NEWS RELEASE

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MARINER SPACECRAFT

Mariner 2, the second of a series of spacecraft designed for planetary exploration, will be launched within a few days (no earlier than August 17) from the Atlantic Missile Range, Cape Canaveral, Florida, by the National Aeronautics and Space Administration.

Mariner 1, launched at 4:21 a.m. (EST) on July 22, 1962 from AMR, was destroyed by the Range Safety Officer after about 290 seconds of flight because of a deviation from the planned flight path.

Measures have been taken to correct the difficulties experienced in the Mariner 1 launch. These measures include a more rigorous checkout of the Atlas rate beacon and revision of the data editing equation. The data editing equation is designed as a guard against acceptance of faulty data by the ground guidance equipment.

The Mariner 2 spacecraft and its mission are identical to the first Mariner. Mariner 2 will carry six experiments. Two of these instruments, infrared and microwave radiometers, will make measurements at close range as Mariner 2 flys by Venus and communicate this information over an interplanetary distance of 36 million miles.

Four other experiments on the spacecraft -- a magnetometer, ion chamber and particle flux detector, cosmic dust detector and solar plasma spectrometer -- will gather information on interplantetary phenomena during the trip to Venus and in the vicinity of the planet.

Flight time will vary from 92 days to 117 days, depending on the launch date. The closest approach of Mariner to Venus will be about 10,000 miles. The overall flight distance will be approximately 191 million miles, based on an August 17 launch.

(over)

NASA assigned two launches for Mariner in 1962 because of the inherent difficulty of an interplanetary mission and to take advantage of the period this year during which Venus will be close to earth. The next launch opportunity for Venus will not occur for 19 months, in 1964.

Several factors make the Venus mission difficult -- the long flight time and the resultant demands in the spacecraft; subjecting of the spacecraft to a prolonged variation in temperature caused by the variation in distance from the sun and the increasing intensity of the sun; radiation effects in interplanetary space are not fully known; the problem of transmitting a considerable amount of information over an extreme range, and a complex trajectory problem.

Project Management for the Venus Mission was assigned to the California Institute of Technology Jet Propulsion Laboratory by the National Aeronautics and Space Administration. This includes responsibility for the spacecraft system and space flight operations. The Marshall Space Flight Center has the responsibility for providing the launch vehicle, with the support of the U.S.A.F. Space Systems Division. The Atlas D first stage is provided by General Dynamics Astronautics, and the Agena B second stage is provided by Lockheed Missiles and Space Company.

Key personnel in the Mariner Project are: Fred D. Kochendorfer, Mariner Program Chief, NASA Headquarters; D. L. Forsythe, Agena Program Chief; Roberts J. Parks, Planetary Program Director for JPL; J. N. James, JPL, Mariner Project Manager; W. A. Collier, JPL, Assistant Project Manager; Dan Schneiderman, JPL, Spacecraft System Manager; Friedrich Duerr, MSFC, Launch Vehicle Systems Manager; Major J. G. Albert, Mariner Launch Vehicle Director for AFSSD; and H. T. Luskin, Director for NASA Programs, Lockheed Missiles and Space Company.

Mariner tracking and communication will be provided by JPL's Deep Space Instrumentation Facility with permanent stations at Goldstone, California, Woomera, Australia, and Johannesburg, South Africa and mobile stations at Cape Canaveral and near the permanent station at Johannesburg. Data flowing into these stations from the spacecraft will be routed to JPL's Spacecraft Flight Operations Center for correlation by an IBM 7090 computer system.

SPACECRAFT DESCRIPTION

The Mariner weighs 447 pounds and, in the launch position, is five feet-in-diameter at the base and 9 feet, 11 inches in height. In the cruise position, with solar panels and high-gain antenna extended, it is 16.5 feet across in span and 11 feet, 11 inches in height.

The design is a variation of the hexagonal concept used for the Ranger series. The hexagon framework base houses a liquid-fuel rocket motor, for trajectory correction, and six modules containing the attitude control system, electronic circuitry for the scientific experiments, power supply, battery and charger, data encoder and command subsystem, digital computer and sequencer, and radio transmitter and receiver. Sun sensors and attitude control jets are mounted on the exterior of the base hexagon.

A tubular superstructure extends upward from the base hexagon. Scientific experiments are attached to this framework. An omnidirectional antenna is mounted at the peak of the superstructure. A parabolic, high-gain antenna is hinge-mounted below the base hexagon. Two solar panels are also hinged to the base hexagon. They fold up alongside the spacecraft during launch, parking orbit and injection and are folded down, like butterfly wings, when the craft is in space. A command antenna for receiving transmission from earth is mounted on one of the panels.

The solar panels contain 9800 solar cells in 27 square feet of area. They will collect energy from the sun and convert it into electrical power at a minimum of 148 watts and a maximum of 222 watts. The amount of power available from the panels is expected to increase slightly during the mission due to the increased intensity of the sun. Each solar cell has a protective glass filter that reduces the amount of heat absorbed from the sun, but does not interfere with the energy conversion process. The glass covers filter out the sun's ultraviolet and infrared radiation that would produce heat but not electrical energy.

Prior to deployment of the solar panels, power will be supplied by a 33.3-pound silver-zinc rechargeable battery with a capacity of 1000 watt hours. The recharge capability is used to meet the long-term power requirements of the Venus Mission. The battery will supply power directly for switching and sharing peak-loads with the solar panels and also supply power during trajectory correction when the panels will not be directed at the sun.

The power subsystem will convert electricity from the solar panels and battery to 50 volt, 2400 cps; 26 volt, 400 cps, and 25.8 to 33.3 volt DC.

Two-way communication aboard the Mariner is supplied by the receiver/transmitter, two transmitting antennas: the omnidirectional and high-gain antenna; and the command antenna for receiving instructions from earth. Transmitting power will be 3 watts.

The high-gain antenna is hinged and equipped with a drive mechanism allowing it to be pointed at the earth on command. An earth sensor is mounted on the antenna yoke near the rim of the high-gain dish-shaped antenna to search for and keep the antenna pointed at the earth.

Stabilization of the spacecraft for yaw, pitch and roll, is provided by ten cold gas jets, mounted in four locations (3,3,2,2,), fed by two titanium bottles containing 4.3 pounds of nitrogen gas pressurized to 3500 PSI. The jets are linked by logic circuitry to three gyros in the attitude control subsystem, to the earth sensor on the parabolic antenna and to six sun sensors mounted on the spacecraft frame and on the back of the two solar panels.

The four primary sun sensors are mounted on four of the six legs of the hexagon, and the two secondary sensors on the backs of the solar panels. These are light-sensitive diodes which inform the attitude control system--gas jets and gyros--when they seen the sun. The attitude control system responds to these signals by turning the spacecraft and pointing the longitudinal or roll axis, toward the sun. Torquing of the spacecraft for these maneuvers is provided by the cold gas jets fed by the nitrogen gas regulated to 15 pounds per square inch pressure. There is calculated to be enough nitrogen to operate the gas jets to maintain attitude control for a minimum of 200 days.

Computation for the subsystems and the issuance of commands is a function of the digital Central Computer and Sequencer. All events of the spacecraft are contained in three CC&S sequences. The launch sequence controls events from launch through the cruise mode. The midcourse propulsion sequence controls the midcourse trajectory correction maneuver. The encounter sequence provides required commands for data collection in the vicinity of Venus.

The CC&S provides the basic timing for the spacecraft subsystems. This time base will be supplied by a crystal control oscillator in the CC&S operating at 307.2 kc. This is divided down to 38.4 kc for timing in the power subsystem and divided down again to 2400 and 400 cps for use by various subsystems. The control oscillator provides the basic "counting" rate for the CC&S to determine issuance of commands at the right time in the three CC&S sequences.

The subsystems clustered around the base of the spacecraft are insulated from the sun's heat by a shield covered with layers of aluminum coated plastic film. At the bottom of the spacecraft, just below the subsystem modules, is a second Temperature Control Shield. It prevents too rapid loss of heat into space which would make the establishment of required temperatures difficult to maintain. The two shields form a sandwich that helps to minimize the heat control problem.

Temperature control of the attitude control subsystem is provided by louvers actuated by coiled bimetallic strips. The strips act as coil springs that expand and contract as they heat and cool. This mechanical action opens and closes the louvers. The louvers are vertical on the face of the attitude control box and regulate the amount of heat flowing into space. This is a critical area as some of the equipment may not function properly about 130° F.

Paint patterns, aluminum sheet, thin gold plate, and polished aluminum surfaces are used on the Mariner for passive control of internal temperatures. These surfaces control both the amount of internal heat dissipated into space and the amount of solar heat reflected away, allowing the establishment of temperature limits. The patterns were determined from testing of a Temperature Control Mode. The TCM was subjected to the variations of temperature anticipated in the Venus Mission in a space simulation chamber at JPL.

Communication with the spacecraft will be in digital form. The command sybsystem aboard the Mariner will decode incoming digital commands and send them to the designated subsystems. Data from engineering and scientific sources will be encoded to digital form for transmission to earth.

Synchronizing pulses will be spaced at regular intervals between the data signals from Mariner. Ground bases receiving equipment will generate identical pulses and match them with the pulses from the spacecraft. This will provide a reference to determine the location of the data signals allowing receiving equipment to separate data signals from noise.

MISSION DESCRIPTION

The launch vehicle for the Mariner will be an Atlas D-Agena B. The Atlas and the Agena will boost Mariner to an altitude of 115 statute miles and an orbital speed of 18,000 miles an hour.

Mariner will use the parking orbit technique which is a means by which the geometry imposed on a Venus launch by the location of the Atlantic Missile Range at Cape Canaveral, Florida, is corrected by using the second-stage rocket as a mobile launching platform in space.

During the launch phase, the Mariner spacecraft is protected against aerodynamic heating by a shroud. After Atlas cutoff, approximately five minutes after liftoff, the shroud is jettisoned by eight spring-loaded bolts which shove it ahead of the vehicle. At almost the same time, the Agena B separates from the Atlas. The Agena B then pitches down from an attitude almost 15 degrees above the local horizon to almost level with the local horizon.

In this horizontal attitude the Agena B fires for the first time and burns for almost two and a half minutes to reach orbital speed of about 18,000 miles an hour. After this burning time, Agena B shuts down and coasts in a parking orbit for more than 13 minutes until it reaches the optimum point in time and space in its orbit to fire for the second time.

The second Agena B burn injects the Agena B and Mariner, still as one unit, on an escape trajectory at 25,700 miles an hour. Injection occurs approximately over Ascension Island in the South Atlantic Ocean and approximately 23 to 34 minutes after launch, depending on time of launch.

A little more than two minutes after second burn cutoff or injection, Mariner is separated from Agena, again by spring-loaded bolts. Agena then yaws 140 degrees in the local horizontal plane and performs a retro maneuver which reduces the Agena velocity and moves the Agena into a different trajectory. Propulsion for the retro maneuver is provided by ejecting the unused fuel on the Agena through small jets. The retro maneuver serves two purposes: to prevent the Agena from impacting Venus, and if Agena B follows Mariner too closely, the spacecraft optical sensors might mistake reflected sunlight from Agena B for the sun or earth and confuse its acquisition system.

Separation from the Agena will cause the Mariner to begin a tumbling motion. These residual separation rates are cancelled out by the yaw, pitch and roll gyros acting on the gas jet stabilization system.

Mariner now is on a trajectory that will take it fairly close to Venus. The omnidirectional antenna is working and radiating the radio transmitter's full three watts of power. Before and during launch, the transmitter had been kept at about 1.1 watts. This is required during the period the launch vehicle passes through a critical area between 150,000 and 250,000 feet, where a tendency exists for devices using high voltage to arc over and damage themselves; hence, the transmitter is kept at reduced power until this area is passed.

Following is the sequence of events that Mariner will conduct on its flight to Venus.

The first command is issued by the CC&S 44 minutes after launch. Explosive pin pullers holding the solar panels and the radiometer in their launch position are detonated to allow the spring-loaded solar panels to open and assume their cruise position and free the radiometer to scan Venus as it passes by the spacecraft. Although the radiometer will not function until Venus encounter, it is convenient to unlock it at this point.

At launch plus 60 minutes, the CC&S turns on the attitude control system and the sun acquisition mode will begin. The sun sensors, linked to the valves controlling the gas jets, jockey the spacecraft about until its long axis is pointed at the sun thus aligning the solar panels with the sun. Both the gyros and the sun sensors can activate the gas jet valves. A backup radio command capability is provided to initiate the CC&S function and sun acquisition.

In order to conserve gas, the attitude control system permits a pointing error toward the sun of one degree, or .5 degree on each side of dead on. The mixing network in the attitude control system is calibrated to keep Mariner slowly swinging through this one degree of arc pointed at the sun. The swing takes approximately 60 minutes. As Mariner nears the .5 degree limit on one side, the sensors signal the gas jets and they fire again. This process is repeated hourly through the effective life of Mariner. It is calculated that the gas jets will fire one-fiftieth of a second each 60 minutes to keep the spacecraft's solar panels pointed at the sun. When the sun has been acquired, the gyros are turned off to conserve their life and to lower the power demanded of the solar panels.

The sun acquisition process is excepted to take less than 30 minutes. When it is completed, the secondary sun sensors on the backs of the solar panels are turned off to avoid having light from the earth confuse them.

As soon as the solar panels are locked on the sun, the power system will begin drawing electric power from the panels. The battery will now only supply power in the event of a peak demand that the panels cannot handle. Excess power from the solar panels will be utilized to recharge the battery.

The next event initiated by the CC&S is the acquisition of earth by the high gain directional antenna. This does not occur, however, until 167 hours (seven days) after launch. The earth sensor used to align the antenna is so sensitive that it would not operate properly if used earlier. Once again, a radio command capability is provided to back up the initiation of this event.

During earth acquisition, the spacecraft maintains its lock on the sun, but with its high-gain directional antenna pointed at a preset angle, it rolls on its long axis and starts to look for the earth. It does this by means of the three-section, photo-multiplier-tube operated earth sensor mounted on and aligned with the high-gain antenna. During the roll, the earth sensor will see the earth and inform the gas jets. The jets will fire to keep the earth in view of the sensor and thus lock onto the earth. The sensor has a lens system to magnify the earth image.

The spacecraft now is stabilized on two-axes--the solar panel-sun axis and the earth-directional antenna axis. There is some danger that the earth sensor, during its search for the earth, may see the moon and lock onto that, but telemetry later will inform earth stations if this has occurred, and Goldstone has the ability to send an override command to the attitude control system to tell it to look again for the earth. If this is not sufficient, the stations can send a hinge override command to change the hinge angle and then order another roll search. When the earth is acquired, the transmitter stops transmitting on the omni-antenna and starts transmitting on the high-gain antenna.

A rise in signal strength will be an indication that earth acquisition has been achieved by the parabolic antenna. Positive proof will be afforded by analysis of telemetry to determine the angle of the antenna hinge.

With sun and earth acquisition achieved, Mariner is now in its cruise mode.

The cruise mode will continue until time for the midcourse trajectory correction maneuver. After launch, most of the activity on the Venus Mission will be centered at the DSIF stations and at the Space Flight Operations Center at JPL.

Tracking data collected by the DSIF stations will be sent to JPL and fed into the 7090 computer system. The computer will compare the actual trajectory of the Mariner with the course required to yield a 10,000 mile fly-by. If guidance errors before injection have put Mariner off the optimum trajectory, the computer will provide the necessary figures to command the spacecraft to alter its trajectory. This involves commands for roll, pitch and motor burn. Roll and pitch point Mariner for the trajectory correction. Motor burn will provide the additional velocity required to change direction.

The first command from Goldstone will give the direction and amount of roll required, the second will give the direction and amount of pitch needed and the third will give the amount of velocity increment needed. this data is stored in the CC&S until Goldstone transmits a "go" command.

Prior to the "go" command, Goldstone will have ordered Mariner's transmitter to switch from the dish-shaped directional antenna, at the base of the craft, to the omni-directional antenna mounted at the peak of the super-structure.

Commands preprogrammed in the CC&S for the midcourse sequence initiate the following: the earth sensor, mounted on the dish-shaped antenna, is turned off; the hinged-mounted directional antenna itself is moved out of the path of the midcourse motor's exhaust, and the gyros will have been turned on an hour earlier to warm up. During the maneuver the gyros will inform the attitude control subsystem of the rate of pitch and roll as they occur for reference against the orders from earth. A pulse balanced accelerometer will be turned on to provide acceleration rates during motor burn to the CC&S. Each pulse from the accelerometer represents a velocity increment of 0.03 meters per second.

The roll maneuver requires a maximum of 12 minutes of time, including two minutes of settling time, and the pitch maneuver requires a maximum of 22 minutes. When these are completed, the midcourse motor is turned on and burns for the commanded time. As the attitude control gas jets are not powerful enough to maintain the stability of the spacecraft during the propulsion phase of the midcourse maneuver, moveable jet vanes extending into the exhaust of the midcourse motor controls the attitude of the spacecraft in this period.

The jet vanes are controlled by an auto pilot subsystem in the attitude control system that functions only during the midcourse maneuver. The auto pilot accepts information from the gyros to direct the thrust of the motor through the spacecraft's center or gravity to stabilize the craft.

The liquid monopropellant motor weighs, with fuel and the nitrogen pressure gas system, 37.3 pounds. Hydrazine fuel is held in a rubber bladder inside a doorknob-shaped container called the pressure dome. On the command to fire, nitrogen under 3000 pounds of pressure per square inch, is admitted inside the pressure dome and squeezes the rubber bladder, forcing the fuel into a combustion chamber.

Because hydrazine is a monopropellant, it needs a starting fluid to initiate combustion and a catalyst to maintain combustion. The starting fluid, in this case nitrogen tetroxide, is admitted into the combustion chamber by means of a pressurized cartridge and causes ignition. The catalyst, aluminum oxide pellets, is stored in the combustion chamber. Burning stops when the valves turn off nitrogen pressure and fuel flow.

The midcourse motor is so precise that it can burn in bursts of as little as 50 milliseconds and can increase velocity by as little as seven-tenths of a foot per second or as much as 187 feet per second. It has a thrust of 50 pounds for a maximum of 57 seconds.

After the midcourse maneuver has put Mariner on the desired trajectory, the spacecraft again goes trhough the sun and earth acquisition modes.

During midcourse Mariner has been transmitting through the omni-antenna. When earth is acquired, the transmitter is switched to the high-gain directional antenna. This antenna will be used for the duration of the flight.

Mariner will continue in the cruise mode until planet encounter. During this period, tracking data from the three permanent DSIF stations will be sent to JPL where the 7090 computer system will refine the earlier calculations for planet encounter made at launch.

The CC&S was programmed to begin the encounter sequence ten hours in advance of encounter. This allows time for calibration of the planetary encounter scientific instruments before encounter in the event that the spacecraft might fail to perform the midcourse trajectory correction. If this should occur, then the predicted encounter time could vary in time up to ten hours.

Under any circumstances, the tracking-computer system has the capability of predicting the time of encounter to within 15 minutes.

At the ten hour period the CC&S will switch out the engineering data sources, leaving on the interplanetary science experiments, and turn on the two planetary experiments. During the fly-by, only scientific data will be collected and transmitted.

The radiometer will begin a fast search wide scan until Venus is sensed and then go into a slow scan. The planetary experiments will collect data on Venus for a half an hour as Mariner passes the planet.

The encounter mode of transmission--scientific data only--will continue 56.7 hours after encounter. At the end of this period the CC&S will switch on the engineering data sources and, again in the cruise mode, both engineering and interplanetary scientific data will be transmitted.

MARINER SCIENTIFIC EXPERIMENTS

EXPERIMENTS	DESCRIPTION	EXPERIMENTERS
Microwave Radiometer	Determine the temperature of the planet surface and details concerning its atmosphere.	Dr. A.H. Barret, Massachusetts Institute of Technology; D. E. Jones, JPL; Dr. J. Copeland, Army Ordnance Missile Command; Dr. A. E. Lilley, Harvard College Observatory.
Infrared Radiometer	Determine any fine structure of the cloud layer.	Dr. L. D. Kaplan, JPL and University of Nevada; Dr. G. Neugebauer, JPL; Dr. C. Sagan, University of California at Berkeley.
Magnetometer	Measure changes in the planetary and interplanetary magnetic fields.	P. J. Coleman, NASA; Dr. L. Davis, Caltech; Dr. E. J. Smith, JPL; Dr. C. P. Sonett, NASA.
Ion Chamber and Particle Flux Detector	Measure charged-particle intensity and distribution in interplanetary space and in the vicinity of the planet.	Dr. H. R. Anderson, JPL; Dr. H. V. Neher, Caltech; Dr. J. Van Allen, State University of Iowa.
Cosmic Dust Detector	Measure the density and direction of cosmic dust.	W. M. Alexander, NASA Goddard Space Flight Center.
Solar Plasma Spectrometer	Measure the intensity of low energy protons from the sun.	M. Neugebauer, and Dr. C. W. Snyder, JPL.

MARINER SCIENTIFIC EXPERIMENTS

The Mariner spacecraft contains six scientific experiments representing the efforts of scientists at nine institutions: The Army Ordnance Missile Command, the California Institute of Technology, the Goddard Space Flight Center, Harvard College Observatory, the Jet Propulsion Laboratory, the Massachusetts Institute of Technology, the State University of Iowa, the State University of Nevada, and the University of California at Berkeley.

The two planetary experiments are a microwave radiometer and an infrared radiometer. They will operate during a period of 30 minutes at distances ranging from approximately 23,400 miles to 14,000 miles as Mariner approaches Venus. These radiometers will obtain information about the planet's temperature and atmosphere.

The other experiments will make scientific measurements during the cruise through interplanetary space and in the near vicinity of Venus. They are a magnetometer, charged particle detectors, including an ionization chamber and several Geiger-Mueller counters; a cosmic dust detector; and a solar plasma detector.

One of the important considerations in choosing these experiments was the compromise between what scientists would like to measure during the mission, and what was technologically possible. For example, of the 447 pounds that could be placed in a trajectory to intercept Venus, only about 41 pounds could be allocated to scientific experiments.

Another restricting factor is time. Venus is in a favorable position for investigation by a Mariner-type spacecraft only during a few weeks period every 19 months.

In addition, scientists will ask Mariner to convert electrical power from the sunlight, report its findings from as far as 36 million miles, and, though sensitive and unattended, remain in precise working order for three to five months in the void of space.

Although Venus is our closest planetary neighbor there are many things about it that remain a mystery. Its surface is continually hidden under a mask of dense clouds impenetrable in the small region of the electromagnetic spectrum visible to the eye. Spectrographic observations (identification of materials according to the manner in which they absorb and emit light) suggest that the atmosphere of Venus contains carbon dioxide, but has probably little free oxygen or water vapor.

Earth-based temperature measurements have been made of Venus in the microwave and infrared regions of the electromagnetic spectrum. The former indicates near surface temperatures of about 615 degrees Fahrenheit, while the latter shows readings of minus 38 degrees Fahrenheit in the upper atmosphere. Because of the tremendous distances over which these measurements were made scientists cannot be sure of the exact altitude in the atmosphere where these temperature readings apply.

As a result of the fragmentary information about Venus, several theories have been proposed that attempt to explain the nature of the atmosphere and the reason for the wide range of temperatures measured.

Some scientists believe that because of the carbon dioxide in the atmospher a "greenhouse" effect is created that holds most of the heat absorbed from the sun beneath the thick blanket of clouds. This theory relies on the assumption that water vapor is present in the atmosphere of Venus.

Other scientists say that Venus has an ionosphere with an electron density thousands of times that of the earth. If this is the case this layer of electrons could easily mislead scientists measuring temperatures of Venus from earth.

Another theory states that Venus is heated by friction produced by high winds and dust clouds.

There are still other theories that describe Venus as a swamp, a desert covered with oil and smog, and containing carbonated water.

One of the missions of the Mariner spacecraft will be to make several scientific measurements of the planet which may substantiate one of these theories, or call for the formulation of a new one.

During the cruise and encounter of Venus, the Mariner will be telemetering information to earth. As the sensors of the six experiments receive information they feed it to a data conditioning system (DCS), which is located in one of the modules in the hexagonal base of the spacecraft. The DCS prepares information from the experiments for transmission to earth in the form of a digital code.

Since all of the data collected by Mariner cannot be transmitted at the same time, an electronic clock has been built into the DCS. This clock controls the equipment so that the receiver "listens" to one experiment at a time for about one second. After 20.16 seconds the DCS switches off the scientific telemetry and starts to send spacecraft engineering data for 16.8 seconds. This cycle is continued during the cruise in interplanetary space.

Beginning at ten hours before it passes Venus, however, the spacecraft devotes its telemetry system to the full-time transmission of scientific information from its six experiments.

The integration of the scientific experiments and the generation of a number of the experiments was carried out at JPL under the direction of Dr. M. Eimer. JPL project scientist was R. C. Wyckoff and J. S. Martin was responsible for the engineering of scientific experiments.

THE EXPERIMENTS:

MICROWAVE RADIOMETER

This experiment should help to resolve two vital questions about Venus: what is the atmosphere like, and what is the temperature of the surface.

As the Mariner spacecraft flies past Venus, the microwave radiometer will scan its surface to detect electromagnetic radiation at two wave lengths, 13.5 and

19 millimeters. In the electromagnetic spectrum 13.5mm is the location of a microwave water absorption band. If there is water vapor above certain minimal concentration in the atmosphere it will be possible to detect it.

The 19mm wave length, however, is not affected by water vapor, and should be capable of "seeing" through the atmosphere to the surface.

Scientists studying the results of this experiment will be able to determine whether water vapor exists in the Venusian atmosphere by noting the difference in temperatures obtained from measurements at the two wave lengths.

The 19mm wave length, in addition to measuring the surface temperature may be able to test two of the theories about the atmosphere of Venus by detecting one of two conditions called "limb brightening" or "limb darkening."

The former effect may be detected if the apparent high temperatures are due to a dense ionosphere. As the microwave radiometer scans the planet it would detect larger concentrations of electrons around the limb or edge of the planetary disk. This is somewhat analogous to looking at the earth from thousands of miles out in space on a day when it was completely covered with a fine mist. The mist would be more evident at the limbs than in the center, since the observer would be looking through a thicker concentration of the mist at the limb. In much the same way, the microwave radiometer would detect effects of greater intensity around the limb of Venus. On the other hand, limb darkening would indicate that the high temperatures originate from the surface. In this case a limb-to-limb scan would show a gradual increase and decrease of temperature readings.

The microwave radiometer is mounted on the hexagonal base of the Mariner. Both wave lengths are detected by a parabolic antenna that is 20 inches in diameter and three inches deep.

At ten hours prior to Venus encounter the radiometer is turned on. Driven by an electric motor it starts a scanning or nodding motion of 120 degrees at the rate of one degree per second. When its signals determine that it has acquired the planet the DCS sends a command to slow the scan rate to 1/10 of a degree per second.

In order to confine its attention to the planet's disk, a special command system has been built into the DCS. Whenever the radiometer indicates that it has reached the limb and is about to look out into space, the DCS reverses the direction of the scan.

In this mode it scans Venus for about 30 minutes. Since the spacecraft will be going roughly in the direction of the sun, the radiometer will first scan part of the dark side of Venus and then part of the sunlit side.

The microwave antenna is only capable of moving in a nodding motion. Lateral movement is provided by the motion of the spacecraft across the face of the planet.

As the radiated microwave energy is collected by the parabolic antenna it is focused onto a receiving horn located opposite the face of the antenna on a quadripod. The energy from both wave lengths travel down two hollow legs of the quadripod called wave guides.

Located on top of the antenna are two reference horns that are matched to receive the same two microwave bands as the parabolic antenna. These horns point at an angle of 60 degrees away from the axis of the dish antenna, and consequently are always looking at empty space.

The signals from the dish antenna and the reference horns are alternated or chopped electronically. Then they are sent to a crystal video type receiver located behind the dish antenna. Thus, this receiver measures the difference between the signals from Venus and the reference signals from space.

This information is then telemetered to earth.

The microwave radiometer weighs 23.8 pounds and requires 3.5 watts of power when operating, and 8.9 watts during calibration. The calibration sequences are automatically initiated by the DCS a number of times during the mission.

Experimenters on the microwave radiometer are Dr. A. H. Barrett, Massachusetts Institute of Technology, Dr. J. Copeland, Army Ordnance Missile Command, D. E. Jones, Jet Propulsion Laboratory, and Dr. A. E. Lilley, Harvard College Observatory.

INFRARED RADIOMETER

This is a companion experiment to the microwave radiometer. As the Mariner spacecraft flies past Venus simultaneous measurements from the two experiments will enable scientists to get a better idea of the temperature and atmospheric conditions of the planet.

The infrared radiometer is rigidly attached to the microwave antenna. In this way both scan the same surface areas of Venus.

The infrared experiment operates in the 8 to 9 and the 10 to 10.8 micron wave length regions of the electromagnetic spectrum.

Measurements from earth in these two wave lengths indicate temperatures below zero. It is not clear to scientists whether all of this radiation comes from the cloud tops, or whether some of it eminates from the atmosphere or planetary surface.

The close approach of Mariner to Venus may enable scientists to measure some of the finer details of the atmosphere. This will primarily involve finding out if there are any "breaks" in the cloud cover of Venus, and if so, the amount of heat that escapes through them into space. For many years some astronomers have been able to see occasionally some kind of markings on Venus' cloud cover that change with no apparent regularity. The lack of regularity in these markings has left their nature in doubt.

If these markings are indeed cloud breaks, they will stand out with greater contrast in the infrared than if observed in the visible part of the spectrum. If the radiant energy detected by this experiment comes from the cloud top, and there are no breaks, then the temperatures obtained at both infrared wave lengths will follow a similar pattern.

If there are appreciable breaks in the clouds a substantial difference will be detected between measurements at the two wave lengths.

The reason for this is that in the 8 to 9 micron region the atmosphere is transparent, (except for clouds). In the 10 to 10.8 micron region, the lower atmosphere is hidden b the presence of carbon dioxide. Through a cloud break the former would penetrate to a much lower point in the atmosphere. By a comparison of temperatures from both regions, combined with microwave data, scientists will have a more detailed picture of conditions on Venus.

The infrared radiometer is six inches long and two inches wide. It weighs 2.7 pounds and consumes two watts of power.

It contains two optical sensors, one of which scans the surface of Venus while the other obtains reference readings from space. The latter is aimed at an angle of 45 degrees away from the planetary scanner.

Radiation from Venus is collected by two f/2.4 optical systems with three inch focal lengths. As the infrared energy enters the optical system it first passes through a rotating disk with two apertures. These are positioned so that the two sensing devices can alternately see Venus and empty space. The infrared beam is chopped in this way at the rate of 20 cycles per second.

After the beam passes the disk, it is split by a dichroic filter into the two wave length regions. A second pair of filters further refines these wave lengths before they reach the radiometers sensing devices. The sensing devices are two thermistor bolometers, which are sensitive to infrared energy. The electrical output from these detectors is amplified and sent to the Mariner's DCS for processing and transmission to earth.

Experimenters on the infrared radiometer are Dr. L. D. Kaplan, and Dr. G. Neugebauer, of the Jet Propulsion Laboratory, and Dr. C. Sagan, of the University of California at Berkeley.

MAGNETOMETER

The magnetometer aboard Mariner is designed to measure the strength and direction of interplanetary and Venusian magnetic fields.

Many scientists believe that the magnetic field of a planet is due to a fluid motion in its interior. If such a Venusian field exists then it could be detected as Mariner approached the planet. This would depend, of course, on the strength of the field and the distance of Mariner at encounter. Also the trajectory of Mariner will permit the measurement of interplanetary magnetic fields and any variation with respect to time and distance from the sun.

Present-day theories of magnetohydrodynamics--the study of the relation between the motion of charged particles and the magnetic field which surrounds them say that the plasma which flows away from the sun should drag with it the local solar magnetic field, since the motion of charged particles not only responds to but also creates magnetic fields. The mathematical description of this interaction between the stream of charged particles leaving th sun and the magnetic field which surrounds the sun is extremely complicated. The theories which have been used to describe these phenomena are incomplete and often contradictory.

The measurement of interplanetary magnetic fields by Mariner will be combined with simultaneous measurements from earth to help scientists understand something about the inter-relationships of these fields.

Moreover, by investigating the magnitude of any Venusian field it may be possible to draw some conclusion about the interior of the planet, as well as about planetary radiation belts, magnetic storms, and aurorae.

The magnetometer is a three axis fluxgate type. The sensors of the experiment are housed in a metal cylinder six inches long and three inches in diameter. It is located just below the Mariner's omnidirectional antenna. In this way the sensors are as far away as possible from any spacecraft components that may have magnetic fields associated with them.

Inside the cylinder are three mu-metal tubes, each alligned along a different axis. Each tube has two windings of copper wire around it, much the same as some transformers. The primary winding leads from a frequency oscillator which produces a current. The secondary winding leads to an amplifier.

In the absence of a magnetic field the current induced in the secondary winding has a special symmetrical wave shape. The presence of a magnetic field changes the symmetry of this wave and produces a component with amplitude in proportion to the field strength. A third winding around the rods prevents magnetic interference from the spacecraft. This renders the three axis of the instrument sensitive to $\frac{1}{2}$ gamma, or a field strength roughly 100,000 times weaker than that of the earth.

The magnetometer weighs 4.7 pounds and consumes six watts of power.

Experimenters are P. J. Coleman and Dr. C. P. Sonett of the National Aeronautics and Space Administration, and Dr. L. Davis and Dr. E. J. Smith of JPL.

HIGH ENERGY RADIATION EXPERIMENT

This experiment consists of an ionization chamber and a group of three Geiger-Mueller tubes. Together they will measure the number and intensity of energetic particles in interplanetary space and near Venus.

These particles are primarily cosmic rays, which are made up of protons (the nuclei of hydrogen atoms), alpha particles (the nuclei of helium atoms), the nuclei of heavier atoms, and electrons.

The measurement of these particles may contribute significantly to the knowledge of hazards to manned space flight.

Scientists have theorized that the sun has a pronounced effect on cosmic rays. During solar activity (sun spots or flares), for example, huge quantities of plasma race outward from the sun. These plasma clouds, or solar wind, carry along magnetic fields. In a rather complicated manner, not fully understood by scientists the plasma's magnetic fields interact with those of the sun and planets. Scientists have noticed that following this solar activity, there is a considerable change in the character of the radiation that reaches the earth.

Unfortunately, because of our atmosphere and magnetic field, we cannot measure all of these complicated inter-relationships from earth. We must take measurements from spacecraft traveling far from the earth. In this way we may learn something about the sun's influence on radiation.

A decrease in the number and intensity of cosmic radiation detected as we go closer to the sun would indicate that the sun's magnetic field is deflecting cosmic rays away from the solar system.

Thus by comparing the intensity of magnetic fields, with the amount of cosmic radiation at earth, Venus, and in interplanetary space, some insight may be gained to these complicated inter-relationships.

The ionization chamber is of the Neher type. It consists of a five-inch-in-diameter stainless steel shell with a wall thickness of 1/100 of an inch. The sphere is filled with argon gas and is located on the superstructure of Mariner. Inside the sphere a quartz fibre is placed next to a quartz rod. Initially, both fibre and rod have the same electric potential.

As charged particles penetrate the wall of the sphere they leave behind a wake of ions in the argon gas. Negative ions accumulate on the rod, giving it a static electric charge. This causes the bibre to be attracted to the rod in proportion to the amount of the charge. Eventually, as the charge increases the two touch. This produces an electric pulse which is amplified and sent to earth. The rod is recharged, and the fibre returns to its starting position.

In order to penetrate the wall of the ionization chamber, particles must have an energy greater than 10 million electron volts (Mev) for protons, $\frac{1}{2}$ Mev for electrons, and 40 Mev for alpha particles.

This instrument measures the rate of ionization of cosmic rays.

Two of the GM tubes are considered companion instruments to the ionization chamber. They can be directly penetrated by particles above the same energy levels as the chamber, and can count these particles.

Both tubes consist of an enclosed volume of gas with two electrodes, at a different electrical potential. The wall of the tubes serve as the negative electrode and a thin central wire is the positive electrode. The tubes generate a current pulse each time a charged particle enters.

The second tube has a beryllium shield 24/1000 of an inch thick. Both tubes are 2.3 inches long and .6 of an inch in diameter. Because of the difference in shiel it will be possible for scientists to infer the ratio of electrons to other particles. These two GM counters along with the ionization chamber make it possible for scientists to measure the flux (velocity times the density) and the average amount of ionization of particles.

A third GM sensor is of the end window type. It measures the flux of particles not capable of penetrating th other detectors. The window is made of mica and admits protons with energies greater than one Mev, electrons over 40 thousand electronvolts.

A magnesium shield around the rest of the GM tube permits passage of protons over 20 Mev and electrons over 1 Mev. This gives the counter the ability to determine the approximate direction of particles which penetrate only the window.

The GM detectors are mounted on the superstructure of the spacecraft where they will be as far as possible from large masses that tend to produce secondary particles when struck by cosmic rays.

The three GM tubes protrude from a box that houses their electronic circuitry. The box is six inches wide, six inches long and two inches thick. The end window GM tube is inclined at an angle of 20° from the other two tubes.

The total weight of both experiments is 2.78 pounds and they consume 4/10 of a watt.

Experimenters are Dr. H. R. Anderson of JPL, Dr. H. V. Neher of Caltech, and Dr. James Van Allen of the State University of Iowa.

SOLAR PLASMA DETECTOR

The purpose of this experiment is to determine the flow and density of solar plasma and the energy of its particles.

Solar plasma is frequently called "solar wind" and consists of charged particles that are continually streaming outward from the sun. Since direct measurements such as the one on Mariner have been infrequent, scientists know very little about the solar plasma. Some feel that it is merely an extension of the sun's atmosphere, or corona. Although there are many theories, some conflicting, we do know that during solar activity (sun spots or flares) the flux of plasma increases.

One of the most complicated and interesting areas of space science is the study of how solar plasma interacts with the magnetic fields in space. Since the plasma carries an electrical charge, it not only is affected by magnetic fields, but also creates one of its own.

If a field is strong enough it may control and divert the solar winds, and, conversely, if the electrical energy in the plasma is great enough, the planetary magnetic fields may be trapped in the cloud and move with it through space.

Therefore, to study the complex interractions between solar wind and magic fields, space probes that carry plasma experiments generally carry magnetometers.

Most particle detectors are designed to operate inside a sealed tube and the tube walls keep out very low energy particles. The solar plasma detector on Mariner, however, is open to space and can collect and measure positively-charged particles of very low energy.

The sensor for this experiment is mounted on the outside of one of the electronic boxes in the base of the Mariner. The aperture of the analyzer is pointed along the roll axis of the spacecraft, and during most of the mission will be facing the sun.

As a charged particle enters the analyzer it finds itself in a curving tunnel. The two sides of this tunnel are metal plates carrying static electric charges--one negative, and the other positive. The charged particle is attracted by one plate and repelled by the other, and so follows a curved path down the curved tunnel. If it is moving too slowly or too rapidly, it runs into one wall or the other, but if it is moving at just the right speed, it passes to the end and is detected by a charge collecting cup. The electric current produced by the flow of charged particles is measured by a very sensitive electrometer circuit.

Thus, all the particles moving in the ring direction to enter the tunnel and moving with the right speed to get all the way through will be detected.

Periodically the amount of voltage on the plates is changed and a different energy is required by the particles to get through to the collector cup. The voltage is automatically changed ten times. In this way it is possible to measure a spectrum of particle energies of 240 to 8400 electron volts.

The plasma detector has a total weight of 4.8 pounds and a power requirement of 1 watt. Experimenters are Dr. C. W. Snyder and M. Neugebauer of JPL.

COSMIC DUST DETECTOR

This experiment is designed to measure the flux and momentum of cosmic dust in interplanetary space and around Venus. It may contribute to an understanding of the hazards of manned flight through space.

This information will help scientists in understanding the history and evolution of the solar system.

There are many theories about these dust particles. One is that when the solar system was formed billions of years ago by the condensation of a huge cloud of gas and dust, these cosmic particles were debris left over, or they could be remnants of comets that rush through the solar system leaving a trail of dust behind. Some scientists believe cosmic dust has its origin in gallactic space and is somehow trapped by the interaction of magnetic fields from the sun and planets.

Scientists have been trying to study cosmic dust recently with earth satellites and sounding rockets, but Mariner may provide the first data on its distribution in interplanetary space.

The experiment is located on the top of Mariner's hexagonal bus. It consists of a rectangular magnesium "sounding board" five inches wide and 10 inches long. A crystal microphone is located in the center of this plate. This acoustical device measures the impact of particles of cosmic dust.

As a particle hits the acoustical plate it is recorded by the microphone whose output excites a voltage sensitive amplifier. The number of dust particles striking the plate is recorded on two counters, one for particles with high momentum and one for particles with low momentum.

During the cruise part on the trajectory the data conditioning system will read out the counters every 37 seconds and telemeter this to the ground. During planetary encounter the counting rate will be reduced to 20-second intervals.

The cosmic dust detector weighs 1.85 pounds and consumes .08 milliwatts of power. It was designed by a group at NASA's Goddard Space Flight Center, Greenbelt, Maryland, under the direction of W. M. Alexander.

VENUS TRAJECTORY

The boost portion of the Mariner mission consists of three phases: ascent into a circular parking orbit of approximately 115 miles, coast in the parking orbit to a pre-determined point in space, and reignition of the Agena to boost the spacecraft out of the parking orbit to greater than escape speed.

The Atlas D/Agena B space booster will rise vertically and pitch over in the required direction determined by the exact time of launch. The vehicle will gain speed and altitude until a signal from the ground guidance system commands shutdown of the Atlas engines and separation of the Agena/Mariner from the Atlas. The Agena engine ignites after a short coast period and accelerates itself and the spacecraft into the parking orbit at a speed of about 18,000 mph.

The Agena/Mariner will be traveling in a southeasterly direction over the Atlantic Ocean towards the coast of South Africa. Just before reaching Africa, at a point in space determined by the launch date, time of launch, and desired flight time to Venus, the Agena engine will re-ignite and accelerate the spacecraft to a speed of about 25,503 mph.

Shortly after the Agena engine shuts down, the Mariner spacecraft is separated from the Agena. This is "injection." The speed of the spacecraft exceeds the escape velocity at this altitude by 898 mph and the spacecraft moves off in the hyperbolic orbit relative to earth. Because of the rapid change of altitude, the rate at which it moves around the earth decreases until it is traveling essentially in a straight line outward from earth. During the time from injection to escape, the radius vector from the earth's center to the spacecraft moves through an angle of about 148°.

At the same time it is moving out, the spacecraft is slowing down relative to earth because of earth's gravity. When it reaches a distance of about 600,000 miles, after about three days, and has essentially "escaped earth", the velocity will have decreased from the original 25,503 mph to 6874 mph. The time and direction of the second Agena burn will have been chosen so that this velocity relative to earth is in a direction opposite to that of the earth in its orbit about the sun. Thus, the spacecraft will be moving about the sun 6874 mph slower than the earth's approximate 66,000 mph; that is, about 59,426 mph.

Because of the lower orbital velocity about the sun, the spacecraft will be moving too slowly to maintain a circular orbit against the sun's gravity. It will, therefore, start falling inward toward the orbit of Venus.

The combination of the inward motion and the circular motion around the sun produces an ecliptic orbit that will intersect the orbit of Venus some 116 days later.

About eight days after launch the accumulated tracking data will be used to compare the trajectories of the spacecraft with the trajectory necessary to provide the planned Venus encounter. The midcourse maneuver will depend on the difference between these two trajectories.

Now Mariner will begin to curve in towards the sun and gradually increase its speed. Eventually, due to the inward curving path, Mariner's speed will exceed that of the earth and it will catch up and pass earth. Later, it will catch up with rapidly moving Venus, approaching the planet on its dark side at a speed of more than 84,000 mph relative to the sun.

Entering the sphere of gravitational influence of the planet, Mariner's path will begin to be deflected due to its pull. Its speed will be increased even greater, reaching over 91,600 mph relative to the sun, as it passes Venus on its sunny side at a distance of about 10,000 miles from the surface. In addition, Mariner's path will be bent about 40 degrees in traveling past the planet.

At about 65 minutes before closest approach, or at a distance of 18,600 miles from the planet's surface, the planetary experiments will begin to scan Venus. They will operate for 30 minutes, after which the mission is officially over.

The path of the spacecraft in the vicinity of Venus has been designed so that Venus will not block the spacecrafts view of either the sun or earth. This is necessary to insure continuous communication with earth and proper functioning of the sun and earth sensors. The latter provide reference directions for attitude control of the spacecraft. The communication distance at the time of arrival is about 36 million miles.

After leaving the sphere of influence of Venus, the spacecraft will have even greater speed than when it entered. In essence, it will experience an increase in energy and speed due to the bending of its course by Venus. This phenomenon is similar to that sometimes experienced by comets which travel too close to the planet Jupiter. The energy increase is sometimes sufficient to cause the comet to escape the solar system. Such will not be the case for Mariner however.

Designing an interplanetary trajectory is a complex task that taxes the capabilities of high-speed computers. The trajectory engineer faces a task complicated by the interactions of the motion of the earth about the sun, the motion of Venus, the spin of the earth, and the effect of gravitational fields of earth, sun, moon, venus, jupiter and even the pressure of the sun's radiation, on the path of the spacecraft.

The trajectory designer, therefore, must calculate a trajectory from minute to minute for that portion of each day during the launch opportunity that launch could occur. He must keep his trajectory with range safety limits (the early portions of the launch must be over water, not land masses) and he must keep the trajectory within range of the tracking stations.

Meshing all these factors into a successful trajectory, spanning millions of miles and nearly four months in time, is a formidable task.

THE PLANET VENUS

During the centuries man has been studying Venus he has accumulated relatively little in the way of indisputable scientific information.

Astronomers are hampered in their attempts to investigate the planet because it is continually covered by a dense blanket of clouds.

Venus, our closest planetary neighbor, is in an orbit between the earth and the sun. Traveling at the speed of 78,300 miles an hour it has a sidereal period, (or year) of 225 days. Its average distance from the sun is 67,200,000 miles.

During its nearly circular orbit, Venus comes within 26,300,000 miles of the earth at closest approach or inferior conjunction. At superior conjunction, or point at which the earth and Venus are at opposite sides of the sun, it is 162 million miles away.

Inferior conjunction occurs every 584 days. As Venus approaches inferior conjunction Mariner will be launched to intercept the planet three to four months after launch.

One of the puzzling features of Venus is the changeable dark and light markings that appear on its cloud layer. Scientists have speculated that these markings could be breaks in the cloud cover, but as yet there seems to be little evidence of any regularity.

One of the outstanding features of Venus is its brightness. Because it is close to the sun, and has a reflective cloud layer, Venus is the third brightest object in our sky, after the sun and moon. Its reflectivity is measured about 60 percent, as compared to 7 percent for our moon.

Because it was not observed throughout the night, but appeared in morning and evening skies, ancient astronomers thought Venus to be two bright stars.

Venus has been referred to as the earth's twin. It has an estimated diameter of 7800 miles, as compared to 7926 miles for the earth. Also, it is believed to have a mass and gravitational field similar to that of earth.

Spectrographic studies (identification of materials by presence of absorptive features, lines or bands in the spectrum) seem to indicate that Venus contains carbon dioxide, and nitrogen but probably little free oxygen or water vapor. Measurements taken in the infrared region of the electromagnetic spectrum indicate that temperatures of minus 38 degrees Fahrenheit exist somewhere in the atmosphere. The microwave regions, however, show temperatures of 615 degrees Fahrenheit at or somewhere near the surface. The surface temperature is still in doubt.

Scientists are not in agreement as to the altitude from which these temperatures emanate. Indeed, there is one theory that a Venusian ionosphere, with thousands of times the electron density of the earth, gives the impression that the planet is extremely hot. Another explains that the high temperatures are due to a "greenhouse" effect in which the sun's energy is trapped beneath the dense clouds. A third theory holds that the surface of Venus is heated by friction produced by high winds and dust clouds.

Recent radar measurements suggest that Venus rotates at a slow rate, perhaps once every 225 days, which is the length of the Venusian year. This would mean that Venus always keeps the same side facing the sun, much the same way our moon, keeps the same side facing the earth.

DEEP SPACE INSTRUMENTATION FACILITY

Two-way communications with Mariner will be provided by JPL's Deep Space Instrumentation Facility (DSIF) a world circling network of three permanent tracking stations, a mobile tracking unit and at the Atlantic Missile Range, Cape Canaveral, Florida, a launch checkout station.

The DSIF is under the technical direction of the California Institute of Technology Jet Propulsion Laboratory for the National Aeronautics and Space Administration. Dr. Eberhardt Rechtin is JPL's DSIF Program Director.

The DSIF will track Mariner throughout the 100 to 140-day mission, receive and record telemetry from the spacecraft and transmit commands to the spacecraft.

The three permanent stations are at Goldstone in the California Mohave Desert, near Woomera Village in Australia, and near Johannesburg, South Africa.

The mobile station will be located approximately one mile east of the DSIF installation at Johannesburg. The mobile station will acquire Mariner shortly after injection when the spacecraft is too low to be readily picked up by the larger installation. The mobile station is equipped with a 10 foot-in-diameter dish antenna with a wide beam width (9 degree) and a fast tracking capability of 10 degrees a second.

The larger 85 foot-in-diameter antenna of the permanent installation has a 1 degree beam width and a 1 degree per second tracking capability.

As soon as the mobile station has acquired Mariner, tracking information and the position of the spacecraft will be sent to the permanent installation telling it where to look. It is expected that the large antenna will lock onto Mariner shortly thereafter.

The installations at Johannesburg and Goldstone have the capability of sending commands to Mariner, as well as to receive telemetry. The Woomera installation, the mobile unit and launch checkout station cannot command, but can transmit a signal to the spacecraft for doppler calculations. The mobile and launch checkout stations do not have the range of the larger antennas and function only in the initial stages of the mission.

The three permanent installations are located approximately 120 degrees apart around the earth. Their ranges overlap to provide continuous contact with the spacecraft.

The following are visibility times based one one possible launch date and time. The figures would change slightly relative to actual date and hour that launch occurred. Since the mobile and South African stations are close together they have the same visibility periods. The times when the spacecraft will be visible to the different stations are as follows. I stands for injection, which is the end of Agena second burn.

VISIBILITY PERIODS

Johannesburg and mobile	I. plus 2 mins	I. plus 26 mins.
Woomera	I. plus 17 mins.	I. plus 6 hrs. 35 mins.
Johannesburg and mobile	I. plus 1 hr. 45 mins	I. plus 14 hrs. 10 mins.
Goldstone	I plus 13 hrs	I. plus 23 hrs. 10 mins.
Woomera	I. plus 19 hrs. 15 mins.	I. plus 31 hrs. 10 mins.
Johannesburg	I. plus 26 hrs. 40 mins.	I. plus 38 hrs. 25 mins.

Throughout the mission the stations will continue to lock onto the Mariner, track it until the rotation of the earth carries the station to the limits of its horizon, and then pass the spacecraft on to the next station.

During the first ten days of the Venus Mission the DSIF stations will maintain contact with Mariner 24 hours a day. This will be lowered to ten hours a day during the cruise portions of the mission. During midcourse maneuver and planet encounter the stations will revert to 24-hour contact.

Each station is manned by a 25-man staff. It takes three hours to prepare a station to acquire the spacecraft and one hour to shut down following a tracking period.

Each station is linked with the Spacecraft Flight Operations Center at JPL by leased teletype circuits over which is sent all tracking and telemetry information to JPL for processing by an IBM 7090 computer system.

The launch checkout station at Cape Canaveral has two trailers; one for the transmitter and receiver and the other for test equipment, recording equipment and equipment for processing portions of the received signals for real-time display on strip charts; a six foot-in-diameter dish antenna for receiving and transmitting, and a collimation tower for calibrating and checking of station equipment. The tower simulates the spacecraft for checkout procedures, transmitting on the same frequency to be used by Mariner. The station has a 15-man crew.

Function of this station is to receive telemetry from the Mariner during pre-launch tests and record spacecraft telemetry from launch until the station loses contact as the spacecraft passes over the horizon.

The Goldstone station is operated for JPL by the Bendix Radio Corporation JPL's engineer in charge is Walter Larkin. Goldstone has two 85 foot-in-diameter antennas separated by seven miles and a ridge of hills to minimize interference.

The Australian station is 15 miles from Woomera Village and has one 85 foot-in-diameter receiving antenna. The station is operated by the Australian Department of Supply, Weapons Research Establishment. Dr. Frank Wood represents the WRE. Richard Fahnestock is the resident engineer for JPL.

The South African station is equipped with an 85 foot-in-diameter receiving antenna and it is located in a bowl-shaped valley approximately 40 miles northwest of Johannesburg. The station is operated by the South African government through the National Institute for Telecommunications Research, Dr. Frank Hewitt, Director. NITR is a division of the Council for Scientific and Industrial Research. Resident engineer for JPL is Paul Jones.

LAUNCH VEHICLE

NASA's launch vehicle for the Mariner R Venus Fly-By is the Atlas Agena-B -- the reliable combination that sent America's first payload to the moon.

An Atlas Agena-B vehicle launched Ranger IV April 23 on such a trajectory that the Ranger payload landed on the moon, even without a midcourse maneuver.

The Atlas "D" serves as the booster and the Agena-B as the vehicle's second stage.

The vehicle is provided to NASA by the Air Force systems Command's Space Systems Division which functions as a "prime contractor" to the NASA vehicle group -- the Marshall Space Flight Center, Huntsville, Ala.

This relationship is spelled out in the NASA-USAF agreement which provides for NASA procurement through the Air Force of a number of vehicles consisting of modified Atlas booster with modified Agena-B's serving as second stages. The Agena was developed for the Discoverer satellite program in which it has achieved a significant reliability record.

It has also been used in four Ranger flights.

Major contractors involved in the vehicle operation are Lockheed Missile and Space Company and General Dynamics/Astronautics. The vehicle is launched by these companies under the direction of NASA's Launch Operations Center, Cape Canaveral.

(The Venus mission flight plan is described in another section of the press kit entitled "Venus Trajectory.")

AGENA-B SECOND STAGE

The Agena-B stage of the rocket is an improved and enlarged version of the Agena-A, which was used in the Discoverer satellite program.

The Agena-B vehicle has integral, load-carrying propellant tanks with twice the capacity of Agena-A tanks and is powered by a Bell Aerospace turbopump-fed engine. It burns unsymmetrical dimethylhydrazine (UDMH) as fuel and inhibited red fuming nitric acid (IRFNA) as the oxidizer.

The new engine gives substantially higher performance than prior Agena engines and has a shutdown and restart capability.

An inertial reference system is capable of establishing attitude control during the coast and engine operation phase. An on-board timer initiates programmed signals for the starting, stopping and maintaining of various equipment during flight.

Here is a description of the Agena B:

Propulsion: Single rocket engine using liquid propellants -- inhibited red fuming nitric acid and unsymmetrical dimethlhydrazine.

Thrust: 15,000 pounds at altitude

Size: Approximately 22 feet long including adapter to accept Mariner-R spacecraft.

Control Systems: Pneumatic using high-pressure gas metered through external jets for use during coast phases. Hydraulic through gimballing rocket engine for pitch and yaw control during powered portions of flight. Corrections provided by airborne guidance system.

Guidance: The guidance system -- which is made up of timing devices, an inertial reference system, a velocity meter and an infrared horizon sensing device -- is entirely self-contained.

Contractors: Lockheed Missile and Space Company, prime-contractor; Bell Aerosystems Co., engine.

ATLAS "D" BOOSTER

The Atlas booster used for the Atlas Agena-B program is a modification of the Air Force ICBM and has been operational for some time. An Atlas booster is also being used in the NASA Project Mercury manned-flight program. Many of America's satellites were sent aloft by Atlas boosters.

Here is a description of the Atlas "D" space booster:

Propulsion: Cluster of three rocket engines; two boosters, one sustainer; using liquid oxygen and kerosene propellants.

Speed: Approximately 12,000 statutue miles per hour for the Mariner missions.

Thrust: Total nominal thrust at sea level more than 360,000 pounds.

Size: Approximately 78 feet high including adapter for Agena; 16 feet wide across flared engine nacelles. Ten feet wide across tank section.

Weight: Approximately 260,000 pounds at moment of launch, fully loaded with propellants.

Guidance: Radio command guidance. Ground radars sense velocity vectors, transmitting this data to ground computer. Computer determines corrections necessary and information is transmitted to airborne unit which signals control system. Control is accomplished through gimballing and engine burning time.

Contractors: Airframe and assembly -- General Dynamics/Astronautics; propulsion -- Rocketdyne Division of North American Aviation; radio command guidance -- Defense Division of General Electric Company; ground guidance computer -- Burrough Corporation.

KEY MANAGEMENT PERSONNEL

Overall direction for the Agena program is provided at NASA Headquarters by the Office of Space Sciences, headed by Homer E. Newell, Director. Dixon Forsythe is the program manager. MSFC is assigned responsibility for the Agena vehicle system management for the various Agena programs. In particular this assignment includes administration and technical responsibility from vehicle procurement through launch. Within MSFC the Light and Medium Vehicles Office, directed by Hans Hueter, directs the Agena program. Friedrich Duerr is the Agena systems manager.

Major John G. Albert is the director of the NASA Agena B program for the AF Space Systems Division, assisted by Major Charles A. Wurster.

Harold T. Luskin is the Lockheed Missiles and Space Company manager for NASA programs.

Dr. Kurt H. Debus heads the NASA Launch Operations Center which directs launchings.

SUBCONTRACTORS

PASADENA, CALIF. Mariner is part of the National Aeronautics and Space Administration's lunar and planetary space exploration program. The California Institute of Technology Jet Propulsion Laboratory, under contract to NASA, has the responsibility for project management. Thirty-four subcontractors to JPL provided instruments and hardware for Mariners 1 and 2. These contracts amounted to $6.5 million.

Aeroflex Corporation Long Island City, New York	Jet Vane Actuators
American Electronics, Inc. Fullerton, California	Transformer-Rectifiers for Flight Telecommunications
Ampex Corporation Instrumentation Division Redwood City, California	Tape Recorders for Ground Telemetry and Data Handling Equipment
Applied Development Corporation Monterey Park, California	Decommutators and Teletype Encoders for Ground Telemetry Equipment
Astrodata, Incorporated Anaheim, California	Time Code Translators, Time Code Generators, and Spacecraft Signal Simulators for Ground Telemetry Equipment
Barnes Engineering Company Stamford, Connecticut	Infrared Radiometers Planet Simulator
Bell Aerospace Corporation Bell Aerosystems Division Cleveland, Ohio	Accelerometers and Associated Electronic modules
Computer Control Company, Inc. Framingham, Massachusetts	Data Conditioning Systems
Conax Corporation Buffalo, New York	Midcourse Propulsion Explosive Valves Squibs
Consolidated Electrodynamics Corp. Pasadena, California	Oscillographs for Data Reduction
Consolidated Systems Corporation Monrovia, California	Scientific Instruments Operational Support Equipment
Dynamics Instrumentation Company Monterey Park, California	Isolation Amplifiers for Telemetry Operational Support Equipment
Electric Storage Battery Company Missile Battery Division Raleigh, North Carolina	Spacecraft Batteries

Electro-Optical Systems, Inc. Pasadena, California	Spacecraft Power Conversion Equipment
Fargo Rubber Corporation Los Angeles, California	Midcourse Propulsion Fuel Tank Bladders
Glentronics, Inc. Glendora, California	Power Supplies for Data Conditioning System
Groen Associates Sun Valley, California	Actuators for Solar Panels
Houston Fearless Corporation Torrance, California	Pin Pullers
Kearfott Division General Precision, Inc. Los Angeles, California	Gyroscopes
Marshall Laboratories Torrance, California	Magnetometers and Associated Operational Support Equipment
Matrix Research and Development Corporation Nashua, New Hampshire	Power Supplies for Particle Flux Detectors
Menasco Manufacturing Company Burbank, California	Midcourse Propulsion Fuel Tanks and Nitrogen Tanks
Midwestern Instruments Tulsa, Oklahoma	Oscillographs for Data Reduction
Mincom Division Minnesota Mining & Manufacturing Los Angeles, California	Tape Recorders for Ground Telemetry and Data Handling Equipment
Motorola, Incorporated Military Electronics Division Scottsdale, Arizona	Spacecraft Command Subsystems, Transponders, and Associated Operational Support Equipment
Nortronics A Division of Northrup Corporation Palos Verdes Estates, California	Attitude Control Gyro Electronic, Autopilot Electronic, and Antenna Servo Electronic Modules, Long Range Earth Sensors and Sun Sensors
Ransom Research Division of Syle Laboratories San Pedro, California	Verification and Ground Command Modulation Equipment
Rantec Corporation Calabasas, California	Transponder Circulators and Monitors

Ryan Aeronautical Company Aerospace Division San Deigo, California	Solar Panel Structures
Spectrolab A Division of Textron Electronics, Incorporated North Hollywood, California	Solar cells and their installation and electrical connection on Solar Panels
State University of Iowa Iowa City, Iowa	Calibrated Geiger Counters
Sterer Engineering & Manufacturing Company North Hollywood, California	Valves and Regulators for Midcourse Propulsion and Attitude Control Systems
Texas Instruments Incorporated Apparatus Division Dallas, Texas	Spacecraft Data Encoders and Associated Operational Support Equipment, Ground Telemetry Demodulators
Trans-Sonics, Incorporated Burlington, Massachusetts	Transducers

In addition to these subcontractors, there were over 1000 industrial firms who contributed to Mariner. These procurements amounted to over $3.5 million.