Messages from Mars

by JOHN LEAR

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Astronomers confidently say that the year 1969 will be looked back to by future historians as the time when earthly men first began to acquire true understanding of a neighboring planet. The neighbor, of course, is Mars. The source of the understanding is the torrent of Martian photographs radioed to Earth in midsummer by the robot spaceships *Mariner 6* and *Mariner 7*. But why should 1969 be fixed as the historic turning point? Weren't photos of Mars sent to Earth in 1965 by the robot *Mariner 4*? Didn't those photos enable astronomers to predict accurately that *Mariner 6* and *Mariner 7* would find Mars pocked with craters?

Mariner 4 did so perform. And *Mariner 4* did show the Martian craters beyond any doubt. However, true understanding springs from adequate information. And the impression of Mars that *Mariner 4* conveyed was vague and fuzzy compared to the detailed story relayed by *Mariner 6* and *Mariner 7*.

The pictures juxtaposed opposite have been reproduced separately in many newspapers and magazines. But no journal has offered its readers an explanation of the enormous improvement in quality of the images.

Since the American people have paid an extravagant bill for landing a man on the moon and are now being asked to approve like spending to land a man on Mars, the potentialities of *unmanned* space exploration deserve popular exposition. One approach is to place the magnificent performance of *Mariner 6* and *Mariner 7* in the perspective of time. Indeed, their example is so very apt that it prompted me to cross the country and visit the California Institute of Technology's Jet Propulsion Laboratory, the scientific agency to which the National Aeronautics and Space Administration assigned responsibility for successful completion of all the *Mariner* voyages.

On arriving here, I found that the dimensions of the advance that has occurred in unmanned space technology during the past five years are even more impressive than I had thought. In 1965, *Mariner 4* took eight hours to transmit each photograph; each picture was 200 lines deep, with 200 spots of light and shade defining each line. On the 1969 expedition to Mars, the photos were 760 lines deep; each line was composed of 954 dots of light and shade; and each picture was transmitted in only five minutes.

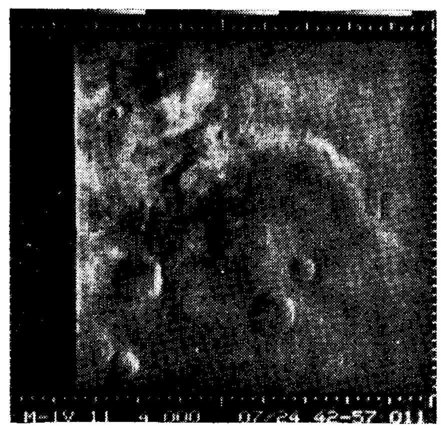
In the plain language of mathematics, then, *Mariner 6* and *Mariner 7* each communicated more than 1,900 times as much information as *Mariner 4* did.

How was it done? The answer amounts to a catalogue of the elements of interplanetary communication.

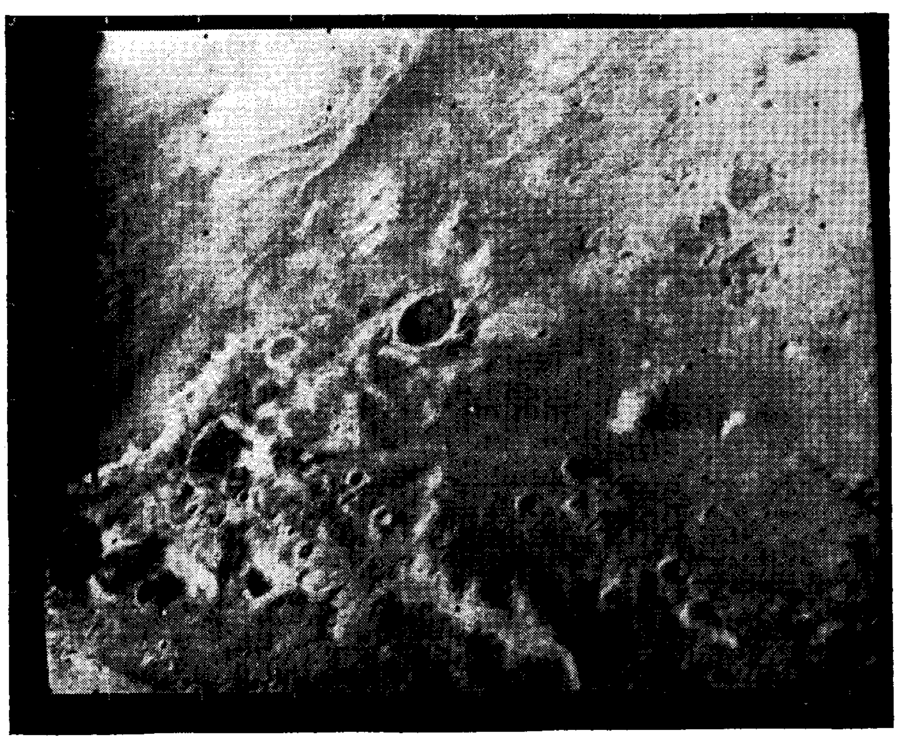
The biggest item in the catalogue is the electronic ear that JPL cocked toward Mars last summer. A signal receiving dish 210 feet in diameter took over the job that had been done by an eighty-five-foot dish in 1965. Since reception of messages improves according to the square of the diameter of the listening ear, the formula reads $(210/85)^2$ and works out to a factor of 7.1. That is to say, the bigger ear could pick up more than seven times as much data as the smaller ear.

The second biggest item in the interplanetary communication catalogue is the distance the messages had to travel. At the time *Mariner 4* reached Mars, that planet was 135 million miles away from Earth. When *Mariners 6* and *7* reached Mars, Mars was only sixty million miles away from Earth. All else being equal, reception of messages improves according to the square of the distance covered. The formula for this reads $(135/60)^2$ and comes out to a factor of 5. In short, communication between Earth and Mars in 1969 was five times better than in 1965 simply because Mars was closer to Earth when *Mariners 6* and *7* paid their calls.

The third biggest item in the interplanetary communication catalogue is noise. Noise interferes with all kinds of messages. Cocktail party talk is notoriously vacuous because too many conversations are going on simultaneously. As the number of drinks consumed rises, an increasing amount of heat is given off in relation to the light conveyed. Electronic ears experience somewhat the same problem. The surface of Earth generates heat, and this registers as noise in the ear if the ear is tilted toward the horizon in order to



"Mariner 4" told a story (above) but "Mariner 7" was eloquent (below).



catch particular messages from the sky.

Because *Mariner 4* needed eight hours for the transmission of one photograph, JPL's eighty-five-foot ear had to listen almost continuously while the robot was in the Martian neighborhood. This meant that the ear had to sweep the whole arc of the heavens as the hours went by. Taking into account the fact that noise levels would be high near the horizon, the JPL engineers slowed their circuits to filter out that level of noise throughout the Martian assignment.

Since *Mariner 6* and *Mariner 7* were able to transmit a photograph in five minutes, JPL's new 210-foot ear was not required to be a slave to the clock. There was no need to listen keenly during those periods when the line of message transmission would fall near the horizon. The broadcasts could be restricted to those times when Mars was high in the sky, directly over the JPL listening post at Goldstone in the California desert. Consequently, the 210-foot ear could accurately bring in 3.2 times as much message content from Mars in 1969 than would have been intelligible in 1965.

We now have three separate orders of improvement in the performance of *Mariner 6* and *Mariner 7* over that of *Mariner 4*: one of 7.1, one of 5, and one of 3.2. By multiplying these we find that we have explained how the amount of information returned to Earth by *Mariners 6* and 7 could be 113.6 times greater than that received from *Mariner 4*. We still seem a long way from our goal of 1,900-fold performance. But the law of arithmetical progression works much faster than most non-mathematicians suppose. The steps that follow will quicken.

Interplanetary communication item 4—signal power. *Mariner 4* had ten watts of power aboard. *Mariners 6* and 7 got new and better broadcasting tubes, and the solar-cell panels powering them were enlarged from seventy to eighty-two square feet. This doubled the strength of the signals from the Martian neighborhood.

(Note that we have now accounted for 227.2 times the performance of *Mariner 4*.)

Interplanetary communication item 5—synchronization. This item is an engineer's nightmare and can most lucidly be disposed of by saying that scientific data and engineering data from *Mariner 4* were reported separately. On *Mariners 6* and 7, the two types of information were synchronized into one stream. The result again multiplied the *Mariner 6* and 7 performance by a factor of 2.3.

(We have now explained how *Mariners 6* and 7 supplied 522.56 times as much information as *Mariner 4*.)

Interplanetary communication item 6—the broadcasting antenna aboard the spaceships. *Mariner 4*'s antenna was an elliptical dish with a major axis forty-six inches long and a minor axis 21.2 inches across. The antennae of *Mariners 6* and 7 were circular, forty inches across. The strength of a signal varies with the square of the radius of the sending antenna. The antennae on these spaceships, therefore, once again multiplied the amount of information made available to Earth—this time by a factor of 1.74.

(Our performance index for *Mariners 6* and 7 as opposed to *Mariner 4* is now up to 909.25.)

Interplanetary communication item 7—message coding. This one is hard to believe. *Mariner 4* sent its messages one bit of data at a time, at a rate of eight and one-third bits per second. *Mariners 6* and 7 transmitted their information at a rate of 16,200 bits per second and did it by complicating the message units. Instead of sending individual numbers—in the form of electrical impulses representing zeros or ones—the 1969 robot observers of Mars sent a set of numerical symbols to represent each number. Instead of 16,200 bits per second, there were 84,600 symbols per second. The system worked because a single error had less chance of passing undetected among the larger number of symbols.

To illustrate, let us take the symbols for the decimal numbers 24 and 25. They are below.

24 = 00000000111111111111111100000000

25 = 01010101101010101010101001010101

It would be difficult to mistake one of these for the other.

For contrast, let us take the number 25 in the decimal enumeration system and express it in the binary arithmetic system. Binary arithmetic uses only 0s and 1s to indicate numerical values. In a binary number the column farthest to the right has a value of 1. If there is no value of 1 to be expressed in that particular number, the column farthest to the right is occupied by a 0. Each succeeding column to the left has twice the value of the preceding column. Thus, the decimal number 1 is expressed this way as a binary:

000001.

The decimal number 2 is expressed this way

000010.

The decimal number 8 is expressed thus

001000.

With this introduction, let us return to decimal number 25, which in binary form is expressed

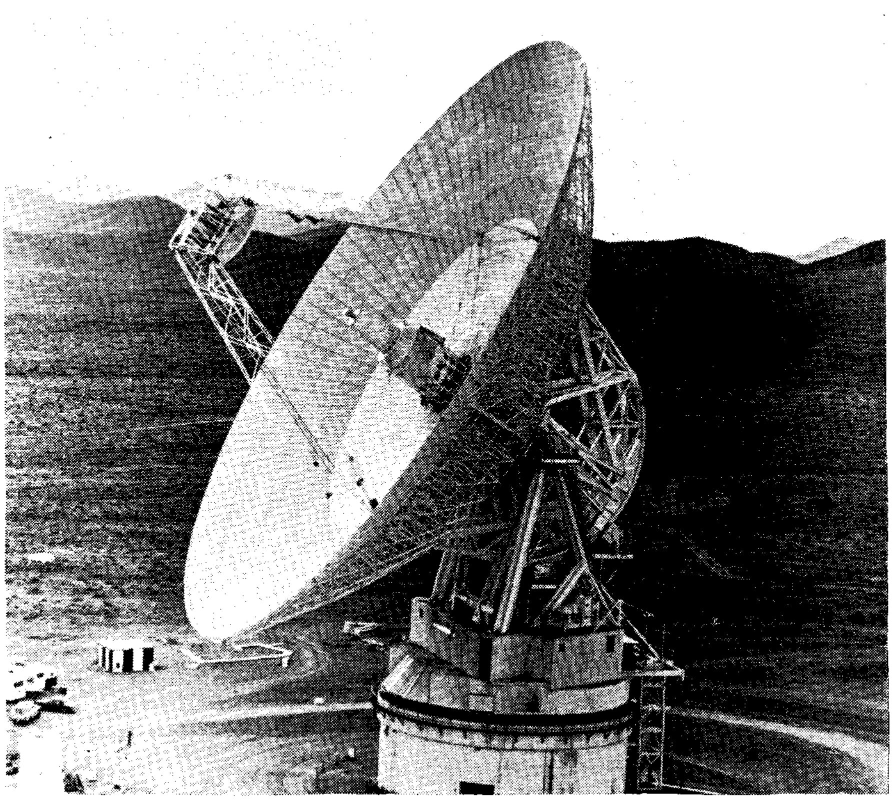
011001.

Here we have one 1, no 2s, no 4s, one 8, and one 16; a total of 25.

If the 1 in the farthest right column were to be lost in transmission, the result would be:

011000.

On the binary arithmetic scale, 011000 is not 25 but 24. The ease with



"The 210" at Goldstone catches signals from the sky in its big dish, which throws them back upward into the small saucer suspended at the base of the inverted metal V. The saucer focuses the information downward again onto the transcribing pencil.

which an error could be made between these two numbers when they are expressed directly in binary form is immediately obvious, and the consequences of such a mistake can be far worse than they appear to the uninitiated, for specific scientific meanings are arbitrarily assigned to particular numbers, and the meaning of one number sometimes departs radically from the meaning of another number.

The symbolic code system, or "block coding," as JPL engineers call it, alone made the *Mariner 6* and 7 messages 1.66 times as informative as *Mariner 4*'s had been.

Altogether, the seven interplanetary communication items we have listed rate the *Mariner 6* and 7 performance 1,509 times as valuable as the performance of *Mariner 4*. Most of the rest of the story of the brilliant success of *Mariners 6* and 7 is accounted for by engineering safety margins. In *Mariner 4*, these had to be set relatively high because *Mariner 4*'s mission had never been attempted before. But after *Mariner 4* had completed its pioneering task satisfactorily, the safety margin could be lowered to fit a more realistic definition of the assignment. This provided another source of improved efficiency for *Mariners 6* and 7—a factor of 1.25. When multiplied by the total of the earlier seven items in the interplanetary communication catalogue, it takes us up to 1,886 times the unmanned spaceship capability of five years ago. There are other items in the interplanetary communication catalogue too technical for brief elucidation in lay language; these raise the cumulative enhancement factor to 1,900 or beyond.

What did this enormous jump in efficiency cost? It isn't easy to separate particular elements in so complex a project as a spaceship voyage. JPL electronic specialists say the new electronic ear at Goldstone and apparatus associated with it cost $2-million, while the devices added to the spaceships cost $50,000. Since others might quarrel about what went into these figures and what was omitted, it is perhaps best to compare the total budgets covering all aspects of the Martian voyages. *Mariner 4* (together with its intended companion, *Mariner 3*, which was taken out of the enterprise by an accident) cost $105-million. *Mariners 6* and 7 together cost $152.1-million. These sums are mere splinters of the billions required to land a man on Mars.

What's Wrong With Objectivity?

by HERBERT BRUCKER

Half a century ago, indeed even a decade ago, critics of objectivity in reporting were few. Everyone agreed with what had been taught those of us who went into newspaper work in the first half of the century: that an accurate, unbiased account of the event reported was journalism's purest gem.

That is precisely what it was—and still is. But today objective news has become anathema to young activists in journalism, to some of the rising generation of university intellectuals, and to others who also should know better.

Not everyone will agree with the late Kent Cooper of the Associated Press, who declared in 1943 that the ideal of impartial, objective news was "the highest original moral concept ever developed in America and given to the world." Still, no one can argue away the fact that American journalism has now struggled for a century and a third to replace partisan propaganda with reporting that gets within hailing distance of the truth. And that kind of reporting is too valuable, not only to journalism but to self-government itself, to be discarded now in an emotional reaction fueled by the current political distemper.

Today's young journalists, and some of their elders, do not see the issue in terms of what is actually at stake, unprejudiced news. Oblivious to this crucial point they seem to see objective news as an obsolete convention that blocks progress toward a better world.

This trend struck me with force in recent years as I noted that able young newsmen, applying for an academic sabbatical at Stanford, repeatedly volunteered the information that their goal was something other and nobler than objective news. This, from one of them, is typical: "It is a great misfortune that many of us in the profession fail to utilize these tools (immediacy and spontaneity), and too frequently deny ourselves the full power of the moment in reporting an event because of our peculiar, and at times perverted, devotion to that which we have mislabeled objectivity."

Even some among journalism's brass have joined the crusade. Bill Moyers, who left President Johnson's inner councils to become publisher of *Newsday*, says he learned at the White House that "of all the great myths of American journalism, objectivity is the greatest. Each of us sees what his own experience leads him to see."

The late Ralph McGill often hammered home the theme that American journalism has not informed the public as it should "for the simple reason that we have been taught to worship a word—objectivity. Truth, I want. But not objectivity. . . . There isn't any such thing as objectivity, and cannot be any such thing."

Again, the British press lord Cecil King, addressing a recent convention of the American Society of Newspaper Editors, denounced "the fetish for objectivity, the fear of editorializing." American reporters, he said, "divest news of its own inherent drama. They cast away the succulent flesh and offer the reader dry bones, coated with an insipid sauce of superfluous verbiage."

Perhaps the best way to untangle all this is to define terms. The dictionaries, not surprisingly, do not support objectivity's critics. Objectivity is the state, quality, or relation of being objective. And objective means "uninfluenced by emotion, surmise, or personal prejudice." It has to do with that which is "based on observable phenomena, presented factually."

One concludes that objective news is news written as something apart from the observer and his feeling about it, like the *Ding an sich* in Kantian epistemology. But if objective news is simply impartial news, why all the fuss? Why the animosity against it on the part of some of today's more thoughtful journalists?

The reason is, I think, that the critics of objective news are not as much against objectivity as they make out. What they denounce as objectivity is not objectivity so much as an incrustation of habits and rules of newswriting, inherited from the past, that confine the reporter within rigid limits. Within those limits the surface facts of an event may be reported objectively enough. But that part of the iceberg not immediately visible is ruled out, even though to include it might reveal what happened in a more accurate—indeed more objective—perspective.

The distinction between surface news and its background was first