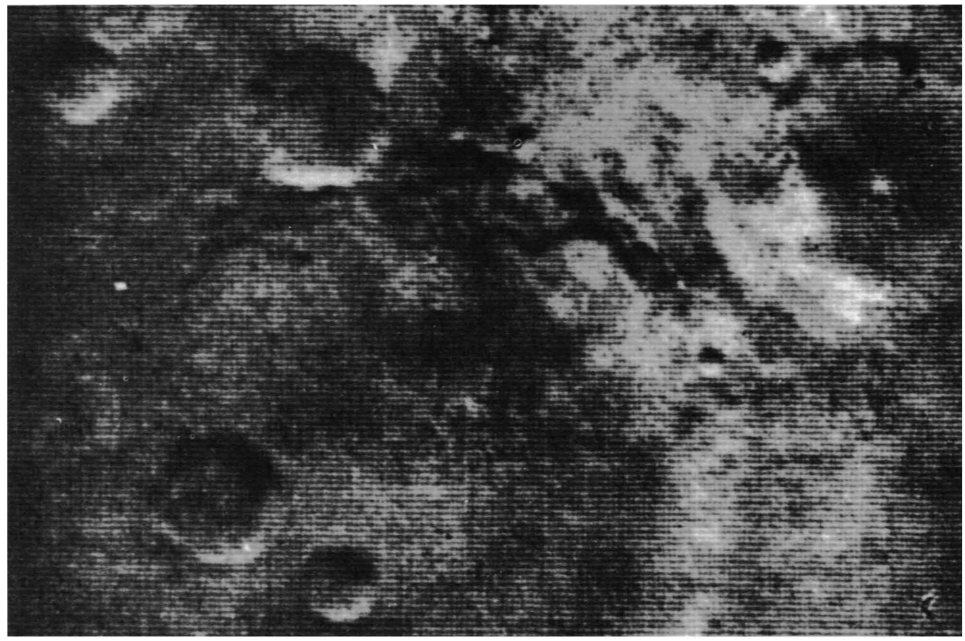
NASA FACTS Vol. III, No. 3

NASA FACTS

A REPORT FROM MARINER IV



The eleventh close-up picture taken by Mariner IV shows an older crater about 75 miles in diameter, whose dimly visible rim encloses more sharply defined smaller and younger craters. The picture covers part of an area called Atlantis, between Mare Sirenum and Mare Cimmerium.

NASA's Mariner IV spacecraft has given man his closest look at another planet. Its relatively close range pictures—taken from distances of 10,500 to 7400 miles away—will be studied by scientists for many years.

Mariner IV actually flew even closer to Mars—as near as 6118 miles. It took no pictures then because it was on the night side of Mars.

The historic photographs were snapped by Mariner IV as it sped by Mars on July 14, 1965. What do the photographs show?

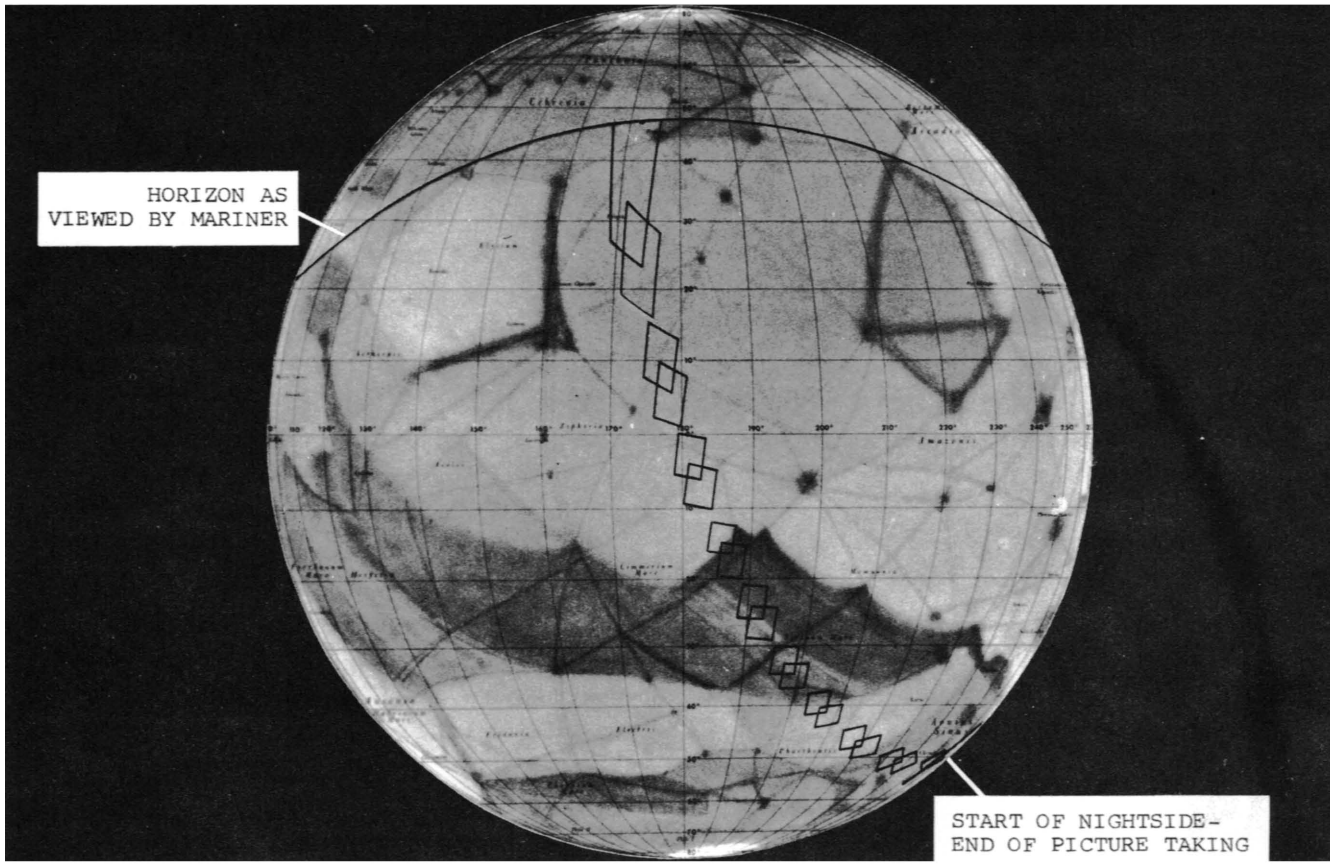
The pictures show a surface pitted with craters. They show a landscape that may not have changed much in billions of years.

Just sending the pictures back to earth gave Mariner a great place in the history of the Space Age. But the spacecraft did much more. Among its other accomplishments:

- Measured radiation, surveyed magnetic fields, and counted the tiny particles of matter called micrometeoroids almost all along a 418 million mile journey through space.
- Gave new and more accurate information on Mars' size, gravity, and path around the sun.
- Showed that the Martian atmosphere is so thin that men would need pressurized suits to live on Mars.
- Revealed that on Mars, as on earth, an ionosphere will, under certain conditions, make radio communications possible between distant points on the planet.

What Mariner IV did not find out was whether Mars has any form of life. Nor was it intended to. The Mariner IV mission, though, blazed the way for later spacecraft to land instruments and, eventually, men on Mars.

REPORT CALLS FOR EXPLORATION OF MARS. A report calling for a program of unmanned exploration of Mars in the decade ahead was issued on April 26, 1965, by a study group set up by the Space Science Board of the National Academy of Sciences. The report urged that the enterprise be assigned "the highest priority among all objectives in space science." The study, entitled "Biology and Exploration of Mars," was started in 1964 and represented the views of 36 prominent scientists whose fields ranged from genetics to theoretical physics.



Mariner IV photographic coverage is shown on pictorial representation of Mars. The curved line at the top is the horizon as viewed from Mariner. Areas to the right of the short line (lower) were on Mars' night side when photographed.

The Mariner project is managed for NASA by the Jet Propulsion Laboratory, Pasadena, California.

CLOSE-UPS REVEAL MOON-LIKE SURFACE

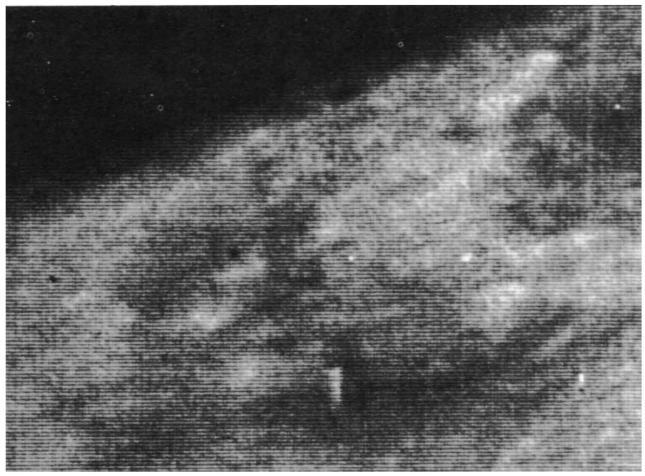
The numerous Martian craters seen for the first time were perhaps the greatest scientific surprise produced by Mariner IV. Mariner's pictures show about 70 craters whose diameters range from 3 to 75 miles. The pictures cover approximately one percent of the Martian surface. If this part of Mars is representative of the entire planet, Mars may be pitted by more than 10,000 craters of the sizes observed. There may also be many smaller craters.

The craters on Mars look like impact craters on the moon and earth. This would mean that the craters are caused by meteoroids falling on Mars. Scientific estimates as to when these collisions occurred range from several hundred thousand to several billion years ago.

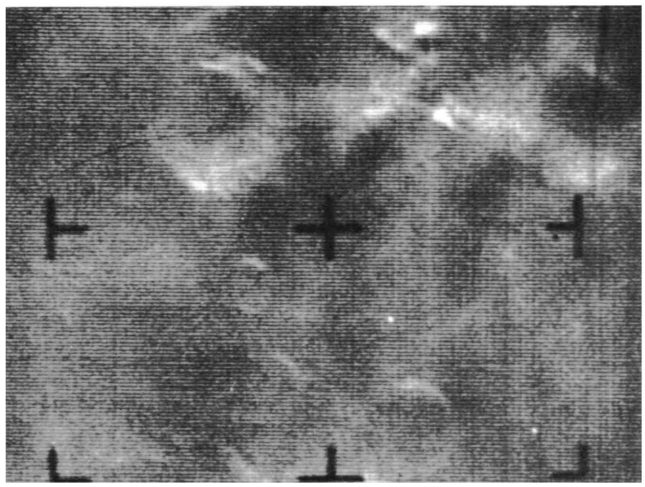
The ages of the craters are very important to scientists. For example, if the craters are billions of years old, it could mean that Mars never had significant moisture nor an atmosphere much thicker than the present thin one. If the craters are geologically young, it would seem that Mars during its history has been swept by wind, water, or other erosive forces which have obliterated older craters.

Supporting the former view is the absence in the pictures of physical features that could have been the basins of former oceans or the beds of ancient rivers, lakes, or seas. However, the

Mariner IV took pictures in pairs that partially overlap. In each pair, one picture was taken through a green filter and the other through a red filter. By analyses of picture pairs, scientists may gain clues to colors and other surface features.



View of Martian horizon from Mariner IV.



A bright region in northwestern Phaethontis, taken by Mariner as it approached Mars' night side, shows craters with what appear to be frost-covered rims.

A bright region in southeastern Zephyria near Mare Sirenum.

pictures cover only about one percent of the Martian surface.

Astronomers on earth have observed what appears to be frost around the Martian polar regions. Mariner IV pictures reveal comparable light colored substances around the rims of some of the Martian craters. Scientists think that if this substance is frost, it may turn directly to vapor and then back again to frost without becoming water.

Several photographs cover areas crossed by the controversial Martian canals. These are narrow markings which some astronomers claim to see on the planet's surface and which they believe to be artificial. The close-ups, however, show no readily apparent straight-line features that can be interpreted as artificial.

No mountain chains, great valleys, or continental masses could be recognized in the picture.

Altogether, Mariner IV returned 21 pictures and a fraction of a 22nd to earth. The close-ups revealed Martian surface features as small as two miles across. Pictures taken through the best telescopes on earth show features 100 miles across.

NASA plans a series of advanced spacecraft called Voyager to study Mars from an orbit around the Red Planet and from an instrumented package landed on the surface. Voyager flights to Mars are scheduled for the 1970's.

The marksmanship achieved in the Mariner fly-by of Mars may be likened to rolling a strike in a bowling lane that is 400 miles long.

ATMOSPHERE ABOUT ONE PERCENT AS DENSE AS EARTH'S

Man will require a pressure suit or have to remain in a pressurized cabin to live on Mars. Data from Mariner IV indicate that the surface pressure of the Martian atmosphere is lower than ten millibars, as compared to the approximately one thousand millibars of actual sea level pressure on earth.

Estimates of the Martian atmospheric pressure, based on studies from earth, have ranged from 10 to 100 millibars. The more precise atmospheric information acquired through the Mariner IV experiment is contributing to design of craft intended for landing on Mars.

Other atmospheric measurements made possible by the Mariner IV mission include those of the characteristics of the ionosphere. The Martian ionosphere, like that of earth, is the portion of the atmosphere that is largely electrically charged. One property of the ionosphere is that it reflects certain radio frequencies.

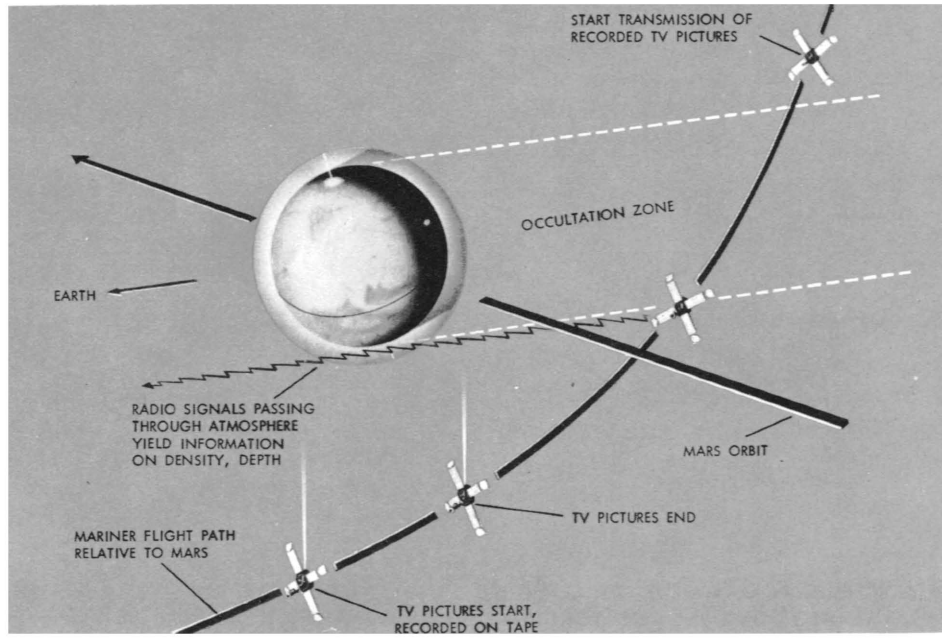
Data from Mariner IV indicated that the Martian ionosphere is capable of reflecting radio frequencies as high as 3000 kilocycles. Earth's ionosphere can reflect frequencies as high as about 20,000 kilocycles.

The fact that the Martian ionosphere can reflect radio waves means that under certain conditions radio communications may be maintained between expeditions at widely separated points on Mars. The comparatively low reflective capability of the ionosphere would facilitate radio communication between points on the Martian surface and a spacecraft orbiting the planet.

Astronomers observe that most meteors reaching earth's vicinity are stopped by earth's upper atmosphere, which is about as thin as the lower atmosphere of Mars. As a result, many believe that the Martian atmosphere is capable of burning up most meteors before they reach the planet.

The Mariner IV atmosphere experiment was termed the occultation experiment because the Martian atmosphere and Mars itself came between the spacecraft and earth. Scientists acquired atmospheric information by analyzing changes in characteristics of Mariner's radio signals caused by their passage through the Martian atmosphere before and after the spacecraft sped behind Mars.

The occultation experiment marked the first time that a *coherent* and directly beamed radio source has been used to measure the atmosphere of another planet. In measurements from earth, radio waves sent from the earth to Mars are reflected off, and *scattered* from, the Martian surface.



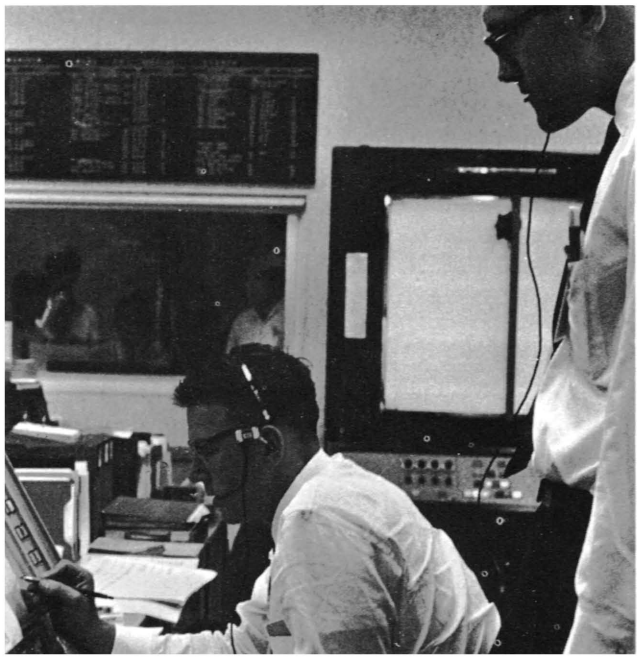
Sketch locates points at which Mariner IV took pictures and sent atmospheric data as it passed near Mars.

NO MARTIAN MAGNETIC FIELD OR RADIATION BELT DETECTED

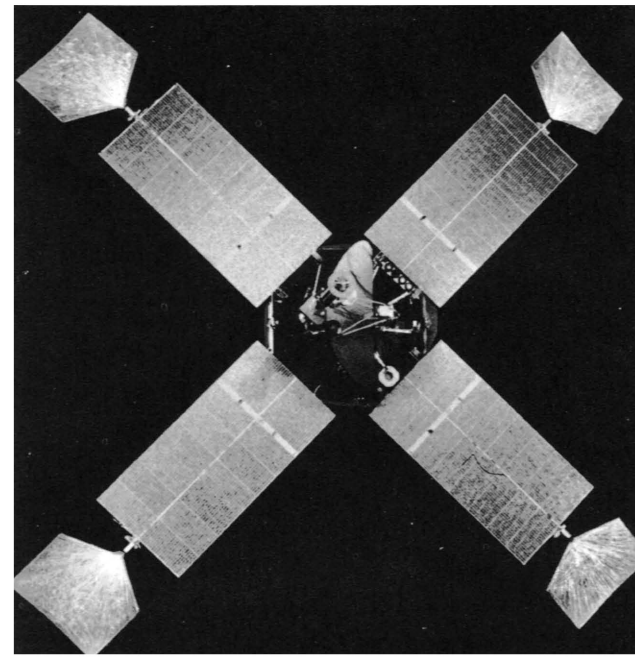
At the altitudes at which Mariner IV passed Mars, it detected no significant change in magnetic forces or radiation intensities from the levels observed in interplanetary space. The fact that Mars rotates had led many scientists to assume that the planet had a magnetic field, which is believed to be associated with the motion of fluid in a planet's core. The absence of a field would indicate that Mars has no core of hot liquid metal as earth is thought to have. Supporting this belief is the absence of mountain chains, great valleys, or what could be continental masses in the pictures of Mars sent by Mariner IV. Such physical features are believed to be produced by stress within the planet. Such stress is usually associated with a molten core.

As Mariner IV sped outward from earth, it passed through and detected the high-intensity radiation of earth's Van Allen Radiation Region. This region is believed to be created by earth's magnetic field which captures energetic particles (protons and electrons) coming towards earth from space.

Mariner IV detected no significant increase in radiation as it passed near Mars. If Mars has no magnetic field to deflect energetic particles, such particles must speed directly into the planet's atmosphere and the higher energy ones penetrate to the planet.



Engineers at the Space Flight Operations Facility study information transmitted by Mariner IV as it flew by Mars.



Mariner IV.

METEOROID ENCOUNTERS INCREASED AT FIRST, THEN FELL

Some scientists anticipated that Mariner IV would report an increasing number of micrometeoroids striking the spacecraft. They reasoned that Mariner IV would be approaching the Asteroid belt which is believed to be a source of meteoroids. The Asteroids are a swarm of small celestial objects in solar orbits, largely between the orbits of Mars and Jupiter.

Micrometeoroid encounters were few at first. As anticipated, there was a gradual increase. This increase continued until about the 154th day of flight when fewer encounters began to be reported. A surprise to many scientists was that Mariner IV reported no significant increase of micrometeoroids near Mars.

Altogether, Mariner IV detected about 200 micrometeoroids during its 7½ month flight to Mars.

INTERGALACTIC RADIATION HIGHER

Mariner IV reported more intergalactic radiation (radiation originating outside of the solar system) present in the solar system than was reported by Mariner II during its mission to Venus in 1962 (see NASA Facts—Mariner II Reports, NF B–4–63). At the same time, Mariner IV detected less solar radiation than did Mariner II.

These data further confirm theories relating to the influence of the sun's activity on the solar system. Briefly, the higher intergalactic radiation and lower solar radiation reported by Mariner IV are attributed to the fact that the sun was in the low period of its 11-year cycle during the Mariner IV flight. The cycle refers to a more or less rhythmic rise and fall of solar activity from high to low and then again to high.

The sun's high period is marked by more frequent sun spots and solar flares. These send high intensity radiation into space. Another result of the heightened activity is a stronger solar wind—hot electrified gases streaming outward from the sun's turbulent surface.

It is theorized that the solar wind drags with it parts of the sun magnetic field and distributes these throughout the solar system. The parts become the interplanetary magnetic fields. Strength and form of the fields vary with the solar wind's force.

Interplanetary magnetic fields drifting throughout the solar system deflect some of the radiation coming from intergalactic or interstellar space beyond our solar system. Their capability for deflecting intergalactic or interstellar radiation increases or decreases with their strength. This is in turn dependent on the strength of the solar wind and the magnitude of solar activity.

During the periods May 25–27 and June 5–7, 1965, Mariner IV detected a new kind of solar event: a burst of high-energy electrons (40 kev) from the sun. (Kev stands for thousands of electron volts. The electron volt is a standard unit of measurement of the energies of atomic particles such as protons and electrons.) This is believed to be the first time such an event has been detected.

ADDED TO INFORMATION ON EARTH'S SHOCK WAVE AND MAGNETIC FIELD

Mariner IV furnished additional information about the shock wave and magnetic field surrounding earth. The wave was first detected by analyses of data from the Explorer XVIII satellite (see NASA Facts—Interplanetary Explorer Satellites, Vol. II, No. 1), launched November 26, 1963. The wave is created by impact of the speeding solar wind with earth's magnetic field.

Mariner IV reported crossing the wave at distances from earth of 138,000 miles, 145,000 miles, and then again at 154,000 miles. The location of the wave is believed to fluctuate with variations in the strength of the solar wind.

Explorer XVIII had confirmed theories that on the earth's night side, the earth's magnetic field takes the shape of a comet's tail, or wake. Explorer XVIII also showed that this wake extends at least 120,000 miles into space. It was theorized that the wake stretches out for perhaps tens of millions of miles.

Although, when about 12 million miles from earth, Mariner passed near where the magnetic wake was presumed to be, the spacecraft detected only interplanetary magnetic features. This may indicate that the wake ends somewhere between 120,000 and 12 million miles from earth. Just where will be determined by other NASA spacecraft.

HOW THE PICTURES OF MARS WERE SENT TO EARTH

Mariner IV had a ten-watt transmitter as compared with the approximately 100,000 watts or more at which a typical metropolitan television station on earth transmits its video signal (picture). Generally, a radio signal weakens with the square of the distance over which it travels. As a result, by the time Mariner's signals had crossed about 140 million miles of space to reach earth, their strength had dwindled to less than a quintillionth (.000-000000000000001) of a watt.

One way to pick up a recognizable picture under these conditions is to have it transmitted

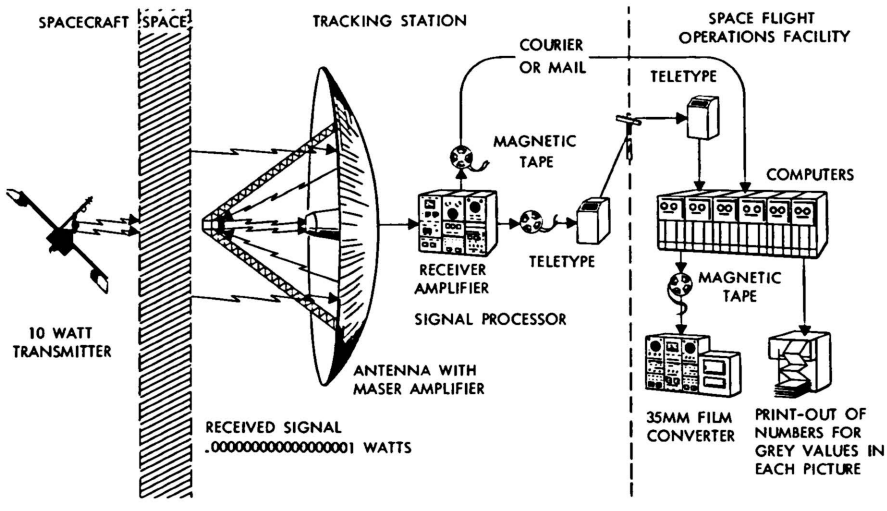
in digital (numerical) form. Usually, video signals are transmitted in the form of electrical currents whose voltages are analogous to the varying brightnesses in the picture. Equipment on board Mariner electronically scanned each picture and converted it to such electrical currents.

However, the current was then fed to another device on Mariner that converted the varying electrical voltages into 64 numbers, representing picture shadings from pure white to jet black. The numerical system used, however, was not our familiar decimal system which employs ten digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9). Instead, it was the binary system in which all counting and calculating is done with only two digits (0 and 1).

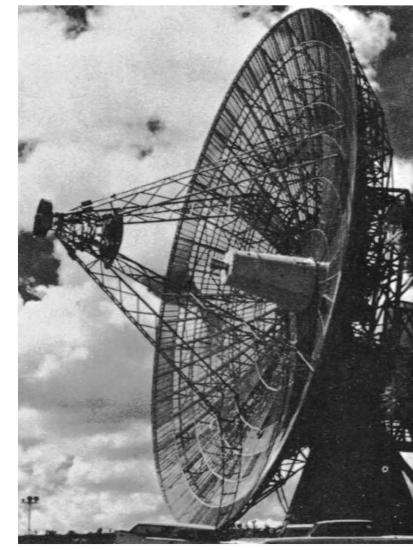
The binary numbers used for the Mariner pictures ranged from 000000, equivalent to decimal number 0 and representing pure white, to 111111 which is equivalent to decimal number 63 and represents jet black. The 62 other shadings were represented by 62 other binary numbers using only the digits 0 and 1.

Mariner IV tape recorded the numbers for later transmission to earth. Upon command, it transmitted the numbers in sequence to earth at a rate of 8.3 bits (acronym for binary digits) per second. The bits were transmitted as pulses which were present (1) or absent (0).

An advantage of this relatively simple form of transmission is that the effects of interference from radio noise in space and of distortion of the radio wave are greatly reduced. Ground receiving stations can acquire the stream of pulses with negligible error.



Transmission and processing of pictures from Mariner IV.

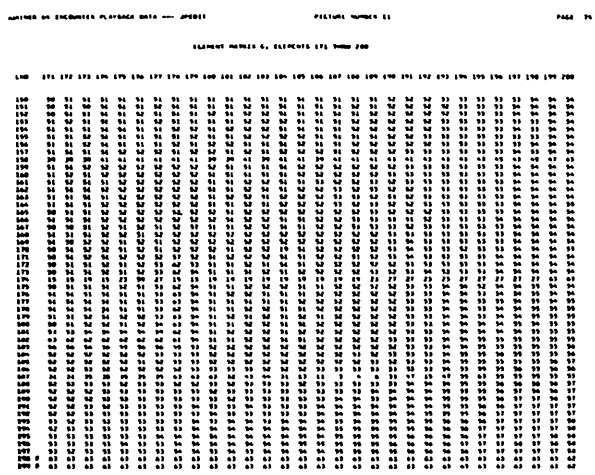


An 85-foot diameter antenna of the Deep Space Network station at Goldstone, Calif.

THE DEEP SPACE NETWORK

The faint Mariner signals were scooped up on earth by the huge 85-foot-diameter antennas of NASA's Deep Space Network (DSN). DSN stations are located at Goldstone, Calif.; Johannesburg, Republic of South Africa; Madrid, Spain; and Woomera and Canberra, Australia. The stations are so spaced that at least one can maintain contact with a spacecraft despite the earth's rotation. Overlapping space coverage by the stations enabled another station to establish contact with Mariner before the previous one was moved out of range by the turning earth.

The DSN took more than 8 hours to acquire the approximately 250,000 bits that constituted a single photograph. Because of the prolonged time involved, data from a single picture were sometimes divided between two or more stations. However, all stations funneled their data to the Space Flight Operations Facility of the Jet Propulsion Laboratory, Pasadena, Calif. The laboratory manages the Mariner project for NASA.



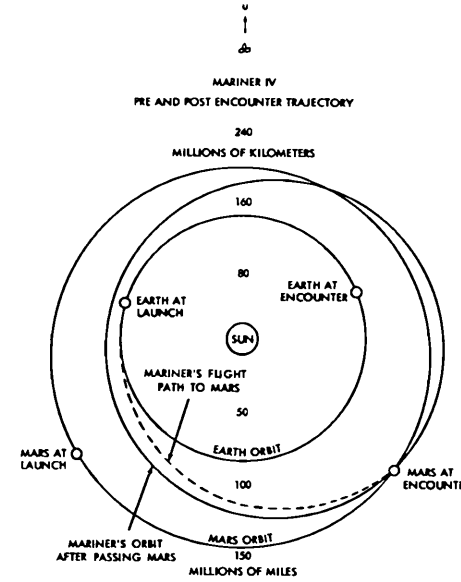
Computer read-out data sheet. It is a digital (numerical) representation of the bottom right corner of Mariner IV picture number 11 which is shown on page 1 of this NASA Facts. Numbers at left show the picture line; those at the top, the place in the line occupied by the digit representing one of 64 shades of picture brightness.

AT THE SPACE FLIGHT OPERATIONS FACILITY

The DSN stations sent picture data to the Space Flight Operations Facility (SFOF) both by teleprint and by mail or courier to assure its arrival. At the SFOF, high-speed computers correlated data from different DSN stations to piece together parts of the same picture. They analyzed the bits to screen out errors in data transmission from the stations. They separated the picture bits from those bits providing other scientific information, such as on radiation near Mars, and from bits furnishing data on spacecraft condition.

Other computers converted the numbers from the binary system to our more familiar decimal system. The resulting numbers 0 to 63 represented 64 different picture shadings from white to black.

The numbers were printed in sequence on a computer read-out data sheet (see illustration). Twenty sheets were required to reconstruct a complete photograph, which is represented by 40,000 numbers.



Orbits of Mariner IV, earth, and Mars around the sun.

Mariner IV far exceeded its designers' expectations. It continued to send useful data on magnetic fields, radiation, and micrometeoroids in space as well as data on its own condition as it sped millions of miles beyond Mars.

On October 1, 1965, NASA stopped acquiring data from the spacecraft. Mariner was then more than 191 million miles from earth. It had traveled a total of 418,749,386 miles in its curving trajectory since launch on November 28, 1964.

From time to time, NASA will attempt to track Mariner IV as it orbits the sun. One day in September, 1967, when, scientists calculate, the spacecraft will swing within 29 million miles of Earth, NASA will attempt to acquire data again from the spacecraft. If the transmitter and other critical systems are still working, Mariner IV will then send several more months of news from space.

The computer read-out data sheet was fed to a digital photographic processor that converted each number to an appropriately shaded dot. The dots from this sheet and other sheets were projected in sequence and line by line onto a cathode ray tube that is an advanced version of the picture tube in the home television set.

Two hundred dots formed a line and 200 lines made up a picture. As each complete picture appeared on the screen, it was photographed by 35-mm. cameras.

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