generator exhaust providing roll control. Guidance commands come from the Centaur system while stability is controlled by the Titan flight control system.

The two five-segment solid strap-on motors use powdered aluminum fuel and ammonium perchlorate oxidizer in a plastic binder. Both burn for approximately 122 seconds. The two solid motors are generally referred to as Stage "O". Each carries a tank for nitrogen tetroxide mounted on the side of the motor for thrust vector control. The nitrogen tetroxide is injected through the nozzle to deflect the motor thrust for flight control.

Centaur D-1T

The Centaur vehicle is 9.1 m (30 ft.) long and 3 m (10 ft.) in diameter. The tank structure is made from pressure stabilized stainless steel 3 mm (0.014 in.) thick in the cylindrical sections. This is approximately the thickness of a dime. Pressure stabilized means that the strength of the vehicle structure depends on pressure inside the tanks and it has often been called a balloon type structure. When the vehicle is not pressurized it must be kept in a special cradle which keeps it stretched to retain its shape.

A double-walled vacuum-insulated bulkhead separates the liquid oxygen section from the liquid hydrogen tank. The forward equipment module attaches to the tank by a short conical stub adapter. The stub adapter is also used as an attach point for a truss type adapter for payloads weighing more than 1,814 kg (4,000 lbs.). Spacecraft smaller than that are supported by a payload adapter mounted on the forward end of the equipment module.

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The entire cylindrical portion of the D-1T vehicle is covered with a new permanent radiation shield consisting of three separate layers of an aluminized mylar, dacron net sandwich. The forward tank bulkhead and tank access doors are insulated with a number of layers of aluminized mylar. The aft bulkhead is covered with a dacron-reinforced aluminized mylar membrane and protected further with a rigid radiation shield supported on brackets. The radiation shield is made of laminated nylon fabric with aluminized mylar on the inside and white polyvinyl fluoride on its outer surface and is necessary to limit the loss of propellants resulting from solar heating during long duration missions.

This permanent insulation system will allow the Centaur stage to coast up to 5 1/4 hours in space and restart its engines. This added capability for coast, over former Centaur vehicles, is necessary for synchronous orbit missions.

Additional hydrogen peroxide for attitude control and propellant settling as well as additional helium for tank pressurization have also been added to the D-1T vehicle to allow for extended missions.

Primary propulsion for the Centaur is its two RL-10A-3-3 engines which provide 66,720 N (15,000 lbs.) thrust each.

During coast, separation and retromaneuvers, attitude control and propellant settling are provided by 12 small hydrogen peroxide thrusters rated at 26.7 N (6 lbs.) thrust.

The Centaur D-1T astrionics system consists primarily of a digital computer unit and an inertial reference unit. The 27.2 kg (60 lb.) digital computer has a 16,000-word random access memory. The inertial reference unit contains a four-gimbal, all-attitude stable platform. Three gyros stabilize this platform on which are mounted three pulse-rebalanced accelerometers.

The Centaur astrionics system handles navigation, guidance tasks, propellant and tank pressure management, telemetry formats and transmission and initiates vehicle events. The system also performs a major role in checking itself and other vehicle systems prior to launch. One of its major advantages is the increased flexibility the new astrionics system offers over the original Centaur system. In the past, hardware frequently had to be modified for each mission. Now most operational needs can be met by changing the computer software.

The Titan III vehicle previously used a radio guidance system. Modifications to mate it with Centaur were designed to retain as much Titan autopilot and programming sequence capability as possible. To keep modifications to the Titan and connections between stages as simple as possible, the Centaur guidance system feeds signals to the Titan flight computer and lets it send the proper commands to Titan systems.

Centaur Standard Shroud

The Centaur Standard Shroud provides a large payload space on the Titan Centaur. In most configurations a payload nearly 8.5 m (28 ft.) long can be accommodated. Inside clearance of the shroud is 3.8 m (12 1/2 ft.). A manufacturing joint is provided which allows for future shroud growth if a need for longer payload accommodations arises.

The nose cap is made from corrosion-resistant steel attached to two conical sections of magnesium. The cylindrical sections are made of corrugated aluminum. A seal and insulation allows a clean and thermally controlled environment in the payload area.

The two halves of the Centaur Standard Shroud join along a longitudinal split line. Approximately 60 seconds after Titan Stage II ignition, the longitudinal and horizontal split lines are severed by a noncontaminating pyrotechnic system. Four compressed springs force the two halves to separate. The cone-shaped bottom section of the shroud is bolted to the inter-stage adapter and is jettisoned later with the Titan stage.

That portion of the Centaur Standard Shroud which surrounds the Centaur vehicle contains 8.3 cm (3.3 in.) fiberglass insulation. This section reduces heat transfer to the Centaur liquid hydrogen and oxygen propellant on the launch pad and during ascent through the atmosphere.

TITAN CENTAUR FLIGHT SEQUENCE

Titan Phase

Liftoff occurs approximately two-tenths of a second after ignition of the solid rocket motors. At 6.5 seconds into the flight, Titan begins a programmed roll maneuver commanded by Centaur guidance. The roll maneuver and all attitude control during the solid rocket motor powered portion of the flight are accomplished by the Titan thrust vector system. Steering is accomplished by injecting liquid nitrogen tetroxide into the solid motor nozzles deflecting the rocket exhaust gases.

Stage I ignition of the Titan occurs when acceleration from the large solid motors reduces to 1.5 g. Approximately 12 seconds later, the solids are jettisoned. Titan Stage I continues thrusting until propellant depletion at approximately T plus 260 seconds.

Titan Stage II ignition occurs at Stage I propellant depletion, and separation takes place approximately one second later. During Stage I and Stage II phases of the flight, the vehicle attitude in pitch and yaw is controlled by the Titan flight control system with guidance steering corrections supplied by the Centaur guidance system.

The Centaur standard shroud is jettisoned by command from the Centaur guidance system approximately 10 seconds after Stage II ignition.

Titan Stage II boosts the vehicle until loss of acceleration due to propellant depletion, approximately 467 seconds after liftoff. The Centaur guidance system commands separation when Stage II acceleration decays to about .012 g. The Centaur interstage adapter is severed by a shaped charge and retro-rockets on the Titan Stage II slow the spent stage.

Centaur Phase

Centaur first main engine start occurs approximately 10.5 seconds after Titan Centaur separation. Centaur main engine shutdown is commanded by the guidance system when the proper parking orbit is achieved.

Continuous propellant settling will be maintained during the parking orbit coast phase. During most of the coast phase the vehicle is aligned along the inertial velocity vector. Prior to second burn the vehicle is realigned to the pitch attitude required for achieving the proper trajectory to Mars.

The second Centaur burn, of approximately 310 seconds, is terminated by the Centaur guidance system.

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C-2

LAUNCH WINDOW

The windows for launches to Mars are determined by the relationship between the Earth and Mars, the amount of energy required to launch a spacecraft of a given weight on each day and such factors as tracking coverage.

The energy level and velocity necessary to reach Mars is lowest when the Earth launch and Mars arrival occur almost on opposite sides of the Sun. This condition occurs during a few weeks every 25 months.

Tracking coverage is important for determining exact course and performance of the launch vehicle. A second factor is range safety. The launch azimuth, or direction of launch, must stay within certain prescribed limits to avoid overflying populated areas in case of a malfunction in the vehicle and re-entry of vehicle stages and shrouds. Because of the Earth rotation, the launch azimuth for most planetary launches varies from minute to minute throughout the launch window. When the launch azimuth to reach Mars does not conform to that required for range safety, the vehicle can be launched down a safe corridor and then perform a dog-leg maneuver to the proper flight azimuth after satisfying range safety requirements.

VIKING A* LAUNCH VEHICLE CHARACTERISTICS

Liftoff weight, including spacecraft	640,827 kg (1,412,759 lbs.)
Liftoff height	48.8 m (160 ft.)
Launch complex	41
Launch azimuth	97 degrees (at window opening)

	Titan Booster	Centaur Stage
Weight	621,273 kg (1,369,650 lbs.)	16,128 kg (35,556 lbs.) (not including shroud & s/c)
Height	29.8 m (98 ft.)	9.6 m (31.5 ft.) (including truss payload adapter but without shroud and interstage adapter)
Propellants	Powdered aluminum and ammonium perchlorate in solid motors; Aerozene 50 and nitrogen tetroxide in Stage I and II, plus UDMH	Liquid hydrogen and liquid oxygen
Propulsion	Two solid motors provide 5.3 million N (1.2 million lbs.) thrust each. LR87AJ-11, Stage I engine, 2.3 million N (520,000 lbs.) thrust. LR91AJ-11, Stage II engine, 445,000 N (100,000 lbs.) thrust.	Two 66,720-N (15,000 lbs.) thrust RL-10 engines. 12 small hydrogen peroxide thrusters.
Velocity	4,957 kmph (3,080 mph) at Stage I ignition, 14,510 kmph (9,015 mph) at Stage II ignition, 23,278 kmph (19,439 mph) at Stage II separation.	26,596 kmph (16,525 mph) at MECO I, 41,231 kmph (25,619 mph) at MECO II, 39,576 kmph (24,596 mph) at spacecraft separation.
Guidance	Centaur inertial guidance	Inertial guidance

*Viking B launch vehicle characteristics vary slightly.

TYPICAL FLIGHT EVENTS FOR VIKING A*

Flight Events	Seconds	Altitude Km	Altitude Miles	Velocity kmph	Velocity mph	Range Km	Range Miles
Solid Motor Ignition	0	0	0	0	0	0	0
Stage I Ignition	110.6	39.3	24.4	4,957	3,080	42.2	26.2
Solid Motor Jettison	121.9	46.1	28.6	5,379	3,342	56.7	35.2
Stage I Cutoff	256.2	109	67.7	14,496	9,007	380.6	236.3
Stage II Ignition	257	109.5	68	14,510	9,015	383.8	238.3
Centaur Shroud Jettison	268	115.2	71.6	14,756	9,169	426.9	265.1
Stage II Cutoff	459.6	164.1	102	23,205	14,418	1,337.9	855.6
Stage II Jettison	465.6	164.8	102.4	23,278	14,439	1,415.6	878.9
Centaur MES-I (Main engine start)	476.1	165.9	103.1	23,230	14,436	1,481.6	920
Centaur MECO-I (Main engine cutoff)	603.3	169.7	105.4	26,596	16,525	2,336.6	1,450.9
Centaur MES-II	1,805.4	162.2	100.8	26,652	16,560	10,998	6,829.3
Centaur MECO-II	2,125.7	307.3	191	41,231	25,619	13,827.7	8,586.3
Spacecraft Separation	2,345.3	941.6	585.2	39,576	24,590	16,012	9,942.6
Start Centaur Blowdown	3,200.2	5,959.6	3,704	31,564	19,612	19,397.6	12,045
End Blowdown	3,450.2	7,663	4,762.6	29,923	18,592	18,790.2	11,667.8

*Based on launch date: 8/11/75; launch time: 4:57 p.m. EDT; launch azimuth: 97 degrees; arrival date in Mars orbit: 6/17/76

TYPICAL FLIGHT EVENTS FOR VIKING B*

Flight Events	Seconds	Altitude Km	Altitude Miles	Velocity Kmph	Velocity mph	Range Km	Range Miles
Solid Motor Ignition	0	0	0	0	0	0	0
Stage I Ignition	110.7	39.4	24.5	4,970	3,088	42.3	26.3
Solid Motor Jettison	122	46.2	28.7	5,385	3,346	56.8	35.3
Stage I Cutoff	257.6	109.1	67.8	14,439	8,971	383.3	238.2
Stage II Ignition	258.4	109.6	68.1	14,452	8,980	396.5	240.2
Centaur Shroud Jettison	269	115	71.5	14,689	9,127	428.2	266.1
Stage II Cutoff	464	163.6	101.7	23,176	14,400	1,393	866
Stage II Jettison	470	164.4	102.2	23,208	14,420	1,431	889
Centaur MES-I (Main engine start)	480.5	165.5	102.9	23,203	14,417	1,497	930
Centaur MECO-I (Main engine cutoff)	609.3	169.3	105.2	26,616	16,537	2,362	1,468
Centaur MES-II	1,977.2	162.6	101	26,669	16,571	12,228	7,598
Centaur MECO-II	2,288.3	294.7	183.2	40,663	25,266	14,962	9,297
Spacecraft Separation	2,507.8	892.5	554.7	39,068	24,275	17,131	10,645

*Based on launch date: 8/22/75; launch time: 3:45 p.m. EDT; launch azimuth: 101 degrees; arrival in Mars orbit: 8/7/76

VIKING LAUNCH PREPARATIONS

The Viking spacecraft will be launched from Launch Complex 41 (LC-41) Titan III Complex, Air Force Eastern Test Range. Two Titan Centaur launches will mark the third and fourth times NASA launches have been conducted from this facility at Cape Canaveral Air Force Station. Launch will be under direction of NASA's Kennedy Space Center, Unmanned Launch Operations Directorate.

Viking launch preparations required eight months of work by a government and industrial team of about 1,200 people, representing the most extensive effort ever associated with an unmanned space project.

The Mars launch opportunity is approximately 40 days, imposing stringent scheduling requirements on the Viking team to launch both spacecraft from a single pad within a short time span. The schedule is even more demanding because of the plan to launch both Viking space vehicles 10 days apart to improve the probability of conducting both launches before the end of the "window" during September.

The Titan III facility has two active pads, LC-40 and LC-41, but only Complex 41 has been modified to accommodate NASA's hydrogen-fueled Centaur.

Launch Facilities

The Titan III Complex, built on manmade islands in the Banana River, consists of solid rocket motor servicing and storage areas, a Vertical Integration Building (VIB), a Solid Motor Assembly Building (SMAB), LC-40 and LC-41, and a double-track locomotive system that transports the mated Titan core and Centaur vehicle from the VIB through the SMAB to LC-41. The rail system covers 32 km (19 mi.) to link the various facilities.

Hardware Assembly

The Titan, Centaur and Centaur shroud are erected and mated in the VIB on a mobile transporter/umbilical mast structure. Attached to the transporter are three vans, housing launch control and monitoring equipment, which remain connected to the transporter and vehicle throughout the receipt-to-launch sequence.

When integrated tests in the VIB are completed, the assembled Titan and Centaur are moved on the transporter to the SMAB. After the solid rocket motors and core stages are structurally mated, the vehicle is moved to the launch complex. A mobile service structure provides access to all mated vehicle stages, and an environmental enclosure ("white room") protects the Centaur and the spacecraft.

Because of the quick turnaround launch sequence required by Viking, the second Titan Centaur (TC-3) launch vehicle was processed first. The Titan liquid stages and Centaur upper stages were assembled atop a transporter in the VIB in January and moved to LC-41 for checkout.

The encapsulated Viking A spacecraft was mated with the launch vehicle at LC-41 in late March, and the space vehicle underwent several key tests in early April, including Flight Events Demonstration and Terminal Countdown Demonstration.

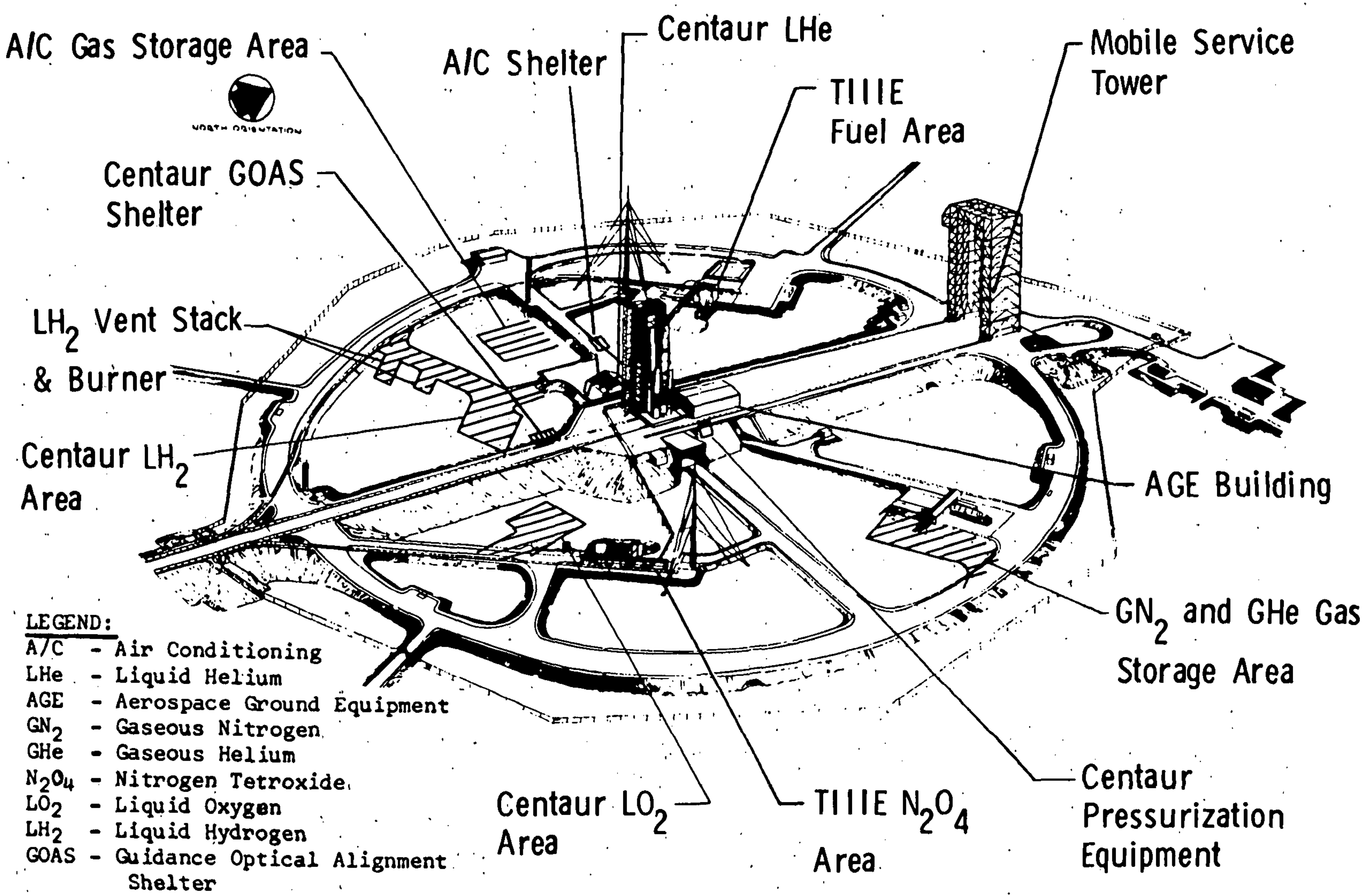
The spacecraft was then de-mated and returned to the KSC Industrial Area for further processing. The TC-3 vehicle was returned to the VIB on its transporter in late April for storage. Just before the Viking A launch on Titan Centaur-4 (TC-4), TC-3 will be moved into the SMAB for attachment of its solid booster motors. It will be moved to LC-41 immediately after launch of Viking A. Viking B will then be mated with its launch vehicle and checkout completed, heading for a launch 10 days after launch of Viking A.

TC-4 processing for the first launch began in early spring. The Titan and Centaur liquid stages were stacked in the VIB before they were moved to the SMAB in late May for attachment of solid booster motors. The vehicle was moved to LC-41 in early June; mating with the first Viking was done in late July. The space vehicle will be cycled through the normal launch preparation sequence, heading for liftoff of the Viking A August 11 at the opening of the 1975 Mars launch period.

Spacecraft Preparations

Flight elements of the Viking spacecraft began arriving at KSC in January for pre-launch operations, including assembly, checkout, fueling, sterilization and encapsulation in the payload section of the shroud. The Orbiters were processed in Hangar AO at Cape Canaveral Air Force Station; the Landers were processed in Spacecraft Assembly and Encapsulation Facilities (SAEF) 1 and 2 in the KSC Industrial Area.

LC-41 VEHICLE SERVICES



LEGEND:
A/C - Air Conditioning
LHe - Liquid Helium
AGE - Aerospace Ground Equipment
GN$_2$ - Gaseous Nitrogen
GHe - Gaseous Helium
N$_2$O$_4$ - Nitrogen Tetroxide
LO$_2$ - Liquid Oxygen
LH$_2$ - Liquid Hydrogen
GOAS - Guidance Optical Alignment Shelter

The Orbiters were later moved across the Banana River to the SAEFs for mating with the Landers. Lander processing included installation of twin 35-watt SNAP-19 radioisotope thermoelectric generators (RTG) for each spacecraft, installation and checkout of Lander science instruments and sterilization of the Landers.

The SAEF buildings are modified Apollo-related structures in the southeast sector of the KSC Industrial Area. Airlocks and clean rooms were built to provide environmental control within the structures. Each SAEF has an "oven" for spacecraft sterilization, connected to the clean room by a passageway. The sterilization chambers are built of stainless steel and insulated with polyurethane.

The Landers were sterilized in mid-June. The craft were placed in the ovens, 7 m long, 6.4 m wide and 4.3 m high (23 by 21 by 14 ft.), and sterilized at a temperature of approximately 113 degrees C. (235 degrees F.) for 40 hours. Sterilization is done in a swirling atmosphere of heated nitrogen gas, held to 97 per cent purity to control oxidation of spacecraft components.

The RTGs were installed early in the checkout flow to permit electrical tests of Lander systems independent of ground power. The power generators remained aboard the Landers during the sterilization process; chilled water units were used to control their heat dissipation.

The Landers underwent post-sterilization testing to make sure their systems had survived the intense, long-duration heating process. Propellants for Lander de-orbit and terminal descent engine subsystems were loaded before the Landers were removed from the sterilization chambers.

The Orbiters were moved to ESA-60 on Cape Canaveral Air Force Station, where their engine subsystems were assembled. Fueled propulsion modules were attached to the Orbiter buses before the Orbiters were transferred to the SAEFs.

The Orbiter and Lander for the first Viking were mated and encapsulated in the payload section of the Centaur shroud in mid-July, then moved to LC-41 later in the month for final preparations.

The Orbiter and Lander for the second Viking were mated and encapsulated in late July. The second Viking will be moved to LC-41 for mating with TC-3 immediately after the first Viking is launched. Launch readiness target date is August 21.

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Launch will be directed from the VIB, a 23-story structure containing nine million cubic feet. In the VIB, located 5,100 m (20,000 ft.) from LC-41, will be Launch Control Titan Centaur core vehicle assembly and initial systems checkout. The Launch Control area, consisting of three rooms, is the nerve center of the Titan Centaur Complex.

SAMSO is responsible for the design, development, procurement, acceptance, testing and delivery of the Titan III-E airborne vehicle and aerospace ground equipment to meet NASA requirements for integration with the Centaur. All Titan launch vehicles are produced for the Air Force by Martin Marietta Aerospace, Denver Division.

SAMSO, headquartered at Los Angeles Air Force Station, is the major Department of Defense development agency for this nation's present and future military space and ballistic missile programs. SAMSO's Deputy for Launch Vehicles, Col. G. J. Murphy, is responsible for the Titan III, with Maj. L. N. Johnson the program manager for Titan III-E. Its 6555th Aerospace Test Wing at Cape Canaveral AFS was responsible for activation of the ITL facility and manages its total operations. It administers the ITL's safety, scheduling, etc. The Wing supports NASA in the conduct of launch operations for Titan/Centaur.

Press Site 3, the press viewing area for Titan III launches, is located to the southeast of the VIB, slightly more than 6,100 m (20,000 ft.) from LC-41.

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Countdown

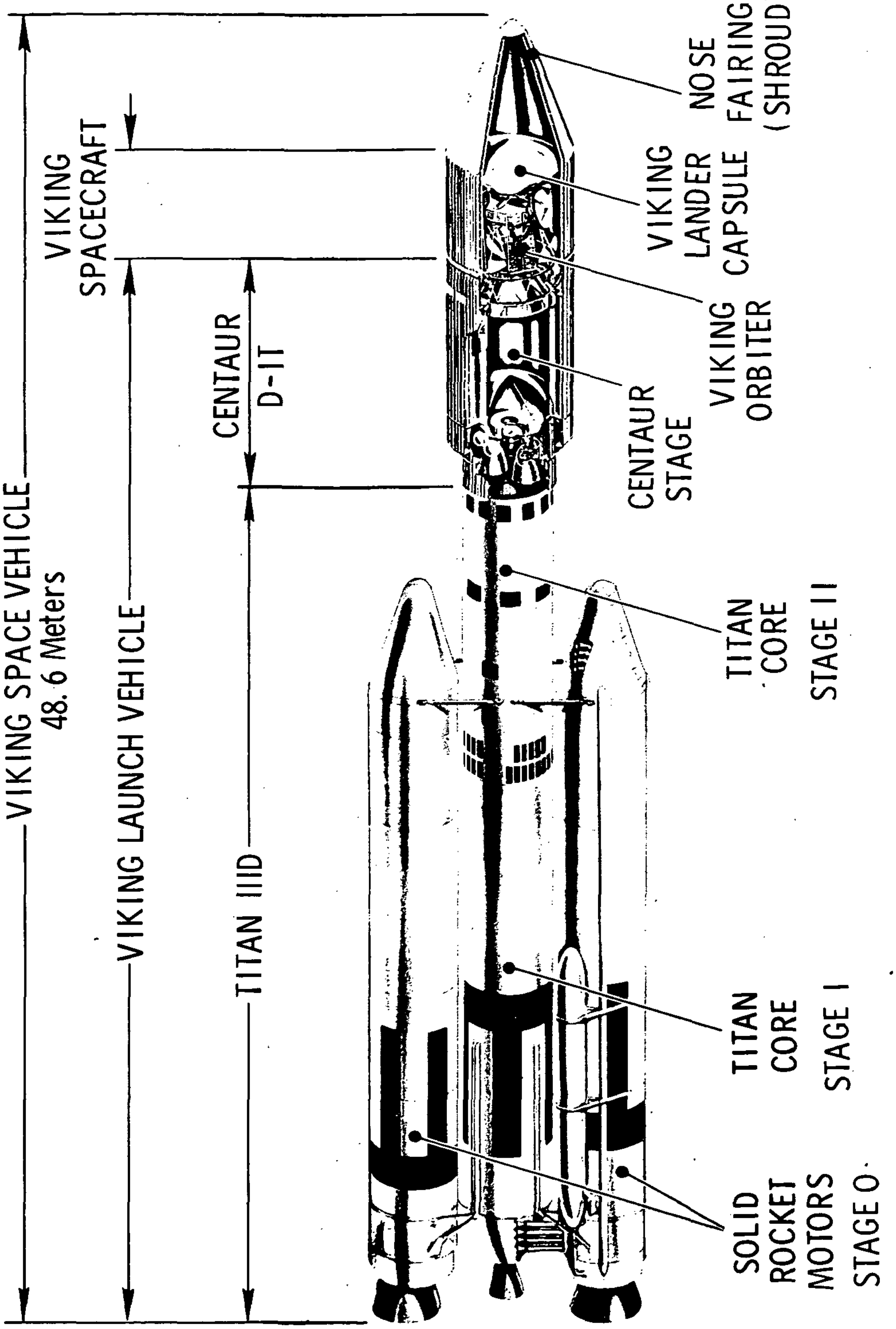
The Viking countdown will be conducted by a team of about 300, representing NASA's Kennedy Space Center, Langley Research Center, Lewis Research Center and Jet Propulsion Laboratory; General Dynamics/Convair, Pratt & Whitney, Martin Marietta Corp., United Technology Center, Aerojet Propulsion Co., RCA and Pan American World Airways. Representatives of the Air Force's 6555th Aerospace Test Group are consultants to NASA.

F - 6 days:	Start Readiness Count, install solid motor and Titan core ordnance and Centaur flight ordnance.
F - 5 days:	Solid rocket motor and Titan integrity inspections; start Titan and Centaur system preparations.
F - 4 days:	Load fuel for Titan first and second stages.
F - 3 days:	Load oxidizer for Titan first and second stages; install Centaur batteries.
F - 2 days:	Install and connect core vehicle ordnance.
F - 1 day:	Connect Centaur ordnance; load and pressurize solid rocket motor oxidizer tanks; conduct range safety system checks; install Titan Centaur destructors; and pressurize Titan propellant tanks.

Launch Day Count

T - 590 minutes:	Begin Titan Centaur systems launch day preparations.
T - 190 minutes:	Begin move of mobile service tower (continues to T minus 160 minutes).
T - 115 minutes:	Begin one-hour, built-in hold. At end of one-hour hold, install solid rocket motor arming plugs.
T - 100 minutes:	Begin Centaur liquid oxygen loading (topping off continues until T minus 75 seconds.)
T - 70 minutes:	Begin Centaur liquid hydrogen loading (topping off continues until T minus 90 seconds).
T - 25 minutes:	Range Safety Command test.
T - 10 minutes:	Enter 10-minute built-in hold.
T - 5 minutes, 30 seconds:	Flight control to launch enable.
T - 5 minutes:	Enter Terminal Count.
T - 2 minutes:	Centaur to internal power; Range Safety Command to arm.
T - 90 seconds:	Centaur hydrogen topping secured.
T - 75 seconds:	Centaur oxygen topping secured.
T - 45 seconds:	Centaur launch permit on.
T - 32 seconds:	Start automatic launch sequence.
T - 31.7 seconds:	Titan on automatic launch sequence.
T - 31 seconds:	Start Centaur Digital Computer Unit Count.
T - 21.5 seconds:	Test solid rocket motor ignition.
T - 17.5 seconds:	Open Titan pre-valves.
T - 8 seconds:	Start inertial guidance.
T - 0:	Ignite solid rocket motors.

VIKING SPACE VEHICLE CONFIGURATION



MISSION CONTROL AND COMPUTING CENTER

The focal point of all Viking flight operations is the Viking Mission Control and Computing Center (VMCCC) at the Jet Propulsion Laboratory. The Viking Flight Team (VFT) is housed in the VMCCC, and through the Center will come all data from the Orbiters and Landers to be processed and presented to the Flight Team for analysis.

Housed in two buildings at JPL, the VMCCC contains all the computer systems, communication and display equipment, photo processing laboratories and mission support areas for mission controllers, spacecraft performance analysts and science investigators.

By the time the first Viking spacecraft arrives at Mars, the facilities will house more than 700 Flight Team members, plus several hundred more VMCCC people, who will operate the facilities, computers, laboratories, maintenance shops and communications networks.

The VMCCC's large and complex computer systems receive incoming Orbiter and Lander data, process them in real time, and display and organize them for further processing and analysis. Data are first received as radio signals by the Deep Space Network (DSN) stations around the world and are transmitted into the VMCCC computers, where processing begins. Software (programs) in these computers does the receiving, display and organizing of data.

Commands that cause the Orbiters and Landers to maneuver, gather science data and do other complex activities are prepared by the Flight Team. Commands are introduced into the computers through the Team's control, and are communicated to a DSN station for transmission to the appropriate spacecraft.

Three sets of computer systems are in the VMCCC. One is a complex of UNIVAC 1530, 1219 and 1616 computers that are designed to receive, process and display all Orbiter data in real time, and do preliminary image reconstruction on video data taken from Orbiter cameras.

Another set is a system of IBM 360/75 computers that receive, process and display in real time all Lander telemetry and tracking (metric) data from the tracking stations. They are the means through which commands are sent to the Orbiters and Landers. They also do early image reconstruction and display of video data from Lander cameras on the surface, and they provide computing capability for many programs that do command preparation, Lander data analysis and mission control functions.

Two large UNIVAC 1108 computers are used in non-real-time to do many detailed analyses such as navigation, science instrument data analysis and data records production.

Exposed film from the computers will be processed in the VMCCC photo processing lab; high quality prints will be quickly made available. These pictures from Mars orbit and from the surface will be analyzed by scientists housed in the mission support rooms of the VMCCC.

The VMCCC system is the responsibility of JPL's Office of Computing and Information Systems.

Image Processing Laboratory

JPL's Image Processing Laboratory (IPL) will correct all of the images (photo products) returned from the Lander and Orbiter spacecraft. Digital computer techniques are used to improve details of returned images, and to correct distortions introduced into the images by the camera systems. Large mosaics will be constructed from the Lander and Orbiter images, using the IPL products.

Special techniques developed for Viking include a program that will display Lander images for stereo viewing. The three dimensional images will be used to evaluate the terrain near the landing site before activating the surface sampler arm. IPL will also do the processing to obtain the best possible discriminability (details) of images acquired by the Orbiter during site certification before landing.

TRACKING AND DATA SYSTEM

Tracking, commanding and obtaining data from the Viking spacecraft are parts of the mission assigned to the Jet Propulsion Laboratory. The tasks cover all phases of the flight, including telemetry from launch vehicle and spacecraft, metric data on launch vehicle and Viking, command signals to the spacecraft and delivery of data to the Viking Mission Control and Computing Center (VMCCC).

The Tracking and Data System (TDS) will provide elements of the world-wide NASA/JPL Deep Space Network (DSN), Air Force Eastern Test Range (AFETR), NASA Spaceflight Tracking and Data Network (STDN), and NASCOM (NASA Communications Network) to support Viking.

During the launch phase, data acquisition will be made by the Tracking and Data System through the near-Earth facilities: AFETR stations, downrange elements of STDN and instrumented jet aircraft. A communications ship in the Indian Ocean may be required for launch of the second Viking.

Radar-metric data obtained immediately after liftoff and through the near-Earth phase will be delivered to and computed at AFETR's Real-Time Computer System facility in Florida, then transmitted to DSN stations, to locate the Vikings in the sky when they appear on the horizon.

Tracking and communication with Viking from the cruise phase until end-of-mission will be done by DSN. It consists of nine communications stations on three continents, a spacecraft monitoring station in Florida, the Network Operations Control Center in the VMCCC at JPL, and ground communications linking all locations.

DSN stations are strategically located around the Earth: Goldstone, Calif.; Madrid, Spain; and Canberra, Australia. Each location has a 64-m diameter (210-ft.) antenna station and two 26-m (85-ft.) antenna stations.

The three multi-station complexes are spaced at widely separated longitudes around the world so spacecraft beyond Earth orbit are never out of view. Spacecraft monitoring equipment in the STDN station at Merritt Island, Fla. covers pre-launch and launch phases of the mission. A simulated DSN station at JPL, called CTA-21, provides pre-launch compatibility support.

Each DSN station is equipped with transmitting, receiving, data handling, and inter-station communications equipment. The 64-m antenna stations in Spain and Australia have 100-kilowatt transmitters; at Goldstone , the uplink signal can be radiated at up to 400 kw. Transmitter power at all six 26-m stations is 20 kw.

Nerve center of DSN is the Network Operations Control Center at JPL. All incoming data are validated here while being simultaneously transferred to computing facilities in VMCCC for real-time use by the Viking Flight Team.

The global stations are tied to the control center by NASCOM. Low-rate data from the spacecraft are transmitted over high-speed circuits at 4,800 bits per second (bps). High-rate data are carried on wideband lines at 28.5 kilobits per second (kbps) and, from Goldstone, at 50 kbps. Commands to the spacecraft are generated in the VMCCC and sent in the opposite direction to the appropriate DSN station.

Ground communications used by DSN are part of a larger network, NASCOM, which links NASA's stations around the world. For Viking NASCOM may occasionally provide a communications satellite link with the overseas stations.

For all of NASA's unmanned deep space missions, DSN provides tracking information on course and direction of flight velocity and range from Earth. It receives engineering and science telemetry and sends commands for spacecraft operations on a multi-mission basis. Concurrent with the Viking Project, the network is maintaining post-Jupiter communications with Pioneers 10 and 11, and complementing West Germany's space communications facilities on the Helios Sun-orbiting mission. DSN will support a second Helios launch, planned for December 1975, and perihelion science activities 3 months later.

Tracking and data acquisition requirements for Viking greatly exceed those of the Mariner and Pioneer projects. As many as six telemetry streams--two from both Orbiters and one or the other Lander--will be simultaneously received. Both Orbiters or an Orbiter and Lander will be tracked and commanded at any given time, although the two Landers will not be operated at the same time.

In the 16 months of the primary mission, the critical period lasts at least 5 months, beginning with Mars approach. Early in this period, two sets of antennas will be communicating with Orbiter A and Lander A , separated and conducting their respective missions. A third set of antennas will be required to track Viking B, still mated and approaching at some distance. During this phase, virtually the entire capability of the DSN is occupied with Viking.

Principal communications links between the Vikings and Earth stations are in the S-band (2,100-2,300 megaHertz). The Orbiters will also carry X-band (8,400 MH_z) transmitters. Operating with the Orbiter S-band system, the X-band transmitter will allow the network to generate dual frequency ranging and doppler data, and will contribute to the Radio Science investigation at Mars.

Telemetry will be immediately routed from DSN stations to the VMCCC for distribution to computers and other specialized processors for data reduction and presentation to Flight Team engineers and science investigators. Simultaneously, range and range-rate information will be generated by DSN and transmitted to the VMCCC for spacecraft navigation computations.

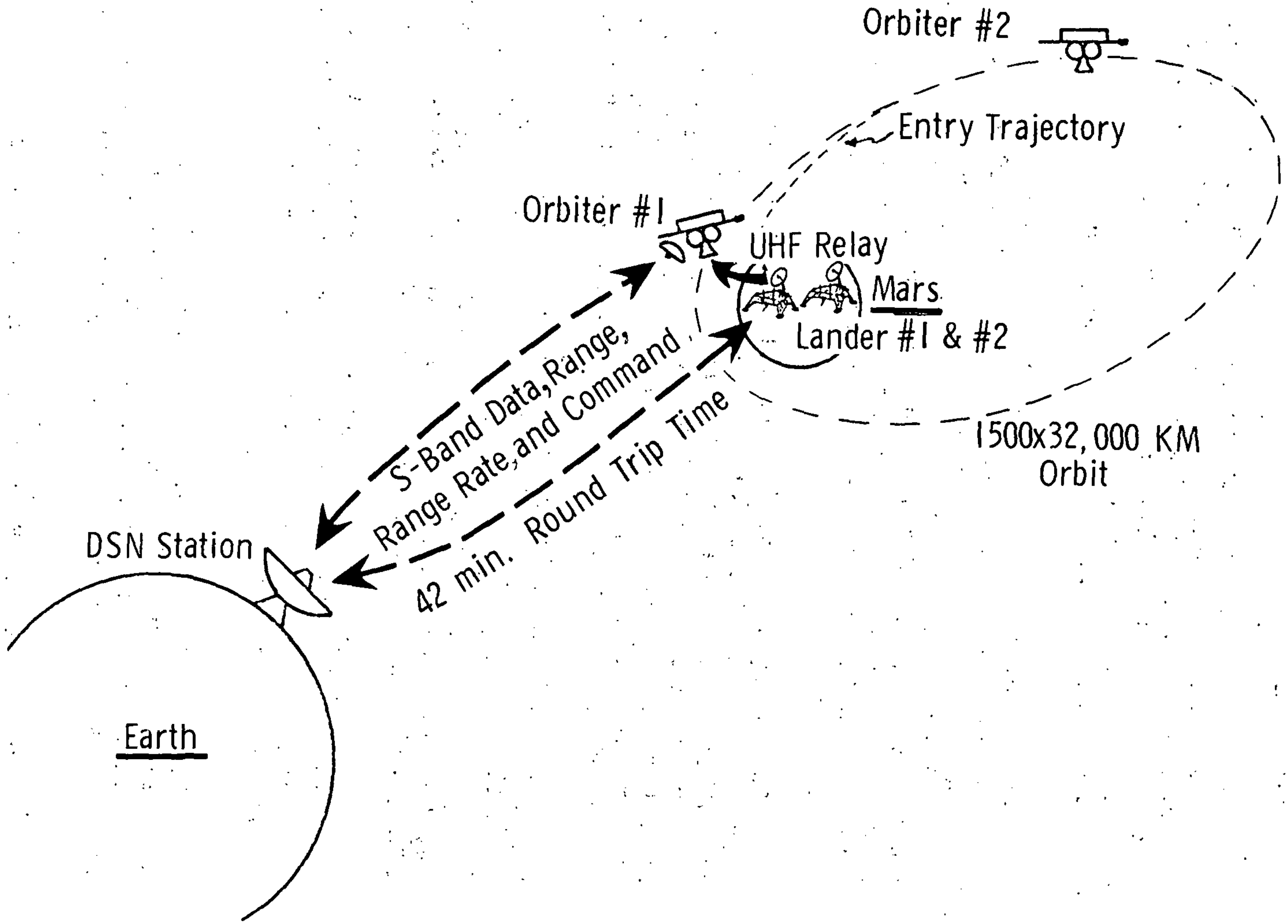
Commands to Viking are transmitted from the VMCCC and loaded into a command processing computer at a DSN station for transmission to the proper spacecraft. Commands may be aborted and emergency commands may be manually inserted and verified at stations after voice authorization from VMCCC.

During planetary operations the network supports celestial mechanics experiments that may use very long baseline interferometry (VLBI), using DSN and other antennas outside the network.

All of NASA's networks are under the direction of the Office of Tracking and Data Acquisition. JPL manages DSN; STDN facilities and NASCOM are managed by NASA's Goddard Space Flight Center, Greenbelt, Md.

The Goldstone DSN stations are operated and maintained by JPL with the assistance of the Aeronutronic Ford Corporation. The Canberra stations are operated by the Australian Department of Supply; the stations near Madrid are operated by the Spanish government's Instituto Nacional de Technica Aerospacial.

VIKING COMMUNICATION LINKS



VIKING PROGRAM OFFICIALS

NASA Headquarters

Dr. Noel W. Hinners	Associate Administrator for Space Science
John M. Thole	Deputy Associate Administrator for Space Science
Dr. Henry J. Smith	Deputy Associate Administrator - Science
Robert S. Kraemer	Director, Planetary Programs
Walter Jakobowski	Viking Program Manager
Dr. Richard S. Young	Chief Program Scientist for Viking
Loyal G. Goff	Viking Program Scientist
Robert Kennedy	Deputy Program Manager (Orbiter)
Rodney Mills	Deputy Program Manager (Lander)
Joseph B. Mahon	Director, Launch Vehicle and Propulsion Programs
Gerald M. Truszynski	Associate Administrator for Tracking and Data Acquisition

Langley Research Center

Dr. E. M. Cortright	Director
J. S. Martin, Jr.	Viking Project Manager
H. T. Wright	Deputy Project Manager
Angelo Guastaferro	Deputy Project Manager (Management)
Israel Taback	Chief Engineer
W. F. Cuddihy	Deputy Chief Engineer

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Langley Research Center (cont'd.)

Dr. G. A. Soffen	Project Scientist
A. T. Young	Mission Operations Manager
W. J. Boyer	Deputy Mission Operations Manager
M. S. Johnson	Flight Operations Integration Manager
J. E. Harris	Spacecraft Performance Manager
N. L. Crabill	Mission Planning and Design Manager
D. H. Ward	Launch Operations Manager
L. P. Daspit	Mission Success Manager
W. L. Watson	Space Vehicle Manager
E. A. Brummer	Lander Sybsystem and Components Manager
H. G. King	Lander Software Manager
G. C. Broome	Lander Science Instruments Manager
J. C. Moorman	Denver Support Manager
W. R. Glenny	Management Operations Manager

Kennedy Space Center

Lee R. Scherer	Director
John J. Neilon	Director, Unmanned Launch Operations
Harold Zweigbaum	KSC Viking Representative
John D. Gossett	Chief, Centaur Operations Division

Kennedy Space Center (cont'd.)

Creighton A. Terhune	Test Engineering Chief
Jack E. Baltar	Test Operations Chief
D. C. Sheppard	Chief, Spacecraft and Support Operations Division
William A. Brosier	Viking Project Engineer
Floyd A. Curington	Centaur Standard Shroud and Interface Operations Engineer

Lewis Research Center

Bruce T. Lundin	Director
Dr. Seymour C. Himmel	Associate Director for Flight Programs
Andrew J. Stofan	Director, Launch Vehicles
Lawrence J. Ross	Acting Titan/Centaur Project Manager
Richard P. Geye	Viking Project Engineer

Jet Propulsion Laboratory

Dr. William H. Pickering	Director
Gen. Charles H. Terhune	Deputy Director
Robert J. Parks	Assistant Laboratory Director for Flight Projects
Henry Norris	Project Manager
Kermit Watkins	Deputy Project Manager
Conway W. Snyder	Orbiter Scientist
Al Wolfe	Spacecraft Systems Manager

Jet Propulsion Laboratory (cont'd.)

Robert L. Crabtree	Mission Director for Operations
George Textor	Deputy Mission Operations Manager
Louis Kingsland, Jr.	Mission Analysis and Engineering
George Gianopulos	Mission Control and Computing Center Manager
Dr. Nicholas Renzetti	Tracking and Data Systems Manager
Douglas J. Mudgway	Deep Space Network Manager

Energy Research and Development Administration (ERDA)

Division of Space Nuclear Systems

David S. Gabriel	Director
Glenn A. Newby	Assistant Director
Harold Jaffe	Chief, Isotope Power Systems Projects Branch
Vincent G. Redmond	Acting Viking Program Manager for ERDA

Space and Missile Systems Organization (SAMSO),

Air Force Systems Command, U.S. Air Force

Col. G. J. Murphy	Deputy for Launch Vehicles
Maj. L. N. Johnson	Program Manager, Titan III-E

VIKING CONTRACTORS

Orbiter Prime Contractor

Jet Propulsion Laboratory
Pasadena, Calif.

Orbiter Subcontractors

Martin Marietta Aerospace Denver, Colo.	Propulsion Systems
Rocketdyne Corp. Canoga Park, Calif.	Propulsion Engines
General Electric Co. Valley Forge, Pa.	Attitude Control System
Honeywell Radiation Corp. Lexington, Mass.	Celestial Sensor
Motorola, Inc. Scottsdale, Ariz.	Relay Radio and Telemetry; Radio Subsystem
Philco-Ford Corp. Palo Alto, Calif.	S-Band and Relay Antennas
General Electric Co. Utica, N.Y.	Computer Command System
Spacecraft, Inc. Huntsville, Ala.	Computer Command System
Motorola, Inc. Scottsdale, Ariz.	Flight Data Subsystems
Texas Instruments Dallas, Tex.	Data Storage Subsystem; Electronics
Lockheed Electronics Plainfield, N.J.	Data Storage Subsystem; Transporter
Electro-Optical Systems Xerox Corp. Pasadena, Calif.	Power Subsystem

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Science Instrument Subcontractors

Ball Brothers Research Corp. Boulder, Colo.	Orbiter Imaging; Visual Imaging Subsystem (VIS)
A.T.C. Pasadena, Calif.	Water Vapor Mapping; Mars Atmosphere Water Detector (MAWD)
Santa Barbara Research Center Goleta, Calif.	Thermal Mapping; Infrared Thermal (Mapping (IRTM)
Bendix Aerospace Systems Div. Ann Arbor, Mich.	Entry Science; Upper Atmosphere Mass Spectrometer (UAMS), Retarding Potential Analyzer (RPA)
Hamilton Standard Div. United Aircraft Windsor Locks, Conn.	Lander Accelerometers
K-West Ind. Westminster, Calif.	Aeroshell Stagnation Pressure Instrument
Martin Marietta Aerospace Denver, Colo.	Recovery Temperature Instrument

Lander Prime Contractor

Martin Marietta Aerospace
Denver, Colo.

Lander Subcontractors

Schjeldahl, Inc. Northfield, Minn.	Bioshield
Martin Marietta Aerospace Denver,Colo.	Aeroshell
Goodyear Aerospace Corp. Akron, Ohio	Parachute System
Rocket Research Corp. Redmond, Wash.	Landing Engines
Celesco Industries Costa Mesa, Calif.	Surface Sampler

Lander Subcontractors (cont'd.)

RCA Astro-Electronics Div. Princeton, N.J.	Communications
Honeywell, Inc. Aerospace Division St. Petersburg, Fla.	Guidance, Control and Sequencing Computer (GCSC) and Data Storage Memory
Martin Marietta Aerospace Denver, Colo.	Data Acquisition and Processing Unit (DAPU) and Landing Legs and Footpads
Teledyne Ryan Aeronautical San Diego, Calif.	Radar Altimeter and Terminal Descent and Landing Radar
Energy Research and Development Administration (ERDA) Washington, D.C.	Radioisotope Thermoelectric Generator (RTG)
Lockheed Electronics Co., Inc. Plainfield, N.J.	Tape Recorder
Hamilton Standard Div. United Aircraft Windsor Locks, Conn.	Inertial Reference Unit (IRU)
General Electric Battery Division Gainesville, Fla.	Batteries

Science Instrument Subcontractors

Itek Corp. Optical Systems Div. Lexington, Mass.	Lander Imaging; Facsimile Camera System
TRW Systems Group Redondo Beach, Calif.	Biology Instrument
Litton Industries Guidance & Control Systems Woodland Hills, Calif.	Molecular Analysis; Gas Chromatograph-Mass Spectrometer (GCMS)

Science Instrument Subcontractors (cont'd.)

Martin Marietta Aerospace Denver, Colo.	Inorganic Chemistry; X-Ray Fluorescence Spectrometer (XRFS)
TRW Systems Group	Meteorology Instrument System
Bendix Aerospace Systems Div. Ann Arbor, Mich.	Seismometer
Celesco Industries Costa Mesa, Calif.	Physical Properties; Various Instruments, Indicator, Mirrors
Raytheon, Inc. Sudbury, Mass.	Magnetic Properties; Magnet Arrays

Launch Vehicle Contractors

Martin Marietta Aerospace Denver, Colo.	Titan III-E
General Dynamics/Convair	Centaur

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CONVERSION TABLE

	Multiply	By	To Obtain
Distance:	inches	2.54	centimeters
	feet	0.3048	meters
	meters	3.281	feet
	kilometers	3281	feet
	kilometers	0.6214	statute miles
	statute miles	1.609	kilometers
	nautical miles	1.852	kilometers
	nautical miles	1.1508	statute miles
	statute miles	0.8689	nautical miles
	statute miles	1760	yards
Velocity:	feet/sec	0.3048	meters/sec
	meters/sec	3.281	feet/sec
	meters/sec	2.237	statute mph
	feet/sec	0.6818	statute miles/hr
	feet/sec	0.5925	nautical miles/hr
	statute miles/hr	1.609	km/hr
	nautical miles/ hr (knots)	1.852	km/hr
	km/hr	0.6214	statute miles/hr
Liquid Measure, Weight:	gallons	3.785	liters
	liters	0.2642	gallons
	pounds	0.4536	kilograms
	kilograms	2.205	pounds
	metric ton	1000	kilograms
	short ton	907.2	kilograms
Volume:	cubic feet	0.02832	cubic meters
Pressure:	pounds/sq. inch	70.31	grams/sq. cm
Thrust:	pounds	4.448	newtons
	newtons	0.225	pounds

June 30, 1975