J. Watson

NEWS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

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FOR RELEASE: FRIDAY
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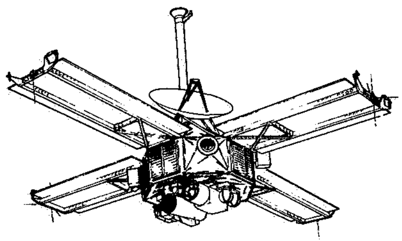

PROJECT: MARINER MARS '69

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2/6/69

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MARINER MARS 1969 LAUNCHES

Two 900-pound Mariner spacecraft, F and G, will be launched from pads 36A and 36B at Cape Kennedy on fly-by missions to Mars by the National Aeronautics and Space Administration during a period beginning Feb. 24, 1969.

Launch dates are 8 p.m. EST, Feb. 24, for spacecraft F and 4 p.m. EST, March 24, for G. If successfully launched, the spacecraft will become Mariners VI and VII. The launch vehicle for each will be the Atlas-Centaur.

Arrival dates at Mars are July 31 for F, and Aug. 5 for G, each arriving at about 1 a.m. EST on these dates. (Pacific Standard Time would be 10 p.m. one day earlier for each spacecraft.) Mariner F will make an equatorial pass over the Mars surface and Mariner G is scheduled for a polar pass five days later to furnish data as different as possible from the standpoint of geography and climate.

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2/6/69

The '69 mission is a follow-on to the 1964-65 Mariner flight to Mars and a precursor to the 1971 and 1973 Mars missions. In 1971 two Mariner-class vehicles will orbit Mars for three months, and in the 1973 mission, Project Viking, two spacecraft will orbit Mars and detach soft landers to descend to the surface.

The Mars '69 mission objectives are to study the surface and atmosphere of Mars to establish the basis for future experiments in the search for extra-terrestrial life and to develop technology for future Mars missions.

The '69 flights will not determine if life exists on Mars but will help establish whether or not the Martian environment is suitable for life.

Two television cameras aboard each spacecraft will photograph the disc of Mars during the approach to the planet and the surface during the fly-by. The best resolution of the approach pictures will be about 15 miles. Best resolution from Earth is about 100 miles. The highest resolution in the surface pictures will be about 900 feet, compared with two miles in the Mariner IV pictures taken in 1965.

Two instruments, an infrared spectrometer and an ultraviolet spectrometer will probe the atmosphere of Mars. An occultation experiment, in which radio signals pass through the Martian atmosphere, will yield data on atmospheric pressures and densities.

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An infrared radiometer will measure surface temperatures on both the light and dark sides of Mars. A celestial mechanics experiment will utilize tracking information to refine astronomical data. This mission represents the first opportunity to make scientific measurements on the night side of Mars.

All the instruments on the spacecraft are designed to return information on Mars itself. No interplanetary instruments will be flown.

The instruments were chosen to allow correlation of the returned data. For example, surface temperature measurements will be made in the areas photographed to allow mapping of temperature variations as they may be related to specific surface features.

A sharp increase in data returns will be achieved over the '64-65 Mariner missions. For example, the television pictures returned by Mariner IV, in 1965, contained 240,000 bits of information. In '69 each picture will contain 3.9 million bits. In 1965 the transmission bit rate from the spacecraft was 8 1/3 bits-per-second. In 1969 the basic bit rate is 270 bits-per-second with an experimental capability, to be used at Mars if possible, of 16,200 bits-per-second. The latter depends on the condition of the spacecraft after a four to five-month journey through space and the condition and availability of the 210-foot-diameter antenna at Goldstone, Calif., one of the world's most sensitive antennas.

NASA assigned project responsibility including mission operations, tracking and data acquisition for the '69 mission to the Jet Propulsion Laboratory which is managed for NASA by the California Institute of Technology, Pasadena, Calif. Launch vehicle responsibility is assigned to the Lewis Research Center, Cleveland. The contractor to Lewis is General Dynamics/ Convair, San Diego. Tracking and communications is assigned to the Deep Space Network, operated for NASA by JPL.

Cost of the Mariner Mars 1969 mission will total $148 million, $128 million for the spacecraft and $20 million for launching and the launch vehicles.

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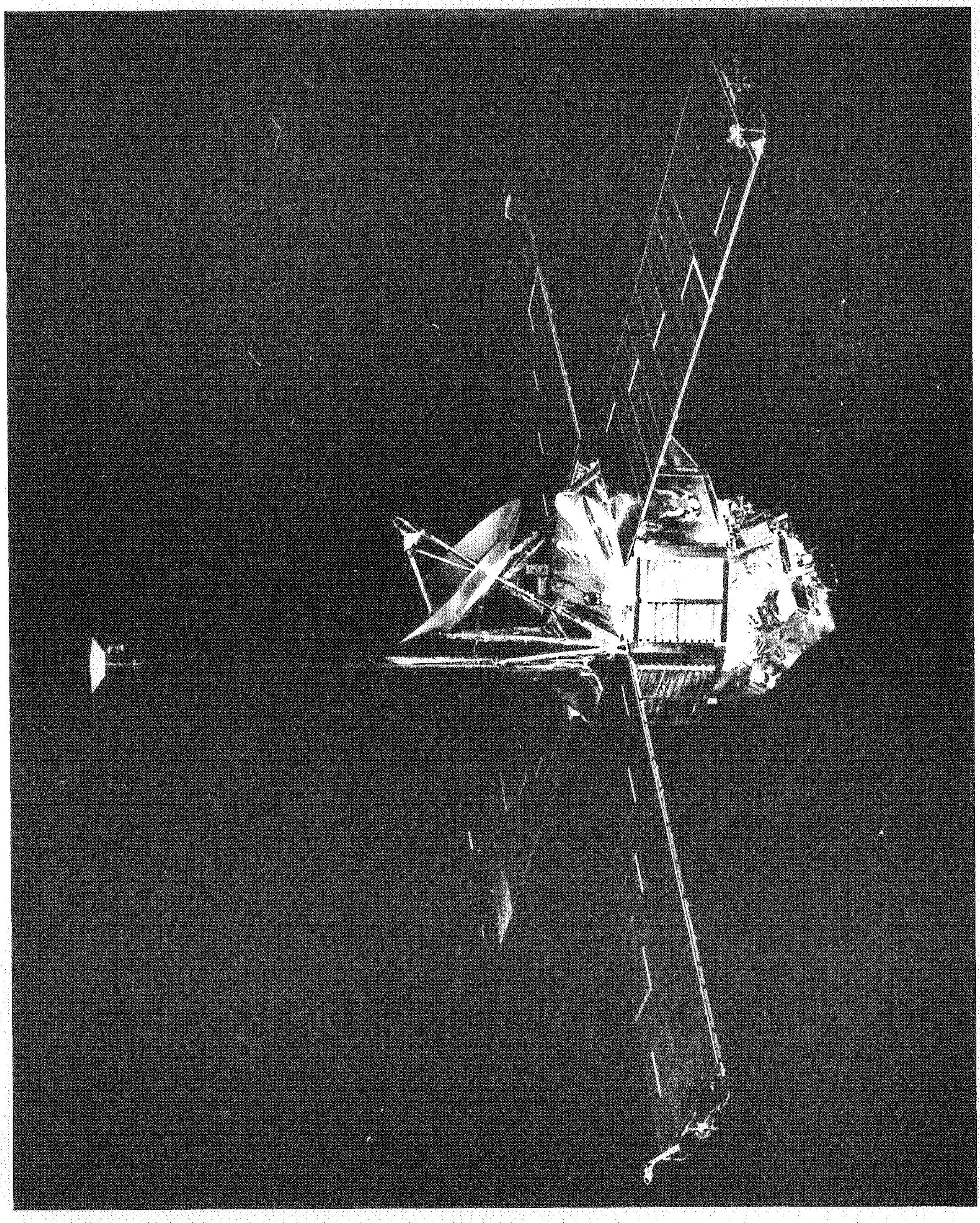


MISSION PROFILE

The two Mariner spacecraft will be targeted to observe different regions of Mars. The first spacecraft to be launched, spacecraft F, will observe the equatorial region, and spacecraft G the southern polar region.

The launches are scheduled for one month apart on February 24 and March 24. The launch period extends into early April. The Mars arrival dates are July 31, 1969, for spacecraft F and August 5 for spacecraft G. The five-day separation at arrival (encounter) is determined by two requirements: that arrival occur over the Deep Space Net station at Goldstone, Calif., and that the instruments observe specific areas.

The computers aboard the two spacecraft will be programmed at launch with two missions for each spacecraft. One standard mission at the high bit rate of 16,200 bits-per-second and back-up mission at 270 bits-per-second. Use of the high bit rate is dependent on the condition of the spacecraft and availability of the highly sensitive 210-foot diameter antenna at Goldstone.

The back-up mission is automatic and can be executed without commands from Earth. The standard mission is automatic with the exception of sending execute commands for the back-up mission.

Both plans can be changed by re-programming the computer by Earth command.

At separation from the Centaur stage the spacecraft's altitude control system is powered, primary and secondary Sun sensors are activated and the Sun acquisition sequence is initiated. In addition, the Central Computer and Sequencer is enabled, the pyrotechnic subsystem is armed for deployment of the solar panels, the Canopus sensor is turned on and the tape recorders are stopped. The latter run during launch to keep tension on the tapes to prevent free-running and snarling.

Sun acquisition will be accomplished approximately 30 minutes after separation from the Centaur. Canopus acquisition will be completed one to four hours after separation. Canopus is acquired by rolling the spacecraft which sweeps the Canopus sensor through a complete circle. The sensor will ignore light sources in ranges below or beyond the intensity of Canopus. However, in the event of a lock-on to a light source other than Canopus, an override command can be sent from Earth.

Each spacecraft has the capability of performing two midcourse corrections. Under normal launch conditions spacecraft F may require two, G will require one. F may require two corrections primarily because of the longer flight time of the early launch. The longer trajectory is more sensitive to midcourse errors. The first midcourse of F will occur between five and fifteen days after the launch, the second between launch plus one to five months. The first midcourse for G will be at about launch plus five days.

The maneuver sequence begins with transmission to the spacecraft of commands giving the direction and amount of a pitch turn and a roll turn and the time of motor burn. These are stored in the Central Computer and Sequencer until an execute command is sent. The maneuver is controlled by the CC&S which can command a maneuver abort if the turns are not performed according to instructions. Earth command can also abort the maneuver.

Approximately 8½ minutes after the pitch and roll turns are completed the CC&S will command firing of the midcourse motors. The CC&S will count the required thrust time and then command the engine off. The necessary internal commands are then given for reacquisition of the Sun and Canopus.

A period of tracking is required to determine the accuracy of the maneuver. However, telemetry at the time of the maneuver will give an estimate of accuracy.

The spacecraft is then returned to the cruise mode until either second midcourse or Mars encounter. The bit rate during cruise will be either 8 1/3 or 33 1/3 bits-per-second depending on the telecommunications performance. The rate is changed by ground command.

The basic encounter phases are far-encounter, near-encounter, occultation and playback.

In the standard mission far-encounter will begin at encounter minus 48 hours for spacecraft F and minus 72 hours for G. Encounter (E) is defined as the point of closest approach as the spacecraft passes Mars.

In the standard plan spacecraft F will take 50 approach pictures and spacecraft G 91 approach pictures. Playback will be at the high bit rate of 16,200 bits-per-second before the fly-by. If it is not possible to follow the standard plan the CC&S will automatically command a sequence of eight approach pictures beginning at about E-21 hours and ending at about E-12 hours for both spacecraft. Pictures from this sequence would be stored and played back after the fly-by.

Prior to far-encounter the CC&S issues turn-on commands to the scientific instruments, the data automation system, tape recorders and scan platform control system. Telemetry is switched to 66 2/3 bits-per-second.

The science instruments are warmed up shortly before the far-encounter sequence. At the proper time the scan platform is commanded to the far-encounter position and the far-encounter planet sensor is turned on. The scan platform control system will switch to automatic tracking when the planet is acquired by the sensor. The far-encounter TV sequence begins with pictures from Camera B only being recorded on the analog tape recorder at required intervals of time for each spacecraft.

All the science instruments except the infrared spectrometer take data during this phase but, as the digital recorder is not yet in operation, the non-TV data is not recorded. However, selected portions of the data are transmitted as acquired.

Near-encounter will begin at the end of the approach picture sequence. The far-encounter planet sensor is disabled to insure that the scan platform will not automatically track during this phase and the platform is commanded to the near-encounter position.

Prior to near-encounter two planet sensors are turned on. "Planet-in-View" signals from the sensors will start the recording of data when preceded by a start command from the CC&S or from Earth.

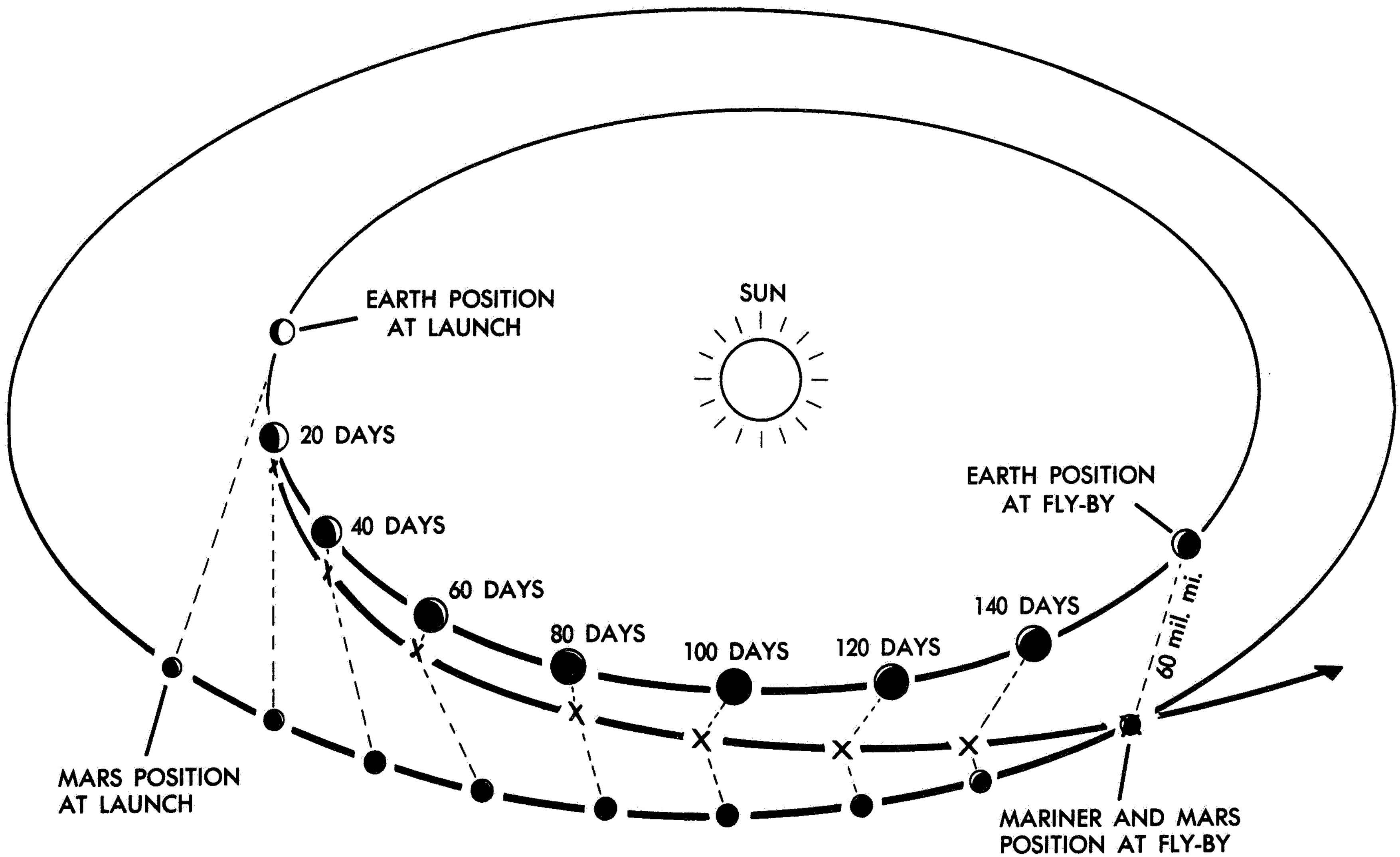
The analog tape recorder, storing TV data only, will be stopped at about the time the scan crosses into the night side of Mars or E plus three minutes. The digital recorder, which has been recording selected portions of TV data (every seventh picture element to aid analysis) and all other science data, is not stopped until E plus nine minutes to allow recording of non-TV data from the planet's dark side.

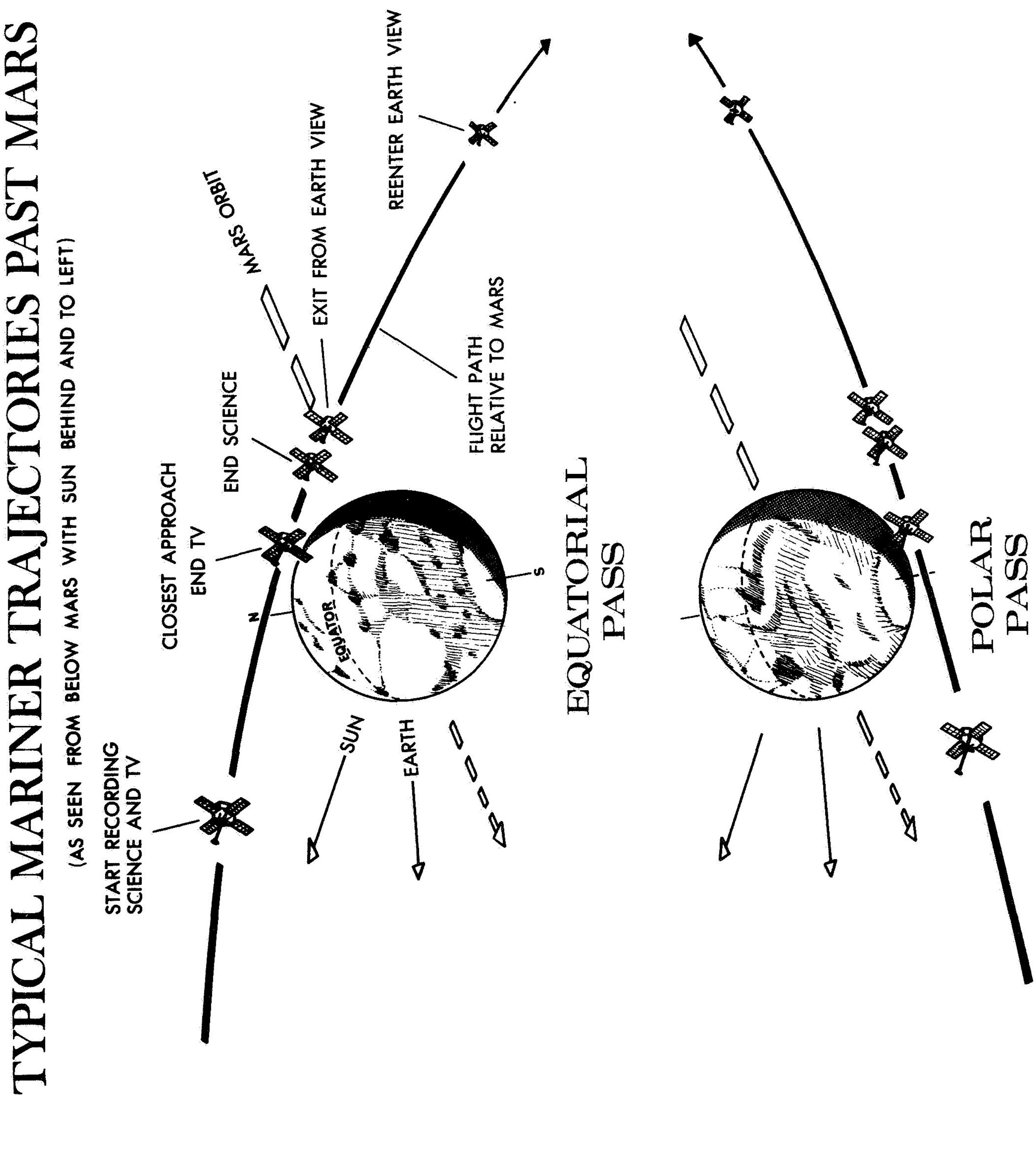
Occultation will begin at about E plus 11 minutes and last for approximately 25 minutes.

At E plus seven hours the CC&S will order the scan control, data automation system and the science instruments turned off.

Playback at 270 bits-per-second from the digital tape recorder will have started at E plus four hours and will continue until E plus 21 hours. It is then stopped and the analog playback (TV data only) begins at the high bit rate of 16,200 bits-per-second.

TYPICAL MARINER FLIGHT PATH TO MARS




TYPICAL MARINER TRAJECTORIES PAST MARS
(AS SEEN FROM BELOW MARS WITH SUN BEHIND AND TO LEFT)
START RECORDING SCIENCE AND TV
CLOSEST APPROACH END TV
END SCIENCE
MARS ORBIT
EXIT FROM EARTH VIEW
REENTER EARTH VIEW
FLIGHT PATH RELATIVE TO MARS
N
S
EQUATOR
SUN
EARTH
EQUATORIAL PASS
POLAR PASS

The analog recorder will play back for two hours and 53 minutes (one complete playback) and then the digital playback is resumed. The first digital playback is completed at approximately E plus 32 hours and the second digital playback begins. The second playback is again interrupted for analog playback.

At the beginning of the first analog playback, encounter of the second spacecraft will be a few days away. Data from the first spacecraft will be closely studied for possible refinement to the encounter plan for the second spacecraft.

After the initial playback of data the analog TV data will be transferred to the digital tape recorder and played back again at 270 bits-per-second.

After completion of data recovery both spacecraft will be placed in the cruise configuration for additional tracking and spacecraft condition data.

Trajectory

The Mariners will be launched on direct ascent trajectories from Cape Kennedy at a sufficient final velocity (injection velocity) to escape Earth plus the additional velocity required to provide an encounter with Mars. Escape velocity (24,400 mph at direct ascent injection altitude) would only be sufficient to place a Mariner in a solar orbit that would be near Earth's orbit. The additional velocity is carefully calculated to yield a solar orbit that will cross the path of Mars on a given date.

The total required velocity is imparted to the spacecraft at the point of injection by the Centaur second stage. The final velocity and the injection point varies from day to day throughout the launch period as the relationship between the position of Earth and Mars changes.

A typical injection velocity is 25,700 miles-per-hour, relative to Earth. At encounter a typical spacecraft velocity would be 17,700 mph, relative to Mars. It is required to state velocities in the relative sense because the velocity of a body in the solar system is based on the position of the observer.

To an observer on Earth the velocity of Mariner at injection would be as stated, 25,700 mph. To an observer on the Sun the velocity of the spacecraft at injection would 91,600 mph. This is because the Earth itself is orbiting the Sun at a speed in excess of 66,000 mph and this velocity plus the injection velocity is imparted to the spacecraft at injection.

The velocity of the spacecraft relative to Earth at injection will slowly diminish as Mariner heads outward from Earth and the Earth's and the Sun's gravitational fields pull on the spacecraft. As Mariner approaches Mars the velocity of Mariner will increase under the attraction of the planet.

At launch Mars will be ahead of Earth. At encounter Mars will be trailing Earth by approximately 60,000,000 miles.

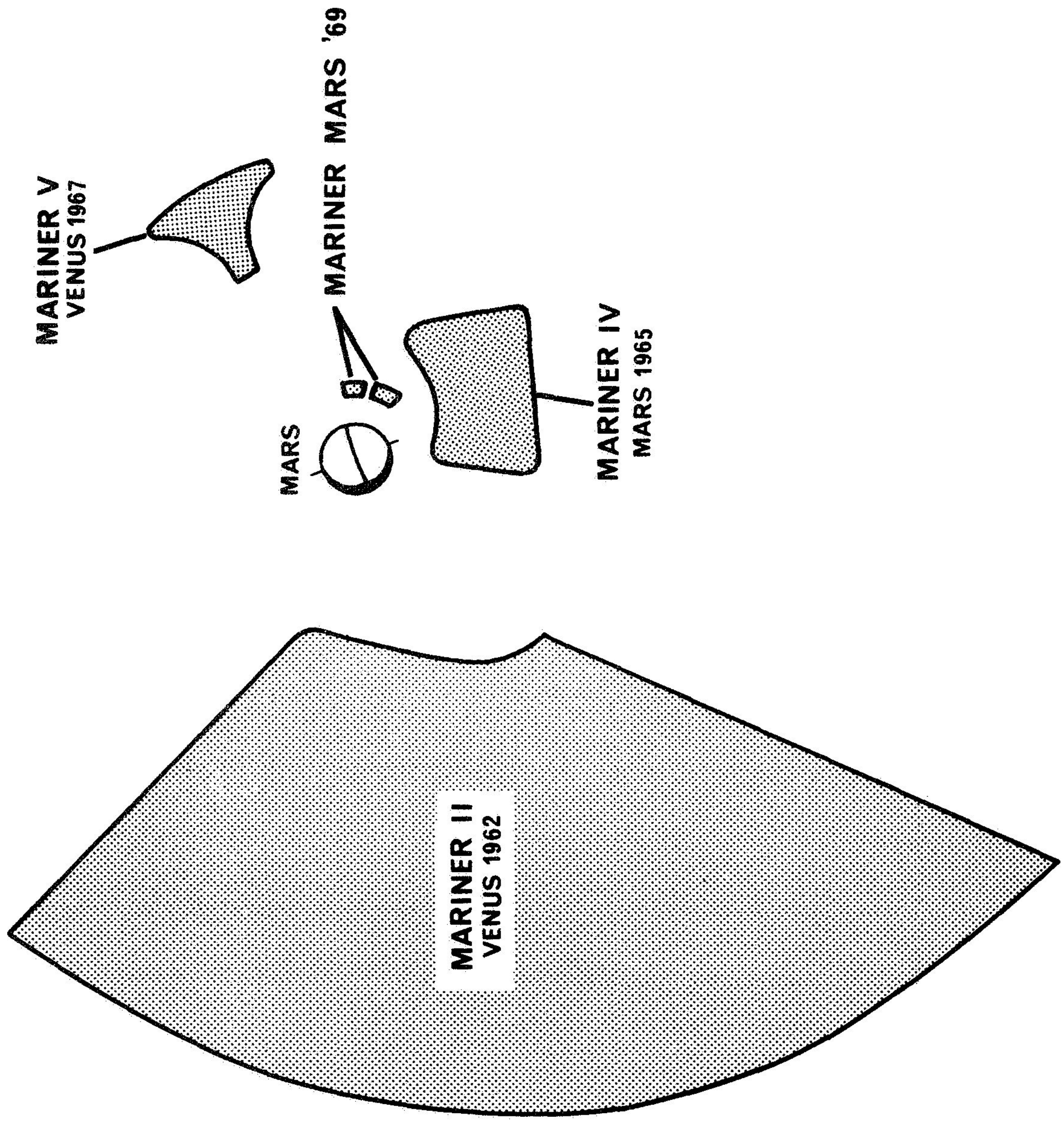
The spacecraft will follow a long curving path around the Sun after injection. It will be ahead of Mars prior to encounter but, as its velocity is still decreasing as a result of the Sun's pull, Mars will catch up with the Mariner, pass it, and be slightly in front of the spacecraft at encounter. Encounter occurs as the path of the planet and the spacecraft cross. Mariner's direction of flight will then carry it behind Mars to allow the occultation experiment. It will be behind Mars for approximately 25 minutes.

In designing trajectories for the Mars mission the trajectory engineer must satisfy numerous restrictions or constraints that influence the final trajectory. For example, the flight time must not exceed certain limits imposed by the lifetime of the spacecraft; injection velocities are prescribed by the capability of the boost vehicle, thus affecting the transit time; an adequate launch period must be provided; communication distances must not be excessive; arrival at Mars must be properly timed to coincide with those regions of maximum interest for scientific viewing; and encounter is designed to occur during the viewing period of Goldstone, the Mojave Desert station of the Deep Space Network.

Other factors influencing interplanetary trajectories include the effect of solar wind pressure on the flight path as well as the gravitational attraction of Sun, Earth, Mars, Mercury, Venus and Jupiter.

In selecting an aiming zone that will determine the path of the spacecraft as it passes Mars, the trajectory engineer must satisfy the many and sometimes conflicting requirements of the scientific experiments of the mission, for example, insure spacecraft occultation by Mars. It is also required to assure that the Mariner will not impact Mars, in order to prevent contamination of the planet by Earth microorganisms.

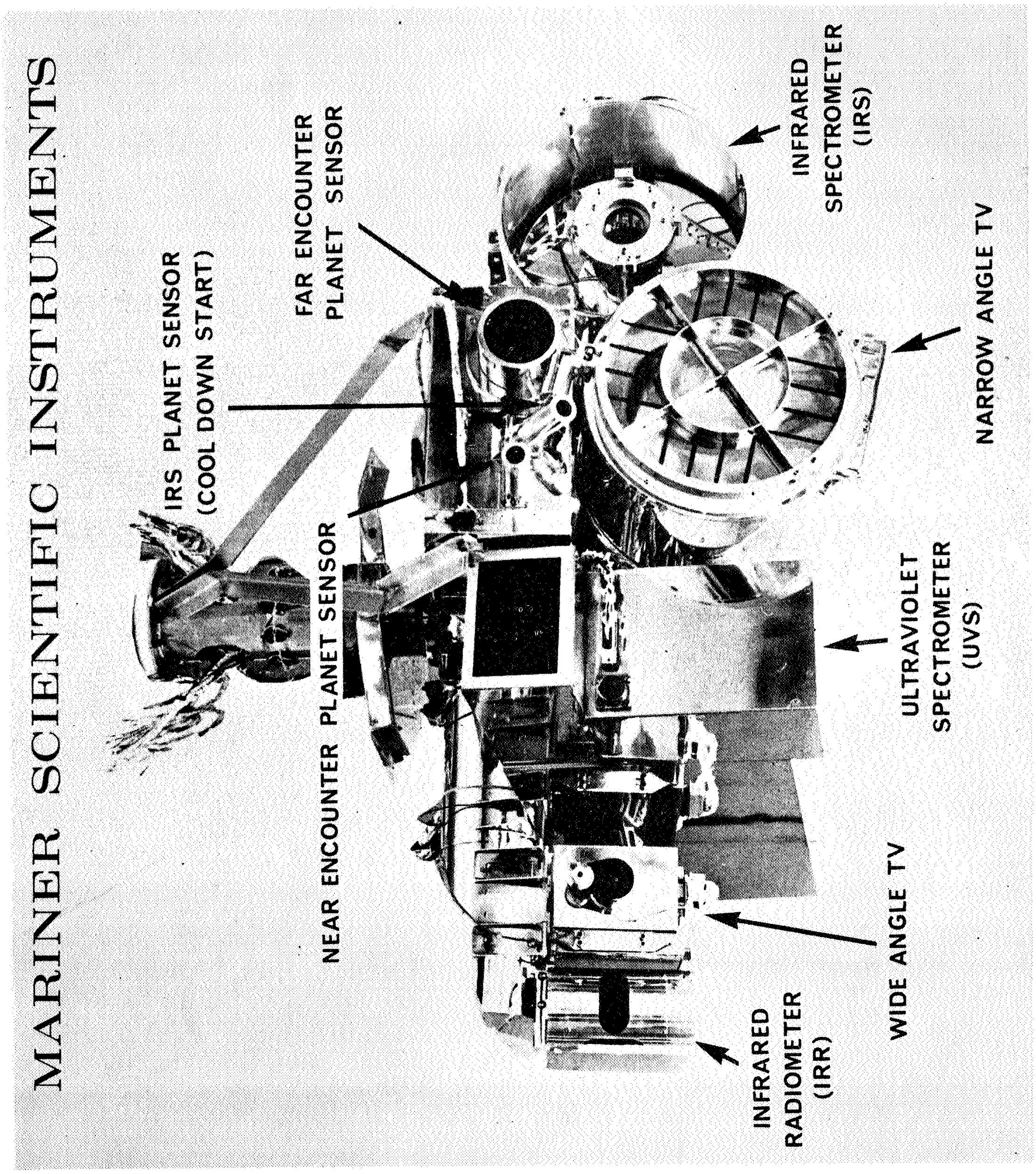
RELATIVE SIZES OF MARINER TARGET ZONES



The accuracy of the encounter with Mars will be influenced by launch accuracy, radio tracking accuracy, flight path calculation accuracy, and the midcourse correction accuracy.

Calculations after launch will determine if the flight path of the spacecraft is within the correction capability of the midcourse motor. Mariner has the capability of performing two midcourse corrections in the event the first does not yield the desired accuracy for encounter.

The accuracies demanded by the launch vehicle and by the midcourse motor can be illustrated by the following numbers. The injection velocity can vary only by plus or minus 40 miles-per-hour or the resulting trajectory will not be within the correction capability of the midcourse motor. At midcourse maneuver, an error of one mile-per-hour will result in moving the spacecraft at Mars by 5,000 miles.


MARINER SCIENTIFIC INSTRUMENTS
IRS PLANET SENSOR
(COOL DOWN START)
FAR ENCOUNTER
PLANET SENSOR
INFRARED
SPECTROMETER
(IRS)
NEAR ENCOUNTER PLANET SENSOR
NARROW ANGLE TV
ULTRAVIOLET
SPECTROMETER
(UVS)
WIDE ANGLE TV
INFRARED
RADIOMETER
(IRR)

SCIENTIFIC EXPERIMENTS

Despite studies from Earth and the flight to Mars of Mariner IV, our understanding of Mars is limited. Many questions remain to be answered.

The purpose for five of the six experiments in the '69 Mars mission is to explore the surface and atmosphere of Mars. The five experiments are designed to yield data on its physical, chemical and thermal properties; the sixth to refine astronomical data.

A successful mission will help establish information about the present environment and provide a basis for determination of the planet's origin and history. One answer being sought is whether or not the past or present environment would allow the existence of life forms.

The experiments will not determine if life exists on Mars. The investigation, however, will help select landing sites for future life detection experiments and help answer other biologically important questions about Mars including temperature ranges and the presence of water.

The best resolution of the surface as seen from Earth is about 100 miles. From Mariner IV it was about two miles. The Mariner pictures, obtained over only one percent of the surface, revealed that area to be heavily cratered.

Earth based studies reveal that about 1/3 of Mars is covered by irregularly shaped dark areas which appear blue in color. The remainder of the planet is covered by brighter areas which are distinctly orange colored. The basic differences--climate, composition, water content--between the light and dark areas are unknown. The '69 mission should provide some answers to these questions.

The remarkably regular and annual wave of darkening that sweeps from the poles toward the Equator over the dark areas at half-year intervals (in local spring) has been construed by some observers as evidence of vegetative life on Mars. Other theories include a chemical reaction to water vapor from the poles and volcanic ash or dust carried by seasonal winds.

Some observers have reported straight line markings in the light areas, termed canals. Whether or not they exist as actual continuous features or a discontinuous series of features is unknown. Photography from the mission is expected to settle this point.

Mars has two polar caps believed to be thin layers of frost or ice. The caps recede in the Martian spring and this may be associated with the wave of darkening. But it is unknown if the caps are carbon dioxide ice, water ice or a mixture of both.

Extremely little water has been detected in the Martian atmosphere and it is not known if the history of the planet included a period when free water existed on the surface. If water existed in the past it is possible that water is frozen under the surface in a form of permafrost. If liquid water does exist on Mars it is believed that it would be found in small, local areas having some source of heat other than Sunlight, possibly a volcanic source. Such areas will be sought as likely areas for the landing of life detection devices.

Prior to the data on the atmosphere returned by Mariner IV it was believed that the atmosphere was denser. Observations from Earth had placed the density at 25 millibars, plus or minus 15. Mariner IV's value was at the lower end of this range. This meant, for example, that water on Mars could only exist as ice or vapor. There is no possibility of any permanent bodies of liquid water existing on the planet but temporary moisture may occur in local areas.

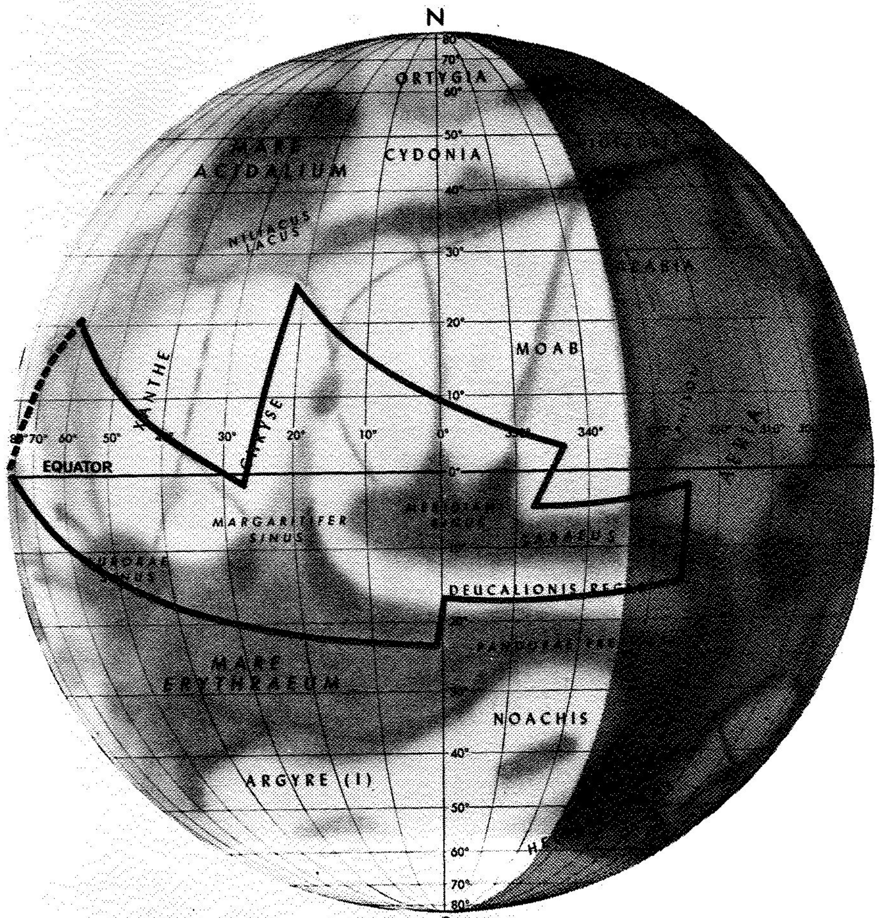
The new pressure value also ruled out landing on Mars with conventional parachutes only. Studies were undertaken on parachutes designed for an extremely thin atmosphere. Landing vehicles are now seen to employ both retro-rockets and special parachutes.

It is essential to an understanding of Mars to know the detailed composition of its atmosphere and related information on pressure and temperature variations, origin of its gases, circulation and cloud forms. The main constituent of the atmosphere is believed to be carbon dioxide. The atmosphere is extremely thin with a value for the surface pressure of 9 millibars as compared with 1,000 millibars for Earth.

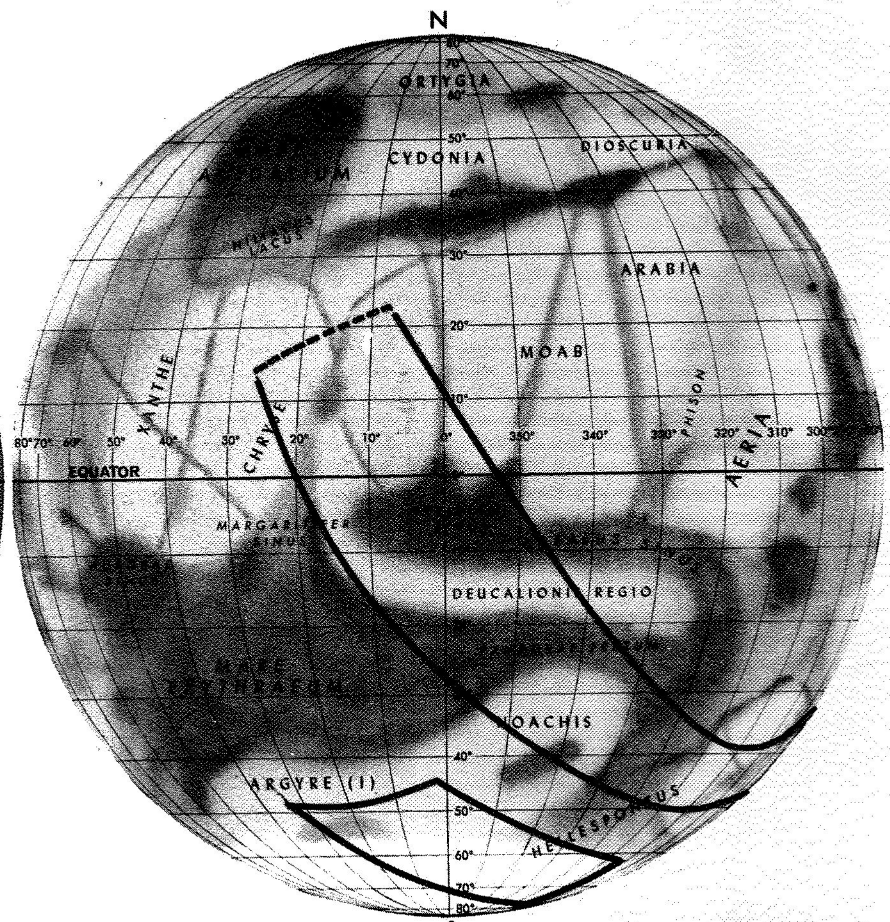
Clouds observed on Mars are attributed to condensed vapor (carbon dioxide or water) and dust. The latter are yellowish in color, can persits for days over large areas and can spread at speeds as high as 100 mph.

The Martian atmosphere also holds another mystery, a general haze that is invisible to the eye but can be photographed in blue or violet light. It usually blots out surface features, but can suddenly clear. This is not understood.

TYPICAL MARINER TV COVERAGE OF MARS



EQUATORIAL FLY-BY
JULY 30, 1969
(PDT)



POLAR FLY-BY
AUGUST 4, 1969
(PDT)

The instruments selected for the '69 mission will probe the surface and atmosphere of Mars in the visible and near visible portion of the electromagnetic spectrum, from the infrared region through the visible portion to the ultraviolet region.

Molecules and atoms absorb and re-radiate the energy of Sunlight in specific wavelengths that are signatures of the type of molecule or atom. By using detectors sensitive to these specific wavelengths the instruments can provide data on the presence and amount of gases or solids, and on temperatures.

The occultation experiment uses the spacecraft radio and requires no other spacecraft hardware. Data for the celestial mechanics experiment is obtained from the effect of bodies in space on the spacecraft flight path as measured by radio tracking.

Television

The objective of the television experiment is to photograph surface and atmospheric features over as much of the planet as possible to determine if there are basic differences between the light and dark areas, learn more about the seasonally varying dark markings, and seek physical clues on the planet's origin and evolution.

To accomplish these aims, and to provide for the unexpected inherent in an exploratory mission, the experimenters designed the experiment to include:

...Two cameras with medium and high resolution to provide both broad and detailed coverage. Camera A, medium resolution (wide angle), Camera B, high resolution (narrow angle).

...Red, green, and blue filters on Camera A to delineate color difference, yellow on Camera B to reduce haze.

...A series of at least eight pictures, and as many as 90, of the disc of Mars will be taken as the spacecraft approaches the planet.

...A series of 24 close-up pictures of the surface taken at a closing range from approximately 6,000 to 2,000 miles from the surface.

...A trajectory chosen so that the close-up photographs will cover as many as possible of the various types of features observed on Mars.

These feature types are: permanent dark markings, changing dark markings, oases, "blue" maria, canals, polar caps, wave-of-darkening areas, white markings on crater rims, circular light areas and light areas that vary in color. Also of interest are various cloud formations observed on Mars.

The first series of photographs will be taken during the far-encounter sequence as the spacecraft approaches Mars. The disk of Mars will be visible in these photographs with the disk appearing larger in each photograph as the distance closes between spacecraft and planet. Most of the surface will be photographed as the planet revolves in front of the approaching spacecraft.

Astronomers photographing Mars from Earth record slightly fuzzy pictures of low resolution because of the great distance of Mars from Earth and because Earth's atmosphere distorts the image of Mars. The Mariner mission provides the first opportunity to photograph the disk close-up without the distortion of Earth's atmosphere.

The approach pictures will give scientists the first detailed pictures of features previously studied from Earth. The photographs may also locate haze, clouds or dust storms, and allow studies of changes during the time each series is made and during the five-day interval between spacecraft.

The television experiment might be useful for detection of moist areas, if any, on the Mars surface. If melting occurred in a locally warm area, the water would quickly vaporize in the low Martian atmospheric pressure and form clouds in the cold Martian air above the planet's surface. Such a water cloud might rise to a considerable height and have a distinctive appearance. If water is present on Mars, it would be a hopeful indicator to biologists of the possibility of some form of life. However water is only one of many requirements for the possible existence of life.

Of prime importance is the possibility of determining whether the surface of Mars has been in its present state over a long period of time or whether the present state is only one stage in a long history of change. If the former were true it would indicate the planet probably has never had a dense atmosphere during its history; if the latter, it would be important to search further for evidence that liquid water might have played a role in shaping the present surface. This would be pertinent to the development of life on the planet.

Of particular interest is the possibility of photographing the areas covered by the 21 close-up pictures of the Martian surface taken by Mariner IV in 1965. These would yield a more exact location of the pictured areas on Mars and aid in determining the relationship of the 21 photographs to surrounding areas. Any changes in the appearance of these areas over the four-year interval would also be of interest.

The existence and nature of straight line markings on the surface, which have been reported by some astronomers and termed canals, may also be clarified by the approach series of photographs.

The innermost of Mars' two Moons, Phobos, might appear in the approach series. To be sufficiently prominent in a photograph to yield information on its size, the Moon would have to be photographed at fairly close range and preferably against a black space background near the edge of Mars' disk. It would probably be invisible if photographed against the bright disk of Mars. To photograph it at very close range against a background of space, however, would require maneuvering the scan platform at a time when the spacecraft was nearing the planet. Other requirements will probably prohibit operation of the scan platform at this time even if the Moon were favorably placed.

Camera B, equipped with a modified Schmidt Cassegrain telescope, will be used for the approach pictures.

The standard approach plan programmed in the on-board computer provides for 50 approach pictures. It is presently planned to increase this to 80-90 approach pictures for spacecraft G by reprogramming the on-board computer after launch. This plan is dependent on the success of the spacecraft F encounter and the condition of spacecraft G. Both of these plans are dependent on the availability of the 210 ft. diameter antenna at Goldstone to allow transmission to Earth at 16,200 bits-per-second before the fly-by. If this is not possible the second programmed plan will be used. It provides eight approach pictures for each spacecraft and transmission to Earth after the fly-by at 270 bits-per-second.

Both cameras will be used during the fly-by to record surface pictures. Camera A is similar to the camera on Mariner IV which photographed Mars in 1965. For the 1969 mission the camera has been equipped with a wide-angle lens which will cover an area 12 to 15 times larger than the Mariner IV camera but will have approximately the same resolution, two miles. The resolution of Camera A will be 1/10 that of Camera B and correspondingly its photographs will cover an area 100 times larger on the surface of Mars. The best resolution for Camera B is expected to be 900 ft. compared with two miles for the 1964-65 Mars mission.

The cameras will operate alternately. They have been timed to provide overlapping of the Camera A photographs with the high resolution Camera B photographs falling inside the overlapped portion to aid in interpretation. Each camera will take one picture every 84.48 seconds.

The cameras will be aimed at a band of specific areas of interest on Mars. Careful studies have been made to determine selection of areas to be photographed. The path of the spacecraft past Mars and the pointing angle of the platform are selected on the basis of these studies.

The principal investigator is Dr. Robert B. Leighton, of the California Institute of Technology. Co-investigators are Dr. Bruce C. Murray, Dr. Robert P. Sharp, Dr. Norman H. Horowitz, all of Caltech; Alan G. Herriman and Richard K. Sloan, of the Jet Propulsion Laboratory; Merton Davies, of Rand Corp., Conway Leovy, University of Washington, and Bradford A. Smith, New Mexico State University.

Infrared Spectrometer (IRS)

This instrument will determine the presence in the lower Martian atmosphere of molecules that suggest biochemical processes, affect temperatures on the surface and limit the amount of ultraviolet reaching the surface; detect variations in the composition of the atmosphere, particularly water vapor, relative to geographic locations.

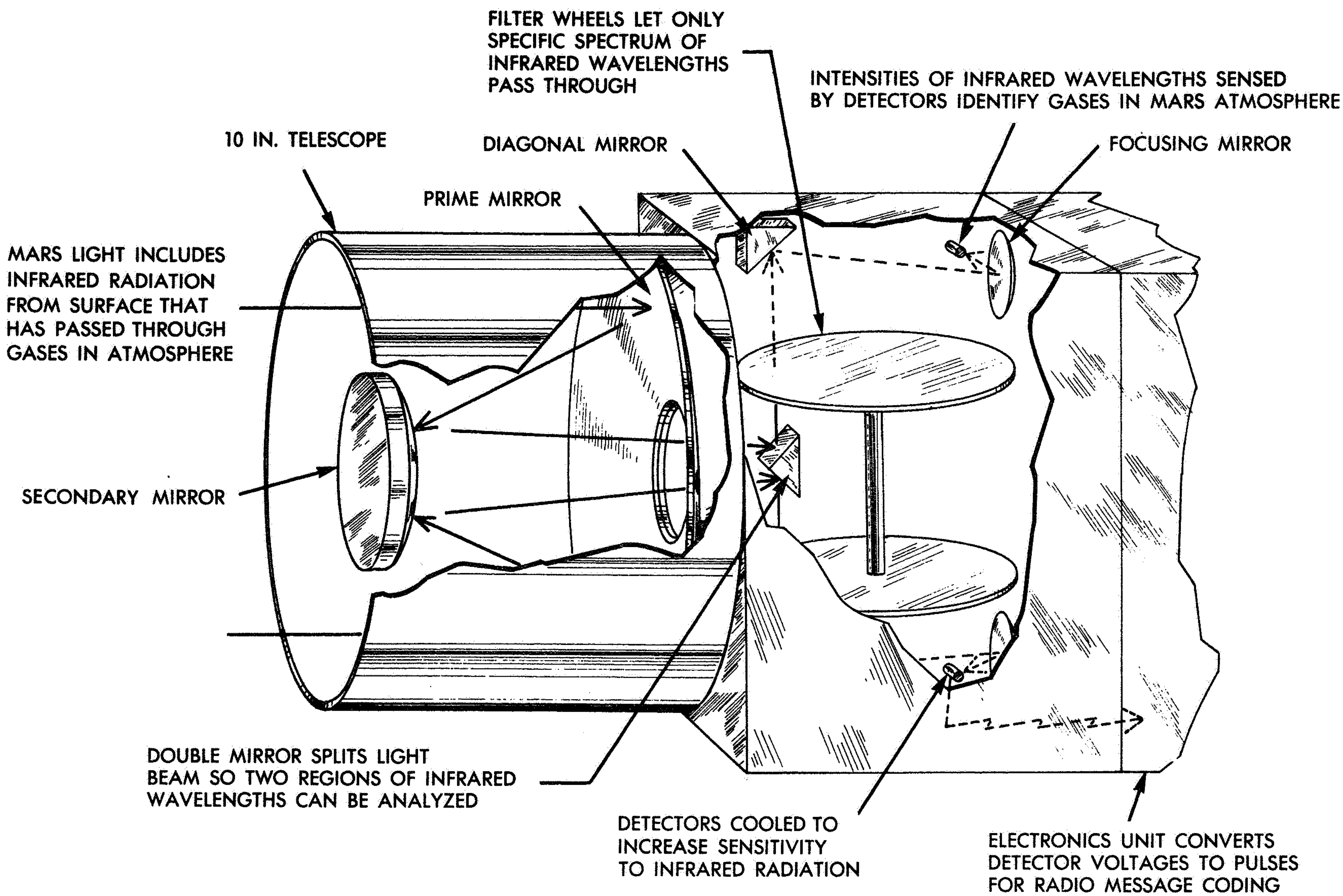
The instrument covers about the same areas as the television cameras to help determine the composition of the light and dark areas visible on Mars. Data from this experiment can also be compared with some of the results from the ultraviolet spectrometer concerning the composition of the Martian atmosphere.

The infrared wavelength region detected by this instrument (1.9 to 14.3 microns) will allow detection, if present, of water, carbon dioxide, methane, ethylene and acetylene as well as other molecules. The presence of organic molecules would lend evidence to the existence of either past or present life on Mars. This detection however would not allow firmly stating either possibility.

The presence of sulfur dioxide and hydrogen sulphide could indicate possible Martian volcanic activity, a valuable clue as to the history and internal structure of Mars.

MARINER INFRARED SPECTROMETER

(TO IDENTIFY GASES IN LOWER ATMOSPHERE OF MARS)



The detection of ozone molecules, correlated with data from the ultraviolet spectrometer experiment, could provide information on the amount of UV reaching the surface. Ozone is a strong absorber of UV.

The distribution of water vapor in the atmosphere can be correlated with ground features to possibly determine differences between light and dark areas. Any large variations in the distribution of water vapor could indicate possible future landing sites for life detection equipment.

Analysis of the data can also yield information on photo chemical processes, surface temperatures, reflected Sunlight, emissivity of surface and possibly chemical composition at the surface.

The experiment weighs 35.8 pounds, and will use approximately eight watts of power during the encounter sequence. During the cruise portion of the mission it will draw four watts of power for heaters.

Principal investigator is Dr. G. C. Pimentel of the University of California at Berkeley. Co-investigator is Dr. K. Herr, also of U.C./Berkeley.

Ultraviolet Spectrometer

The ultraviolet spectrometer is designed to identify gases in the upper Martian atmosphere by detection of various molecules, atoms and ions (molecules or atoms that have gained or lost electrons) and to determine their amounts.

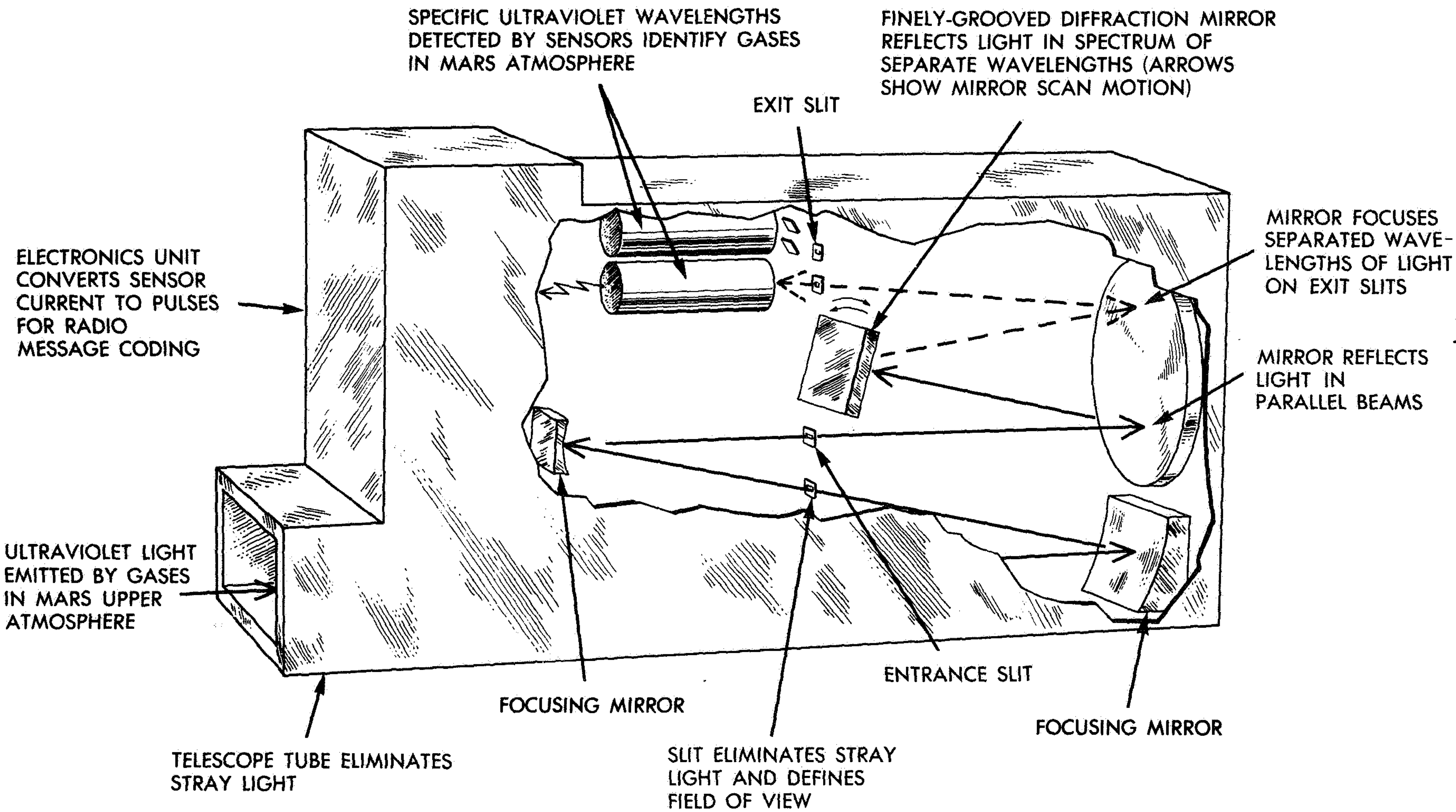
Identification of the gases present in the Mars atmosphere can determine if the atmosphere is the result of condensation of solar material, and therefore, primordial in origin, or was formed by gases released from the planet, as on Earth, or a combination of the two. The composition, and therefore the origin and evolution of the atmosphere can reveal the age and evolution of the planet itself.

A study of the atmosphere can also determine the environment in which life forms, if present on Mars, would have to exist.

A lack of oxygen, for instance, would mean that life forms must have developed some means of obtaining oxygen other than from the atmosphere. The lack of a shielding layer of ozone, that on Earth filters out the ultraviolet wavelengths that are deadly to life forms, would indicate that a life form on Mars would require its own protection to exist or would exist under a protective layer of soil or rock.

MARINER ULTRAVIOLET SPECTROMETER

(TO IDENTIFY GASES IN UPPER ATMOSPHERE OF MARS)



An ultraviolet spectrometer identifies different species (molecules, atoms and ions) by the wavelengths of light that they absorb or emit. Each specie absorbs the energy of light, which is composed of a number of different wavelengths, at one or more wavelengths and re-radiates the absorbed light at the same or longer wavelengths. An atom re-radiates the wavelength it absorbs; the spectrometer can detect certain wavelengths and thus identify the specie.

UV studies of Mars have not been made from Earth because it cannot penetrate our atmosphere. Brief studies have been made above the atmosphere from balloons and sounding rockets. This mission represents the first attempt to utilize a UV spectrometer to identify gases in the Martian atmosphere.

The UV experiment will also yield data on atmospheric density, temperatures relative to altitude and the amount of UV which strikes the surface of Mars.

Principal investigator for this experiment is Dr. Charles A. Barth of the University of Colorado. Co-investigators are William G. Fastie of the John Hopkins University; Fred C. Wilshusen, Kermit Gause, Ken K. Kelly, Ray Ruehle, Jeffrey B. Pearce, Charles W. Hord, all of the University of Colorado, and Edward F. Mackey, of Packard-Bell Electronics.

Infrared Radiometer (IRR)

This experiment will provide temperature measurements of the surface of Mars by detection of thermal radiation in the infrared portion of the electromagnetic spectrum.

The instrument is boresighted with the television cameras to allow correlation of surface temperatures with terrain features and clouds. This will provide a map of the surface relating temperature variations to surface features. If there is frozen water (permafrost) on Mars, there is a possibility of localized moist areas on the surface. This would require a higher surface temperature in the area which would be detectable. Ice will not actually melt in the low Martian atmospheric pressure but will go from the solid state to vapor in one step. However the possibility of small, moist areas remain. Photographs could also reveal a vapor cloud in the same area.

Data from this experiment on the Southern ice cap (the instrument on the spacecraft targeted for the polar pass) may determine if the Martian poles are covered with frozen water or frozen carbon dioxide. If the temperature recorded is approximately -253 degrees F or lower, it is likely that the cap is composed primarily of carbon dioxide, the major constituent of the Martian atmosphere. Temperatures above the point where carbon dioxide would vaporize, in a range above -253 degrees F, would imply that the caps are frozen water. Lower temperatures however would not rule out a mixture of frozen water and carbon dioxide.

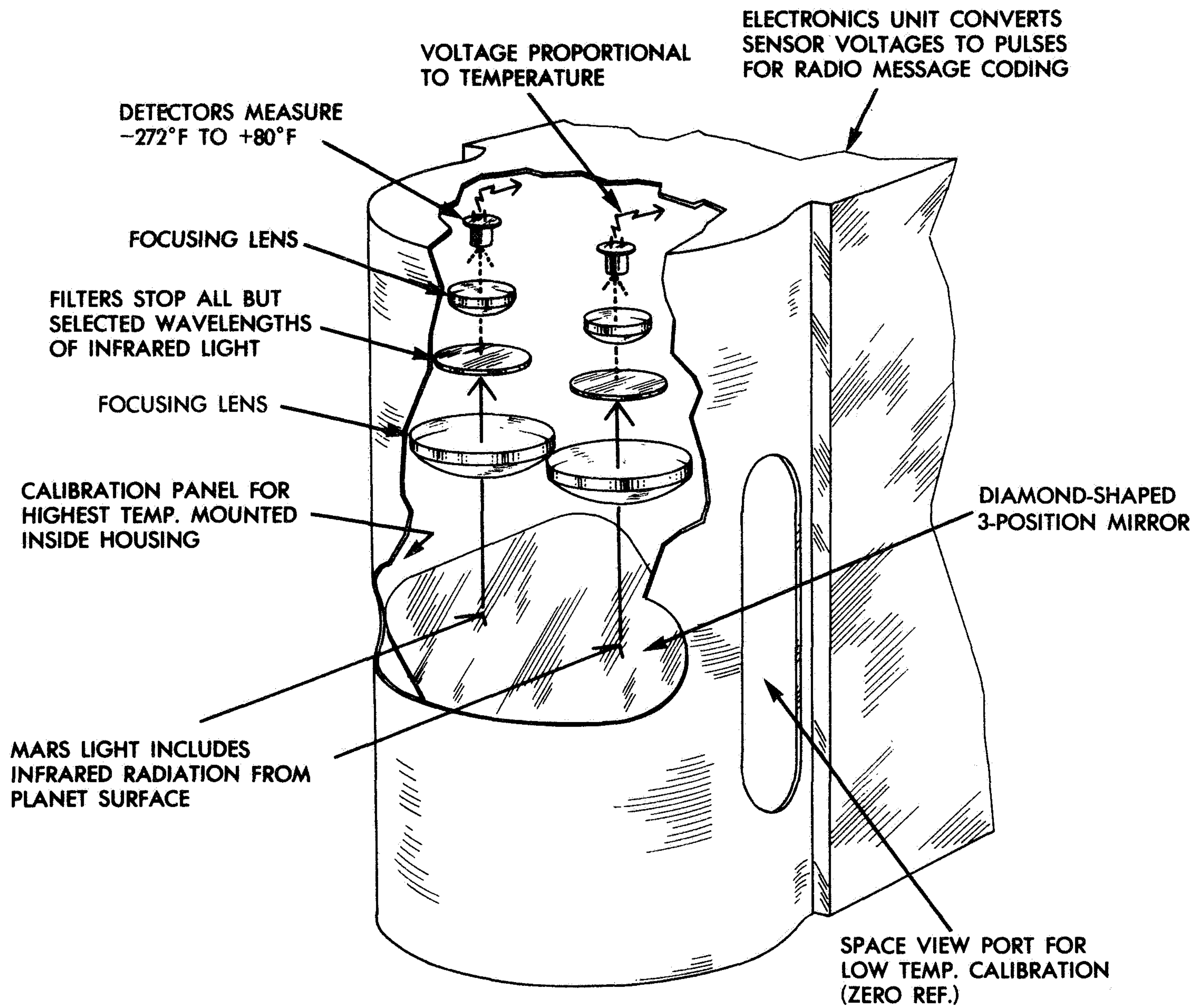
This experiment may also determine if the white rims seen on craters in the Mariner IV photographs of Mars are remnants of carbon dioxide or water ices.

The instruments aboard both spacecraft will scan the Martian surface across the sunlit portion and into the dark side, in effect, from late morning to late evening. This data will yield cooling rates showing the daily variations in temperatures as the surface absorbs heat from the Sun during the day and loses heat during the night hours. This information may indicate if the surface is solid, like rock, or composed of loose material like sand or dust. Data on the dark side of Mars, which is not obtainable from Earth, will be of particular value.

The data will also be analyzed to see if it reveals differences in cooling rates for the light and dark areas on Mars.

MARINER INFRARED RADIOMETER

(TO MEASURE MARS SURFACE TEMPERATURES)



Two detectors in the instrument will each provide 30 readings every 63 seconds. Of the 30 readings, 27 will be planetary temperature, two will be calibration readings and one engineering measurement on the instrument: temperatures or voltages.

Principal investigator for the experiment is Dr. Gerry Neugebauer of the California Institute of Technology. Co-investigators are Dr. Guido Munch, of Caltech, and Stillman C. Chase, of Santa Barbara Research Center.

S-Band Occultation

This experiment was first performed at Mars by the Mariner IV spacecraft in 1965. The data returned provided new values for the atmospheric pressure, density and electron density in the Martian atmosphere. It changed scientific views of Mars considerably. The data provided a new picture of an extremely thin Martian atmosphere about 1/100th the density of Earth's atmosphere.

The objectives of the '69 mission will be to refine this data and, in addition, obtain precise measurements of the radius of Mars and to attempt to measure reflection of radio signals from the surface of Mars. The latter could be correlated with data from other experiments aboard the spacecraft to make estimates of the electrical characteristics.

This experiment utilizes the radio signals transmitted from the spacecraft to Earth and does not require on-board equipment. It does require a trajectory that passes behind Mars, as seen from Earth, thus occulting the spacecraft from the view of tracking stations.

As the spacecraft curves behind Mars, its radio signal will pass through the Martian atmosphere and be cut off at the surface. The signal will reappear as the spacecraft comes out from behind the planet and again the radio signal will pass through the planet's atmosphere.

The atmosphere will refract the radio waves, changing them in frequency and strength. Measurements on Earth of these changes in the radio signal yield the data on the density and pressure of the atmosphere.

Similar changes in the atmosphere of Mars are caused by electron density and are also measurable. As the encounter with Mars will occur during a period of increased solar activity, the electron count is expected to be up to four times the values found by Mariner IV.

If both Mariner F and G successfully encounter Mars the experimenters will have four separate measurements as each spacecraft will provide a measurement on entrance into occultation and exit from occultation.

The trajectories have been planned to provide four points separated in latitude for these measurements. This will enhance the results, as it is expected that there may be variations of pressure at different locations on the surface. The data will also yield an accurate value for the radius and oblateness of Mars. The current values are uncertain, as various forms of measurement are not in agreement. Knowing the radius and figure (shape) of a planet can provide an estimate of its density and aid in understanding its internal structure.

Determination of the atmospheric density of Mars is vital to the design of future landing craft, and is a critical factor in the resolution of important scientific questions on the nature of the planet.

The principal investigator is Dr. A. J. Kliore of the Jet Propulsion Laboratory. Co-investigators are Dr. S. I. Rasool, Goddard Institute for Space Studies; Gunnar Fjeldo, Stanford University, and Boris Seidel, JPL.

Celestial Mechanics

This experiment derives its results from spacecraft tracking information and does not require special hardware on the spacecraft. The effect of bodies in space on the flight path of the spacecraft is used to determine the masses of those bodies. Ground equipment that measures the distance from Earth to the spacecraft will be used to determine the distance from the center of the Earth to the center of Mars at encounter.

The immediate objectives of the experiment are to determine: the mass of Mars; the Earth-Moon mass ratio and the distance from Earth to Mars at encounter. Long range objectives are to obtain an improved ephemeris of Mars (its position at given times in its solar orbit) and to attempt to measure General Relativistic effects on the solar orbit of the '69 spacecraft.

It is expected that the ranging information at encounter combined with radar bounce data will provide a determination of the size of Mars. This technique was used to determine the radius of Venus during the Mariner V fly-by of that planet on Oct. 19, 1967.

Improving the ephemeris of Mars is part of an existing JPL project to improve the ephemerides of all the inner planets. The Mariner tracking data will be combined with radar and optical telescope data to achieve this result.

The principal investigator for this experiment is John D. Anderson of the Jet Propulsion Laboratory, and the co-investigator is Warren L. Martin, also of JPL.

MARINER SPACECRAFT

Mariner Description

The Mariner Mars 1969 fly-by spacecraft were designed, assembled and tested by the Jet Propulsion Laboratory in Pasadena, Calif. Industrial contractors provided the detailed design and fabrication of the subsystems. Component parts were provided by hundreds of manufacturers and suppliers.

Each Mariner weighs 910 pounds and measures 11 feet from the scan platform to the top of the low-gain antenna. With solar panels deployed, the spacecraft spans 19 feet. The octagonal structure measures 54½ inches diagonally and 18 inches in depth.

Mariner's basic structure is a 37-pound eight-sided forged magnesium framework with seven electronics compartments. The compartments themselves provide structural support to the spacecraft.

Four solar panels, each 84 inches long and 35½ inches wide, are attached to the top or sunward side of the octagon. Each panel has a solar cell area of 20.7 square feet, or a total cell surface of approximately 83 square feet for each spacecraft. Two sets of attitude control jets consisting of six jets each, which stabilize the spacecraft on three axes, are mounted at the tips of the four panels.

Metal bottles containing the nitrogen gas supply for Mariner's dual attitude control gas system and regulators for the systems are mounted on the top ring of the octagon. Propellant tank for the liquid-fuel midcourse engine is supported by a cantilever arrangement inside the octagonal cavity, with the rocket nozzle protruding through one of the eight sides of the spacecraft.

The high-gain antenna is attached to the spacecraft by a superstructure atop the octagon. Its aluminum honeycomb dish reflector is circular, 40 inches in diameter, and is parabolic in cross-section. The antenna feed is supported at the focus of the parabola by a fiberglass truss. The reflector, which weighs only 3.3 pounds, is in a fixed position so that Earth enters the antenna beam about 150 days after launch and remains in the effective beam until more than one month beyond Mars.

The low-gain omni-directional antenna is mounted at the top of a circular aluminum tube, four inches in diameter and extending vertically 88 inches from the top of the octagonal structure. The tube acts as a waveguide for the antenna. A cone-shaped thermal control flux monitor is mounted at the top of the antenna mast where it remains in sunlight with a minimum view of other parts of the spacecraft which could reflect light into its detector.

The Canopus star tracker assembly is located on the upper ring structure of the octagon for a clear field of view between two solar panels. Two primary Sun sensors are mounted on pedestals atop the octagon. Four secondary Sun sensors are attached directly to the lower ring structure.

The eight compartments girdling the spacecraft house the following: Bay 1, power conversion equipment, battery charger and squib firing assembly; Bay 2, midcourse maneuver rocket engine; Bay 3, central computer and sequencer and attitude control subsystem; Bay 4, flight telemetry and command subsystems; Bay 5, tape recorders; Bay 6, radio receiver and transmitters; Bay 7, science instrument electronics and data automation subsystem; Bay 8, power booster regulators and spacecraft battery.

Six of the electronics compartments are temperature controlled by lightweight louver assemblies on the outer surfaces. The octagon's interior is insulated by multi-layer fabric thermal shields at both top and bottom of the structure.

The Mariners will carry science instrumentation for four planetary experiments. Two additional experiments, spacecraft occultation by Mars and celestial mechanics, require only the spacecraft communications system as the source of their data.

Two television cameras, an infrared spectrometer, ultraviolet spectrometer, infrared radiometer and two planet sensors are mounted on a motor-driven two-degree-of-freedom scan platform on the bottom or shaded side of the octagon. Total rotating weight of the platform mechanism and its science instrument payload is 167 pounds.

Power

The Mariner power subsystem supplies electrical power to the spacecraft, switches and controls the power and provides an accurate timing source.

Primary power source is an arrangement of 17,472 photovoltaic solar cells mounted on four panels which will face the Sun during most of the flight to Mars. The cells, covering 83 square feet, will collect energy and convert it into electrical power.

A rechargeable silver-zinc battery will provide spacecraft power during launch, midcourse and whenever the panels are turned away from the Sun. The battery will be kept in a state of full charge and will be available during planet encounter as an emergency power backup source.

Two power regulators will provide redundancy. In the event of a failure in one, it will be removed automatically from the line and the second will be switched in to assume the full load.

The solar panels will be folded in a near vertical position above the body of the spacecraft during launch and will be deployed after separation from the launch vehicle. Each panel weighs 27 pounds, including the weight of 4,368 solar cells (2x2 cm. N/P) and protective glass filters that reduce the amount of solar radiation absorbed without interfering with the energy conversion. The cell modules are supported by lightweight panel structures made of thin-gauge aluminum.

Nominal power from the panels is expected to be 800 watts at maximum power voltage for cruise conditions in space near Earth. This power capability decreases to 449 watts at the Mars distance if there is no degradation because of solar flares. Maximum power demand is expected to be 388 watts at encounter.

The battery is a sealed unit containing 18 silver-zinc cells. Its minimum capacity ranges from 1,200-watt hours at launch to about 900-watt hours at planet encounter. Load requirements on the battery may vary between zero amps and 9.5 with battery voltages expected to vary between 25.8 and 33.3 volts. The battery weighs 31 pounds.

The battery will be capable of delivering its required capacity and meeting all electrical requirements within an operational temperature range of 58 degrees to 90 degrees F. At temperatures outside this range, it will still function although its capability will be reduced.

To ensure maximum reliability, the power subsystem was designed to limit the need for battery power after initial Sun acquisition. Except during maneuvers, the battery will remain idle and fully charged.

Under normal flight conditions, the primary power booster-regulator will handle all spacecraft loads. A second regulator will support power loads on a stand-by basis. Should an out-of-tolerance voltage condition exist in the main regulator, the stand-by regulator will take its place on the line.

Primary form of power distributed to other spacecraft systems is 2,400-cycles-per-second square wave. The gyro spin motors use 400 cps three-phase current, and the infrared spectrometer and scan motor are supplied with 400 cps single-phase current. The transmitter amplifier tube, battery charger and temperature control heaters use unregulated dc power from the solar panels or the battery.

A crystal oscillator in the main power inverter controls the frequency to within 0.01 per cent, assuring other spacecraft systems of a reliable, accurate frequency on their power line. A backup crystal oscillator is located in the stand-by inverter. The spacecraft Central Computer and Sequencer (CC&S) uses the oscillator frequency as a timing source.

Telemetry measurements have been selected to provide the necessary information for the management of spacecraft power loads by ground command if necessary.

The battery, regulators and power distribution equipment are housed in two adjacent electronics compartments on Mariner's octagonal base.

Central Computer and Sequencer

Mariner is designed to operate throughout its basic mission without the need of ground commands--with the single exception of the trajectory correction maneuver. This automatic capability is made possible by the on-board command function of the central computer and sequencer (CC&S). Critical events, however, are backed up by the ground command capability.

The CC&S performs the timing, sequencing and computations for other subsystems aboard the spacecraft. It initiates spacecraft events in four different mission sequences--launch, cruise, maneuver, and encounter.

Timing and sequencing are programmed into the CC&S prior to launch but can be modified anytime during the flight by command from the ground.

The launch sequence includes the deployment of solar panels and the turning on of the Canopus sensor and attitude control system to establish spacecraft stabilization and solar energy conversion for the long cruise.

The cruise sequence controls those spacecraft events that occur after the launch sequence and prior to encounter with a single exception--the midcourse trajectory correction. CC&S commands during the cruise sequence switch the spacecraft telemetry transmission to a higher or lower bit rate; unlatch the scan platform; switch the transmitter to either the high-gain or low-gain antenna; and set the Canopus sensor at various cone angles relative to the predicted encounter time.

The maneuver sequence controls the events necessary to perform the midcourse trajectory correction. Coded commands, generated at JPL after analysis of tracking data, are radioed from Earth and stored in the CC&S prior to initiation of the maneuver. They tell the spacecraft how far and in which direction to turn on its pitch and roll axes and how long the midcourse rocket engine must fire. Under normal circumstances, the programmable computer portion and the fixed sequencer portion of the CC&S operate in tandem, providing redundancy. If there is disagreement on any maneuver event, with the exception of the command to turn off the rocket engine, the maneuver is aborted and the spacecraft returns to the cruise condition. A maneuver also can be performed by either portion of the CC&S alone.

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The encounter sequence begins with the switching of the spacecraft transmitter to high power prior to the first far encounter TV picture and continues through the end of the data storage playback phase of the mission. CC&S commands include those controlling the motion of the two-axis science platform; starting and stopping recording on both tape recorders; switching the radio transmitter to high power; selecting the telemetry data rate; and controlling the playback of recorded data. To change the programmed encounter sequence, CC&S commands may be preempted by direct commands from the ground.

The CC&S weighs about 26 pounds and is housed with the attitude control system's electronics in one of the eight compartments girdling Mariner's octagonal base.

Temperature Control

If dependent solely upon direct sunlight for heat, an object in space would be approximately 125 degrees F. colder at Mars than at Earth.

For a spacecraft traveling to Mars, away from Earth and from the Sun, the primary temperature control problem, then, is maintaining temperatures within allowable limits despite the decreasing solar intensity as the mission progresses. In airless space, the temperature differential between the sunlit side and the shaded side of an object can be several hundred degrees.

Heating by direct sunlight on the Mariner spacecraft is minimized by the use of a thermal shield on its Sun side. The side away from the Sun is covered with a thermal shield to prevent rapid loss of heat to the cold of space.

The top of Mariner's basic octagon is insulated from the Sun by a multi-layered shield of aluminized Teflon mounted to the high-gain antenna support structure. The bottom is enclosed by a similar shield, or space "blanket," to retain heat generated by power consumption within the spacecraft.

Temperature control of six of the electronics compartments is provided by polished metal louvers actuated by coiled bi-metallic strips. The strips act as spiral-wound springs that expand and contract as they heat and cool. This mechanical action, which opens and closes the louvers, is calibrated to provide an operating range from fully closed at 55 degrees F. to fully open at 90 degrees F. A louver assembly consists of 22 horizontal louvers driven in pairs by 11 actuators. Each pair operates independently on its own local temperature determined by internal power dissipation.

The science platform and its array of instruments at the bottom of the octagon is covered by a third thermal blanket fitted also with a louver assembly. The platform is designed to be thermally isolated from the main equipment octagon by a plastic collar on the attaching support tube. Temperature control is achieved by electrical dissipation in heaters and in the instruments themselves.

Electric heaters are located within the science platform blanket and in two of the electronics bays to provide additional heat during certain portions of the mission.

Paint patterns and polished metal surfaces are used on the Mariner for passive control of temperatures outside of the protected octagon and covered science platform. These surfaces control both the amount of heat dissipated into space and the amount of solar heat absorbed or reflected away. The patterns were determined from testing a Temperature Control Model (TCM) of the spacecraft in a space simulation chamber at JPL and from the application of actual mission data acquired during the 1964-65 Mariner IV mission to Mars.

The high-gain antenna dish, which is dependent upon the Sun for its surface heat, is painted green to keep it at near room temperature during planet encounter but within its upper thermal limit earlier in the mission.

A temperature control flux monitor (TCFM) will perform an engineering experiment by comparing actual flight thermal performance with that determined by space-simulated tests. The data is expected to provide a standard for future simulator testing and spacecraft design. The cone-shaped TCFM is mounted at the top of the omni-directional antenna mast where it remains in sunlight with no view of the spacecraft which could reflect light into its detector. The TCFM will make an absolute measurement of the solar intensity to within plus or minus 1.5 percent.

Midcourse Propulsion

Mariner's midcourse rocket engine used a liquid monopropellant and is capable of firing twice during the Mars mission. Its function is to provide small trajectory corrections to the spacecraft. The engine uses anhydrous hydrazine as the propellant and a spontaneous catalyst for decomposition of the hydrazine.

The rocket nozzle protrudes from one of the eight sides of Mariner's octagonal base below and between two of the solar panels. The engine's direction of thrust is nearly parallel to the panels, hence perpendicular to the longitudinal or roll axis of the spacecraft.

Hydrazine is contained in a rubber bladder enclosed in a spherical pressure vessel. The propellant is forced into the combustion chamber by nitrogen gas compressing the bladder. Decomposition of the hydrazine, maintained by the catalyst stored in the chamber, causes the rapid expansion of hot gases in the engine.

Firing of the engine is controlled by the Central Computer and Sequencer, which receives the time, direction and duration of required thrust through the ground-to-spacecraft communications link. At the command signal from the CC&S, explosively-actuated valves allow pressure-regulated nitrogen gas to enter the propellant tank and open the propellant line to the engine. For termination of thrust, the CC&S timer actuates another set of valves which stops propellant flow and tank pressurization. During rocket engine firing, spacecraft attitude is maintained by autopilot-controlled jet vanes positioned in the rocket nozzle to deflect the engine exhaust stream.

Restart capability and redundancy are provided by second sets of explosive start and shutoff valves.

Either of the two Mariners may perform one or two midcourse maneuvers. It is anticipated, because of several trajectory factors, that the first spacecraft launched probably will require a second maneuver while the second Mariner will not.

First maneuver for each spacecraft is expected to occur within five to 15 days following each launch. A second maneuver would be conducted about one to four months after launch.

The midcourse propulsion system can burn for as little as 100 milliseconds and can alter velocity in any direction from less than ¼ mile-per-hour to 134 miles-per-hour. Maximum burn time is 102 seconds. Thrust is continuous at about 51.3 pounds.

Launch weight of the midcourse propulsion system, including the gas pressurant and 21½ pounds of propellant, is 47 pounds.

Communications

Two-way communications with the Mariners will be accomplished with a radio link between Earth tracking stations and a dual transmitter-single receiver radio system aboard each spacecraft.

The on-board communications system also includes a telemetry subsystem, command subsystem, data storage subsystem and high and low-gain antennas.

The spacecraft S-band receiver will operate continuously during the mission at about 2115 megacycles. (The receivers in the two Mariners will operate at slightly different frequencies. Similarly, no two transmitters will operate at exactly the same frequency.) The receiver will be used with only one antenna -- the low-gain omni-directional antenna. It receives uplink command and ranging signals from ground stations of the Deep Space Network.

To provide the standard Doppler tracking data, the radio signal transmitted from Earth is received at the spacecraft, changed in frequency by a known ratio and re-transmitted to Earth. In addition, a JPL-developed ranging technique using an automatic coded signal provides range measurements with an accuracy of a few yards at the Mars-Earth distance. The ranging function may be commanded on and off by ground command.

When no uplink signal is being received by Mariner, the transmitted frequency of about 2195 megacycles originates in the spacecraft transmitter. The transmitter consists of two redundant exciters and two redundant radio frequency power amplifiers of which any combination is possible. Only one exciter-amplifier combination will operate at any one time. Selection of the combination will be by on-board failure detection logic with ground command backup.

Both amplifiers on each spacecraft employ traveling wave tubes and are capable of operating at 10 watts or 20 watts output and the signal may be transmitted through either the high-gain or low-gain antenna. Transmission via the high-gain antenna will be required during the encounter and playback phases of the mission.

The low-gain antenna provides essentially uniform coverage in the forward hemisphere of the spacecraft. The high-gain antenna includes a 40-inch-diameter parabolic reflector which provides a highly directional beam for the downlink radio signal. Switchover of the spacecraft transmitter to the high-gain antenna and back to the low-gain, if desired, may be commanded from Earth.

All communications between the Mariners and Earth will be in digital form. Command signals transmitted to the spacecraft will be decoded -- translated from a binary form into electrical impulses -- in the command subsystem and routed to their proper destination.

Three types of commands are transmitted to the spacecraft: a direct command (DC) results in the closure of a switch in one of the spacecraft subsystems; a coded command (CC) provides information to the central computer and sequencer for the midcourse maneuver or to update the CC&S program; a quantitative command (QC) is used to step the scan platform a variable number of increments. There are 53 possible DC's which back up all critical automatic spacecraft functions, choose redundant elements, initiate the midcourse maneuver and perform other functions.

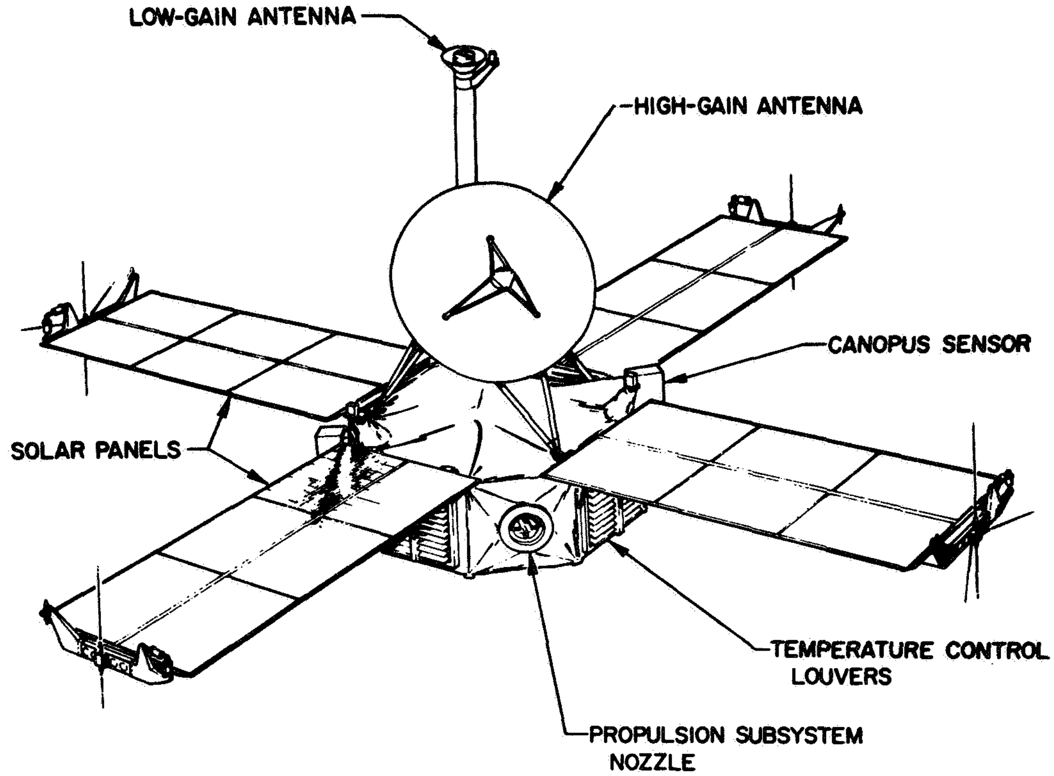
Data telemetered from the spacecraft will consist of engineering and science measurements prepared for transmission by the telemetry subsystem, the data automation subsystem (realtime TV and science) and data storage subsystem (recorded science including TV). The encoded information will indicate voltages, pressures, temperatures and other values measured by the spacecraft telemetry sensors and science instruments.

There are three data channels: the engineering channel which operates throughout the flight; the science channel employed during the encounter and playback phases of the mission; and the high-rate alternate science channel.

Mariner can transmit information to Earth at five different rates: on the engineering channel at 8 1/3 bits-per-second and 33 1/3 bps at any time; on the science channel at 66 2/3 bps during encounter and 270 bps during data storage playback; and on the high-rate science channel at 16,200 bps.

The high-rate channel may be used during the encounter portion of the mission to transmit, in realtime, data being placed on the digital tape recorder -- one of two on-board tape recorders which make up the data storage subsystem. During playback, television data on the analog tape recorder may be fed directly to the telemetry subsystem through an analog-to-digital converter and transmitted at the 16,200 bps rate.

Certain conditions must exist in order to utilize the high-rate channel. These include the availability of the 210-foot diameter antenna at the Goldstone Space Communications Complex of the Deep Space Network for receiving.


LOW-GAIN ANTENNA
HIGH-GAIN ANTENNA
CANOPUS SENSOR
SOLAR PANELS
TEMPERATURE CONTROL LOUVERS
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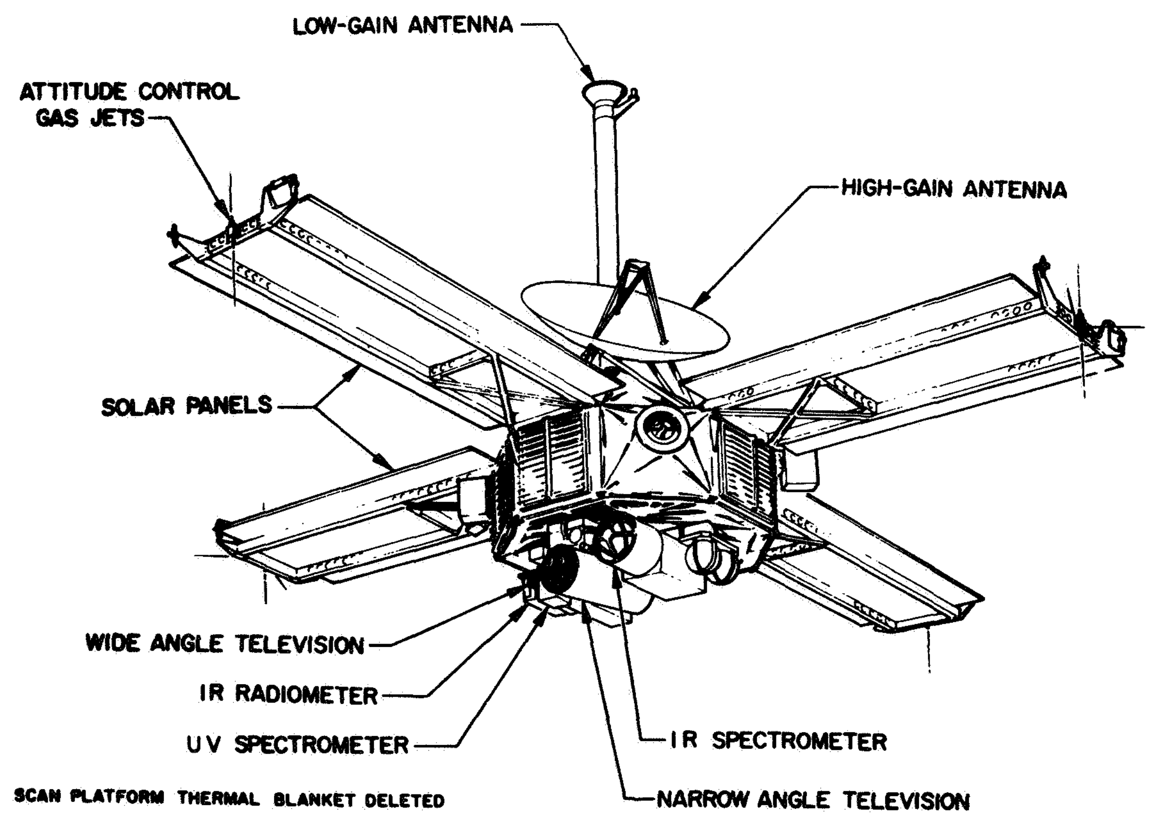
LOW-GAIN ANTENNA
ATTITUDE CONTROL GAS JETS
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SOLAR PANELS
WIDE ANGLE TELEVISION
IR RADIOMETER
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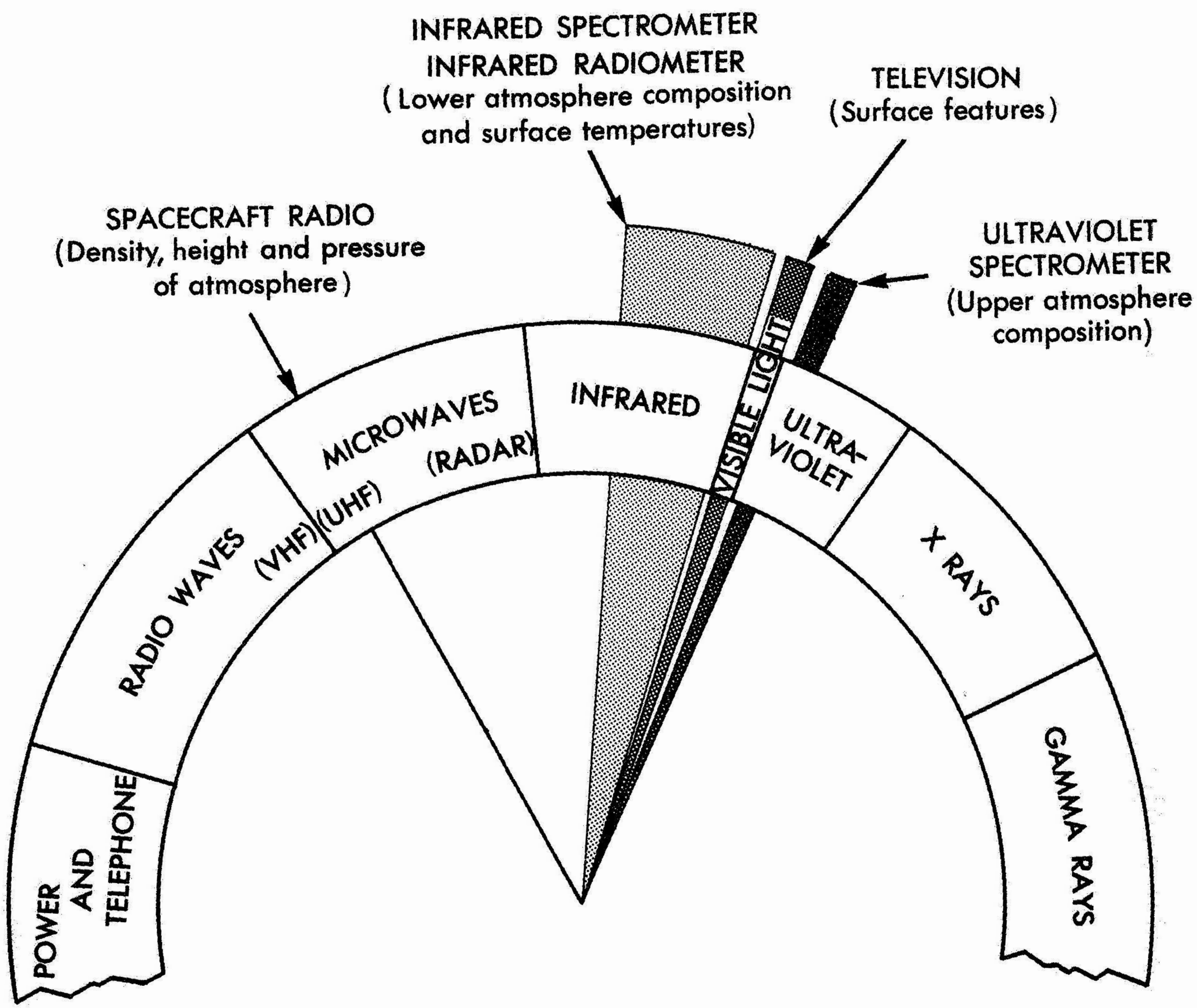
IR SPECTROMETER
NARROW ANGLE TELEVISION
SCAN PLATFORM THERMAL BLANKET DELETED

ELECTROMAGNETIC WAVELENGTH REGIONS USED BY MARINER TO EXAMINE MARS



During playback of the analog tape recorder, this data may be recorded on the digital tape recorder and played back at 270 bps using the standard 85-foot-diameter antennas.

Approximately 90 engineering measurements are obtained by transducers throughout the spacecraft to make up the engineering data. The engineering samples are taken continuously and can be transmitted along with science regardless of the science channel or rate in use.

All video data received from the television cameras is recorded on the analog tape recorder. It can be erased in flight, permitting the recording of a set of TV pictures, playing it back and erasing the tape and then recording another set.

The digital tape recorder will be fed by the data automation system which formats all the measurements from the infrared spectrometer, infrared radiometer and the ultraviolet spectrometer as well as selected data from the television cameras. The digital recorder needs no erasing.

Total capacity of the two recorders is equivalent to approximately 195 million bits of information.

Attitude Control

Stabilization of the spacecraft during the cruise and planet encounter portions of the Mariner Mars mission is provided by a system of 12 cold gas jets mounted at the outer ends of the four solar panels. The jets are linked by logic circuitry to three gyroscopes (one gyro for each of the spacecraft's three axes), to the Canopus sensor and the primary and secondary Sun sensors.

The gas system is divided into two sets of six jets, each set complete with its own gas supply, regulators, lines and valves so that a leak or valve failure will not deplete the gas and jeopardize the mission. Each system is fed by a titanium bottle containing 2½ pounds of nitrogen gas pressurized at 2,500 pounds per-square-inch.

Normally, both sets will operate during the mission. Either system can support the entire flight in the event of a failure in the other.

The primary Sun sensors are mounted on the sunlit side of the spacecraft and the secondary sensors on the shadowed side. The sensors are light-sensitive diodes which inform the attitude control system when they see the Sun. The attitude control system responds to these signals by turning the spacecraft and pointing the solar panels toward the Sun for stabilization on two axes and for conversion of solar energy to spacecraft power. Nitrogen gas escapes through the appropriate jet nozzle, imparting a reaction to the spacecraft to correct its angular position.

The star Canopus, one of the brightest in the galaxy, will provide a second celestial reference (along with the Sun) upon which to base the midcourse maneuver. The Canopus sensor will activate the gas jets to roll the spacecraft about the already-fixed longitudinal or roll axis until it is "locked" in cruise position. Canopus acquisition occurs when the light intensity in the field of view of the sensor matches the intensity anticipated for the star Canopus. Brightness of the sensor's target star will be telemetered to the ground to verify the correct star has been acquired.

The Canopus sensor design incorporates the capability of preventing recurring loss of roll reference caused by bright particles in the sensor field of view. The sensor logic will allow a bright fast-moving particle to drift through the field of view without causing the spacecraft to initiate a new roll search for the star.

Periodically during the flight, the Canopus sensor will be updated to compensate for the changing angular relationship between the spacecraft and the star. The sensor's field of view or "look angle" will be changed electronically to follow Canopus throughout the mission. The update, which will occur four times at approximately three-week to four-week intervals, will be commanded at predetermined times by the on-board Central Computer and Sequencer with ground command backup. A fifth Canopus tracker update will occur about 30 days after the spacecraft flies by Mars.

Upon receipt of commands from the CC&S, the attitude control system orients the spacecraft to align the thrust axis of the midcourse motor in the direction required for the trajectory correction maneuver.

During firing of the midcourse motor, stabilization of the spacecraft will be effected by the use of four rudder-like jet vanes mounted in the downstream end of the engine nozzle. The Mariner's autopilot controls spacecraft attitude during engine firing by using the gyros to sense motion about the spacecraft's three axes for positioning the jet vanes.

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Each vane has its own separate control system and, because the midcourse motor is not mounted along any of the three axes, each is activated by a mixture of signals from the three gyros. Constant adjustment of the angles of the jet vanes ensures that the motor thrust direction remains through the spacecraft's center of gravity.

Scan Control

Mariner's science instruments are mounted on a scan platform which can be rotated about two axes to point the instruments toward Mars during the spacecraft's approach and passage of the planet. The platform is located below the octagonal base of the spacecraft.

The instruments are the ultraviolet spectrometer, infrared radiometer, infrared spectrometer, wide-angle television camera and narrow-angle television camera. Also located on the platform are three planet sensors and two high pressure spheres containing hydrogen and nitrogen for cooling a detector in the IR spectrometer.

The scan control system allows multiple pointing directions of the instruments as the encounter phase of the mission progresses. The platform's two axes of rotation are described as the clock angle motion about the axis of the tube extending vertically from the octagon and cone angle motion about an axis which is horizontal.

The 167-pound platform is motor driven and moves 215 degrees in the clock and 64 degrees in cone.

As Mariner approaches Mars (about three days before closest approach), one of the scan control system's three optical sensing devices -- the far encounter planet sensor -- tracks the center of brightness of Mars enabling the narrow-angle TV camera to begin a series of full-disk pictures of the planet.

The other planet sensors, called narrow-angle Mars gates, initiate several science events during the near encounter portion of the mission. One of the sensors provides a signal which activates the cyrogenic cooldown of the detector in the IR spectrometer. The second provides the information initiating the recording of instrument data.

At about 12 hours before Mariner's closest approach to Mars, the scan platform twists on both axes to a pointing angle set before launch or updated during the flight by ground command.

Data Automation Subsystem

The five scientific instruments on the spacecraft are controlled and synchronized by the Data Automation Subsystem (DAS) and the data from the instruments is converted by the DAS into a suitable digital form for transmittal to Earth.

The experiments controlled by the DAS are television, infrared radiometer, infrared spectrometer and ultraviolet spectrometer. The S-band occultation experiment and the celestial mechanics experiment do not require special equipment aboard the spacecraft and are not controlled by the DAS.

During encounter the DAS accumulates varied scientific data, reduces the data to a common digital form and common rate and then feeds the data to the digital tape recorder or to the radio transmitter telemetry channel at proper intervals.

The DAS is composed of three units: logic circuitry, spacecraft interface circuitry and power converter. The total weight is about 14 pounds and power consumption is 18 watts.

LAUNCH VEHICLE

The launches of Mariners F and G mark the first use of the Atlas-Centaur launch vehicle (AC-19, AC-20) in the Mariner program. Atlas-Agena launch vehicles were used for the previous Mariner missions. Use of the Atlas-Centaur vehicle with its greater payload capability allows for growth of the spacecraft. Mariners F & G weigh approximately 848 pounds compared with 575 pounds for Mariner IV to Mars in 1964 and 542 pounds for Mariner V to Venus in 1967.

The launches of Mariners F and G mark the first use of Atlas-Centaur vehicles for interplanetary missions. In the past, Centaur has been used to successfully launch seven Surveyor spacecraft to the Moon and to place an Orbiting Astronomical Observatory in Earth orbit. Centaur, which was developed under the direction of the Lewis Research Center was the first U.S. rocket to use the high energy liquid oxygen, liquid hydrogen propellant combination.

AC-19 and 20 will use a direct ascent single burn technique for placing the spacecraft on the proper trajectory to Mars. In this mode the Centaur engines will be required to ignite only once in space.

To reach the proper trajectory the launch vehicle will have to make either one or two dogleg maneuvers, depending on the day of launch.

AC-19 and 20 consist of an Atlas SLV-3C booster combined with a Centaur second stage. The two stages are 10 feet in diameter and are connected with an interstage adapter. Both Atlas and Centaur stages rely on internal pressurization for structural integrity.

The Atlas booster develops 395,000 pounds of thrust at liftoff, using two 168,000 thrust booster engines, one 58,000 thrust sustained engine and two vernier engines developing 670 pounds thrust each.

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Centaur carries insulation panels and a nose fairing which are jettisoned after the vehicle leaves the Earth's atmosphere. The insulation panels weighing about 1,200 pounds, surround the second stage propellant tanks to prevent the heat of air friction from causing excessive boil-off of liquid hydrogen during flight through the atmosphere. The nose fairing protects the payload.

The configuration for the Atlas and Centaur vehicles are basically the same as they were for the Surveyor flights. Certain improvements have been introduced since the last Surveyor flights including the use of explicit guidance equations rather than implicit ones, to provide additional operational flexibility.

Launch Vehicle Characteristics

*Liftoff weight including spacecraft:		323,105 pounds
Liftoff height:		113 feet
Launch Complexes:		36A & B
Launch Azimuth Sector		87 - 108 degrees
	SLV-3C Booster	Centaur Stage
**Weight:	284,431 lbs.	37,826 lbs.
Height:	75 feet (including interstage adapter)	48 feet (with payload fairing)
Thrust:	395,000 lbs. (sea level)	30,000 lbs. (vacuum)
Propellants:	Liquid oxygen and RP-1	Liquid hydrogen and liquid oxygen
Propulsion:	MA-5 system (2-168,000-lb.-thrust engines, 1-58,000-lb.-sustainer engine and 2-670-lb.-thrust vernier engines.)	Two 15,000-pound-thrust RL-10 engines. 14 small hydrogen peroxide thrusters.
Velocity:	5,766 mph at BECO 8,372 mph at SECO	22,392 mph at spacecraft separation.
Guidance:	Pre-programmed autopilot through BECO. Switch to Centaur inertial guidance for sustainer phase.	Inertial guidance.

* Measured at two inches of rise
**Weights are based on AC-19 configuration. AC-20 varies just slightly.

Atlas-Centaur Flight Sequence - AC-19*

Event	Nominal Time	Altitude Statute Miles	Surface Range, Statute Miles	Velocity MPH
Liftoff	0	0	0	0
Booster Engine Cutoff	2 min. 32 sec.	36.8	55.9	5,766.1
Booster Jettison	2 min. 35 sec.	38.6	60.6	5,895.7
Jettison Insulation Panels	3 min. 17 sec.	60.5	129.6	6,735.7
Jettison Nose Fairing	3 min. 54 sec.	76.1	200.8	7,750.9
Sustainer Engine Cutoff	4 min. 13 sec.	83.3	240.0	8,372.7
Atlas Separation	4 min. 14 sec.	84.0	244.5	8,369.3
Centaur Engine Start	4 min. 24 sec.	87.5	265.8	8,340.0
Centaur Engine Cutoff	11 min. 39 sec.	201.6	1887.0	24,768.4
Spacecraft Separation	13 min. 14 sec.	339.6	2476.4	24,392.7
Start Centaur Reorientation	17 min. 44 sec.	976.7	3896.5	22,825.9
Start Centaur Retrothrust	19 min. 19 sec.	1263.7	43004.4	22,217.0

* Launch Day -2/24/69
Arrival Day- 7/31/69
Launch Time - Window Open 7:54 p.m. EST
Launch Azimuth -108 degrees
Yaw Index - 22.14

Atlas-Centaur Flight Sequence - AC-20*

Event	Nominal Time	Altitude Statute Miles	Surface Range, Statute Miles	Velocity MPH
Liftoff	0	0	0	0
Booster Engine Cutoff (BECO)	2 min. 32 sec.	36.6	55.1	5,789.3
Booster Jettison	2 min. 35 sec.	38.4	59.8	5,857.5
Jettison Insulation Panels	3 min. 17 sec.	60.3	128.3	6,700.2
Jettison Nose Fairing	3 min. 54 sec.	75.9	199.3	7,722.9
Sustainer Engine Cutoff (SECO)	4 min. 12 sec.	82.9	238.3	8,347.5
Atlas-Centaur Separation	4 min. 14 sec.	83.7	242.8	8,344.1
Centaur Main Engine Start (MES)	4 min. 23 sec.	87.1	264.1	8,315.5
Centaur Engine Cutoff (MECO)	11 min. 36 sec.	186.7	1903.3	25,032.3
Spacecraft Separation	13 min. 11 sec.	312.8	2509.8	24,690.7
Start Centaur Reorientation	17 min. 41 sec.	939.2	3973.6	23,149.8
Start Centaur Retrothrust	19 min. 16 sec.	1229.2	4387.8	22,535.4

* Launch Day - 3/24/69
Arrival Day - 8/5/69
Launch Time - Window Open 4:58 p.m. EST
Launch Azimuth - 104.83 degrees
Yaw Index - 0

Flight Sequence

Flight sequences of the AC-19 and AC-20 rocket vehicles are basically the same with times varying only a second or two in some cases as noted on the accompanying chart. For practical purposes the following sequence description is the one for AC-19 at the opening of the window Feb. 24.

Atlas Phase

After liftoff, AC-19 will rise vertically for about 15 seconds before beginning its pitch program. Starting at two seconds after liftoff and continuing to T+15 seconds, the vehicle will roll to the desired flight azimuth of between 87 and 108 degrees. The azimuth varies according to the day of launch.

After 152 seconds of flight, the booster engines are shut down (BECO) and jettisoned. BECO occurs when an acceleration of 5.7 g's is sensed by accelerometers on the Centaur and the signal is issued by the Centaur guidance system. The booster package is jettisoned 3.1 seconds after BECO. The Atlas sustainer engine continues to burn for approximately another minute and 41 seconds propelling the vehicle to an altitude of about 83 miles, attaining a speed of 8,300 mph. Sustainer engine cutoff (SECO) occurs at propellant depletion. Centaur insulation panels and nose fairing are jettisoned prior to SECO.

The Atlas and Centaur stages are then separated. An explosive shaped charge slices through the interstage adapter. Retro-rockets mounted on the Atlas slow the spent stage.

Dogleg Maneuver

Although the launch azimuth for Feb. 24 is 108 degrees, because of a dogleg maneuver to the south, the equivalent flight azimuth is approximately 130 degrees at window opening on Feb. 24. Safety considerations dictate the difference between the two headings to avoid the Lesser Antilles area during reentry of the vehicle, if destruct is necessary for range safety purposes.

In order to reach the proper equivalent azimuth on Feb. 24 it is necessary for the vehicle to perform two dogleg maneuvers to the south. One begins BECO plus 8 seconds and the second begins at Centaur main engine start plus 4 seconds.

As the required equivalent flight azimuth changes from 130 to 115 degrees the amount of the dogleg maneuver decreases. Between 115 and 108 degrees, only one dogleg maneuver is necessary. Between 108 and 87 degrees a direct planar trajectory is possible and so no extra maneuver is needed.

Centaur Phase

At four minutes, 24 seconds into the flight, the Centaur's two RL-10 engines ignite (MES) for a planned seven minute, 15 second burn. This will place Centaur and the spacecraft on an interplanetary trajectory at a speed of about 24,768 mph. After MECO, the Centaur stage and spacecraft are reoriented with the Centaur attitude control thrusters to place the spacecraft on the proper trajectory after separation.

Separation

Separation of the Mariner spacecraft is achieved by firing explosive bolts on a V-shaped metal band holding the spacecraft to the adapter. Compressed springs then push the spacecraft away from the Centaur vehicle at a rate of 2.1 feet-per-second.

Retro Maneuver

Four and a half minutes after spacecraft separation, the Centaur stage attitude control thrusters are used to reorient the vehicle. The remaining liquid and gaseous propellants are then vented from a special tube in the base of the Centaur rocket.

The retro maneuver insures that there is no possibility of crashing into the planet and thereby violating the Martian quarantine restraint. The spent Centaur stage will go into a solar orbit.

Launch Window

The Mariner F launch window opens at approximately 7:54 p.m. EST on Feb. 24, and the Mariner G window at about 4:58 p.m. EST on March 24. In case of delays the window opens a few minutes earlier for the first few days and afterwards changes more rapidly. Each launch window is restricted to one hour.

TRACKING AND DATA SYSTEM

The Jet Propulsion Laboratory has been assigned by NASA the responsibility for establishing the ground-based facilities for supporting the Mariner Mars '69 project tracking and data acquisition requirements. These requirements cover launch vehicle and spacecraft telemetry; metric data involving the tracking of the launch vehicle by C-band radars and the M Mariner at S-band frequencies; sending of commands to the spacecraft; and real-time transmission of some of these data to the Space Flight Operations Facility (SFOF) at JPL in Pasadena, Calif.

The near-Earth trajectory requirements are met by selected facilities of the Air Force Eastern Test Range, including communications ships on the Atlantic, and the Goddard Space Flight Center managed networks. Tracking and communication with the spacecraft from injection into the transfer orbit to Mars until the end of the mission will be carried out by the Deep Space Network (DSN).

The DSN consists of nine permanent space communications stations on four continents; a spacecraft monitoring station at Cape Kennedy; the Space Flight Operations Facility at JPL; and uses a ground communications system linking all locations.

Permanent stations, placed strategically around the Earth, include four sites at the Goldstone Space Communications Complex in the Mojave Desert in California; two sites in Australia, at Woomera and at Tidbinbilla near Canberra; the Robledo and Cebreros stations near Madrid, Spain; and a station at Johannesburg, South Africa. Each is equipped with an 85-foot-diameter parabolic antenna, with the exception of the Mars Station at Goldstone (210-foot antenna). The spacecraft monitoring station at Cape Kennedy is equipped with a four-foot antenna.

The DSN is under the technical direction of JPL for NASA 's Office of Tracking and Data Acquisition. Its mission is to provide metric data (spacecraft velocity and range from Earth), receive telemetry from and send commands to unmanned planetary spacecraft and Sun-orbiting probes from the time they are injected into orbit until they complete their missions.

The ground communications system, used by the DSN for operational control and data transmission between the stations and the SFOF at JPL, is part of a larger network, NASCOM, which links all of NASA's stations around the world. NASCOM is under the technical direction of the Goddard Space Flight Center, Greenbelt, Md.

The Goldstone DSN stations are operated and maintained by JPL with the assistance of the Bendix Field Engineering Corp.

The Woomera and Tidbinbilla stations are operated by the Australian Department of Supply, Weapons Research Establishment.

The Johannesburg station is operated by the South African government through the National Institute for Telecommunications Research.

At Madrid, JPL operates one station under an agreement with the Spanish government and the support of Instituto Nacional de Tecnica Aerospacial (INTA) and the Bendix Field Engineering Co. Spain operates the second station.

The 1969 Mariner mission of two spacecraft to Mars will span a time period of about six months. The Deep Space Network is capable of monitoring both Mariner spacecraft on a near continual basis with overlapping station coverage during critical events.

Nerve center of the network is in the Space Flight Operations Facility at JPL. The overseas stations and Goldstone are linked to the SFOF by a communications network, allowing tracking and telemetry information to be sent there for analysis.

In addition to the giant antennas, each of the stations of the DSN is equipped with transmitting, receiving, data handling, and interstation communication equipment. Microwave frequencies (S-band) will be used in all communications with the Mariner spacecraft.

The Echo station at Goldstone, along with Woomera in Australia, Cebreros in Spain and Johannesburg in South Africa, will be primary stations for the mission. Each has a 10,000 watt transmitter. The Mars station at Goldstone, with its 210-foot antenna and 20,000 watt transmitter also will be used periodically during the mission, and extensively for receiving science data during planet encounter and playback portions of the mission.

A 30-foot antenna, operated by NASA's Manned Space Flight Network on Ascension Island in the South Atlantic, will provide coverage during the launch and injection portion of each of the two flights.

Metric data obtained immediately after liftoff and through the near-Earth phase will be computed at both the Real-Time Computer System, AFETR, Cape Kennedy and the Central Computing Facility in the SFOF so that accurate predictions can be sent to the DSN stations giving the locations of the Mariners in the sky when they appear on the horizon.

Scientific and engineering measurements radioed from the spacecraft are received at one of the stations, recorded on tape and simultaneously transmitted to the SFOF via high speed data lines and teletype. Incoming information is again recorded on magnetic tape and entered into the SFOF's computer system for processing.

Scientists and engineers seated at consoles in the SFOF have pushbutton control of the displayed information they require either on TV screens in the consoles or on projection screens and automatic plotters and printers. The processed information also is stored in the computer system disc file and is available on command.

The SFOF, designed for 24-hour-a-day functioning and equipped to handle multiple spaceflight missions concurrently, is manned by some 250 personnel of JPL and Bendix Field Engineering Corp., during critical events--launch, midcourse maneuver, planet encounter--of a Mariner mission.

In the SFOF's Mission Support Area (MSA), stations are set up for the project manager, operations director in charge of the mission, operations manager responsible for physical operation of the SFOF and three supporting technical teams--Space Science Analysis, Flight Path Analysis and Spacecraft Performance Analysis.

Space Science Analysis is responsible for evaluation of data from the scientific experiments aboard the spacecraft and for generation of commands controlling the experiments.

Flight Path Analysis is responsible for evaluation of tracking data, determination of flight path and generation of commands affecting the trajectory of the spacecraft.

Spacecraft Performance Analysis evaluates the condition of the spacecraft from engineering data radioed to Earth and generates commands to the spacecraft affecting its performance.

PROJECT TEAMS

Mariner And Atlas-Centaur Teams

NASA Headquarters, Washington, D.C.

Dr. John E. Naugle	Associate Administrator for Space Science and Applications
Oran W. Nicks	Deputy Associate Administrator for Space Science and Applications
Donald P. Hearth	Director, Lunar and Planetary Programs
Newton W. Cunningham	Mariner Program Manager
Joseph B. Mahon	Director, Launch Vehicle and Propulsion Programs
T. B. Norris	Centaur Program Manager

Jet Propulsion Laboratory, Pasadena, Calif.

Dr. William H. Pickering	Laboratory Director
Adm. John E. Clark	Deputy Laboratory Director
Robert J. Parks	Assistant Laboratory Director for Flight Projects
Harris M. Schurmeier	Mariner Project Manager
Gordon P. Kautz	Assistant Manager for Project Control
Henry W. Norris	Mariner Spacecraft System Manager
John R. Casani	Deputy Spacecraft System Manager
Victor C. Clarke	Mission Analysis and Engineering Manager
Dr. John A. Stallkamp	Project Scientist

William H. Bayley	Assistant Laboratory Director for Tracking and Data Acquisition
Dr. Nicholas A. Renzetti	Mariner Tracking and Data Systems Manager
Marshall S. Johnson	Mariner Mission Operations System Manager

<u>Lewis Research Center, Cleveland, O.</u>

Dr. Abe Silverstein	Director
Dr. S. C. Himmel	Assistant Director for Rockets and Vehicles
Edmund R. Jonash	Chief, Launch Vehicles Division
William R. Dunbar	Centaur Project Manager
Jerry D. Striebling	Mariner Mission Engineer

<u>Kennedy Space Center, Fla.</u>

Dr. Kurt R. Debus	Director, KSC
Robert H. Gray	Director, Unmanned Launch Operations
John J. Neilon	Deputy Director, Unmanned Launch Operations
John D. Gossett	Manager, Centaur Operations Branch

<u>Principal Science Investigators</u>

Dr. Robert B. Leighton California Institute of Tech.	Television
Dr. George C. Pimentel University of California, Berkeley	Infrared Spectrometer
Dr. Charles A. Barth University of Colorado	Ultraviolet Spectrometer
Dr. Gerry Neugebauer California Institute of Tech.	Infrared Radiometer
Dr. Arvydas J. Kliore Jet Propulsion Laboratory	S-Band Occultation
Dr. John D. Anderson Jet Propulsion Laboratory	Celestial Mechanics

Mariner Mars 1969 Subcontractors

Following is a list of some key subcontractors who provided instruments, hardware and services for the Mariner Mars 1969 Project:

Spacecraft Engineering Subsystem Contracts

Electro-Optical Systems Pasadena, Calif.	Power Subsystem
Honeywell, Inc. Minneapolis, Minn.	Attitude Control and Scan Subsystems
Litton Systems Inc. Guidance & Control Div. Woodland Hills, Calif.	Data Automation Subsystem
Motorola Government Electronics Div. Scottsdale, Ariz.	Command Subsystem Central Computer and Sequencer
Northrop Corp. Northrop Space Laboratories Hawthorne, Calif.	Engineering Mechanics Subsystem
Philco-Ford Corp. Space & Re-Entry Systems Div. Palo Alto, Calif.	Radio Subsystem
Texas Instruments, Inc. Apparatus Division Dallas, Texas	Telemetry Subsystem Data Storage Subsystem
TRW Systems Group Redondo Beach, Calif.	Propulsion Subsystem Temperature Control Flux Monitor

Science Instrument Contracts

University of California Space Science Laboratory Berkeley, Calif.	Infrared Spectrometer

1st Tier Subcontracts	
Philco-Ford Corp. Space & Re-Entry Systems Div. Palo Alto, Calif.	Electronics
Air Products & Chemicals, Inc. Advanced Products Department Allentown, Penn.	Cryostats
Boeing Corp. Space Systems Div. Seattle, Wash.	Pressure Vessels
Santa Barbara Research Center Goleta, Calif.	Detectors
University of Colorado Laboratory for Atmospheric & Space Physics Boulder, Colo.	Ultraviolet Spectrometer
1st Tier Subcontracts	
Packard Bell Electronics Corp. Space & Systems Division Newbury Park, Calif.	Electronics
Electro-Mechanical Research Inc. Princeton Division Princeton, N. J.	Photomultiplier Tubes
Santa Barbara Research Goleta, Calif.	Infrared Radiometer
Electro-Optical Systems Pasadena, Calif.	Television Electronics
General Electrodynamics Corp. Garland, Texas	Vidicon Tubes for Television
John H. Ranson Laboratories Los Angeles, Calif.	Fab and Test Optical Elements for Television Subsystem

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Other Subcontractors

ABR Pasadena, Calif.	Chassis, Subchassis and Miscellaneous Structural Components
Accessory Products Co. Div. of Textron Inc. Whittier, Calif.	Bladders for Propulsion Subsystem
Adloff and King Pasadena, Calif.	Plating
Air Borne Controls Inc. Sun Valley, Calif.	Operational Support Equipment (OSE) Cables
Almor Development Long Beach, Calif.	Cabling
Advanced Mechanical Components Van Nuys, Calif.	Machine Structural Components
Anadite Inc. South Gate, Calif.	Plating
Astrodata Anaheim, Calif.	T/M Input Module, 4612-1000 Computer, Data Input System, DIS Upgrade
A and T Engineering Burbank, Calif.	Machined Structural Components
Bendix Corporation Electrical Components Division Sidney, N. Y.	Connectors
Brown Metal Finish El Monte, Calif.	Polishing
Cinch Manufacturing Co. Chicago, Ill.	Connectors
Continental Test Lab Inc. Fern Park (Orlando), Fla.	Screening of Electronic Parts
Control Data Corporation Downey, Calif.	Lease General Purpose Digital Computer System and Ancillary Equipment for System Test Complex Data System

Data Science Corporation San Diego, Calif.	Magnetic Logic Modules for CC&S
Dickson Electronics Corp. Hollywood, Calif.	Zener Diodes
Dynamics Instr. Co. Monterey Park, Calif.	Limited Frequency Oscillators
Electric Storage Battery, Inc. Exide Missile & Electronics Div. Raleigh, N. C.	Spacecraft Batteries
Electronic Assemblers Inc. Sun Valley, Calif.	OSE Cables
Electronic Memories Inc. Hawthorne, Calif.	Core Memory Plane Fabrication for CC&S
Engineering Design and Development Pacoima, Calif.	Cables
Fairchild Semiconductor Mountain View, Calif.	Electronic Parts
Fibreform Electronics Los Angeles, Calif.	Chassis
First Plaza Company Mid-Continent Lab Inc. Lincoln, Nebr.	Screening of Electronic Parts
Helioteck A Division of Textron Electronics Sylmar, Calif.	Solar Cells
Hi-Shear Corporation Torrance, Calif.	Power Squib Cartridges
Holex Corporation Hollister, Calif.	Release Assemblies Release Devices and Cartridges
Informatics Inc. Los Angeles, Calif.	Software
Instrument Machine Co. South El Monte, Calif.	Pinpuller Body Assys

ITT Cannon Electric Co. Los Angeles, Calif.	Connectors
Joseph Alzibler Co. North Hollywood, Calif.	Machined Structural Components
Jutco Inc. Gardena, Calif.	OSE Cables
Kearfott Division General Precision Inc. Little Falls, N. J.	Gyroscopes, Pulse Sum to Analog Converter
LaRae Industries Los Angeles, Calif.	Chassis and Structural Supports
Lawrence Industries Burbank, Calif.	Circuit Boards
Lowell Observatory Flagstaff, Ariz.	Mars Polar Cap Studies
New Mexico State University Las Cruces, N. M.	Visual Imaging Observations of Mars
Omega Engineering Sun Valley, Calif.	Machined Structural Components
Optical Coating Lab Inc. Santa Rosa, Calif.	Microsheet Coverglass Filter for Solar Cells
Optics Tech. Inc. Palo Alto, Calif.	Modulation Transfer Function Bench
Pevrick Engineering Co., Inc. Burbank, Calif.	Machined Structural Components
Pierce Precision Sheet Metal Pasadena, Calif.	Sheet Metal Temperature Control Shields
Planning Research Corp. Los Angeles, Calif.	Software
PMP Tool & Eng. Company Sun Valley, Calif.	Thermoelectric Oven Subchassis
Prompt Machine Company Chatsworth, Calif.	Chassis

Protospec Pasadena, Calif.	Chassis
Pyronetics Inc. Santa Fe Springs, Calif.	IRS Cooling System Explosive Valve Assembly, Manifold Assemblies
Rosan Inc. Newport Beach, Calif.	Inserts and Bolts
Roselm Electronics Co. El Monte, Calif.	OSE Cables, Power Supplies
Sheffield Manufacturing Sun Valley, Calif.	Chassis and Subchassis
Sherman Corporation Inglewood, Calif.	Machined Structural Components
Signetics Corporation Sunnyvale, Calif.	Integrated Circuits
Skarda Manufacturing Co. El Monte, Calif.	Chassis
Skyline Components Canoga Park, Calif.	Handling Equipment
Teb Inc. Arcadia, Calif.	Machined Structural Components
Teledyne Precision Inc. Hawthorne, Calif.	Relays
Trans-Sonics Inc. Lexington, Mass.	Transducers
Wems, Inc. Hawthorne, Calif.	Bi-Polar Anabog-to-Pulse Width (A/pw) Converter Modules
Wilorco Long Beach, Calif.	Power Supplies
Wiltronics Monrovia, Calif.	OSE Cables
Whitehead Inc. Van Nuys, Calif.	Chassis & Subchassis

In addition to the above listed contracts and procurements, there were more than 500 individual firms contributing to Mariner Mars 1969 Project. Total procurements amounted to more than $76.6 million.

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