B-10

ACHIEVEMENTS AND OBJECTIVES

OF THE

NASA SPACE SCIENCE AND APPLICATIONS PROGRAM

by

John E. Naugle
Associate Administrator for
Space Science and Applications
National Aeronautics and Space Administration

Today is a particularly apt time to discuss the achievements and objectives of the space program. We have completed a decade of space exploration; we have met almost all of the goals we established at the beginning of that decade; we have a new administration which has stated its interest in keeping this a space-faring nation; and finally, and most importantly, we need to establish new goals for the space program for the next decade. The choice of those goals and the support of them will be determined by the assessment of the potential value of space exploration in the next decade by groups such as this.

Presented at the International Meeting of the American Nuclear Society, Washington, D. C., 13 November 1968.

I welcome the opportunity to discuss the Space Science and Applications Program with a group having a technical background that enables it to provide a realistic assessment of the value of the achievements of the space program and whose interests and activities are such as to make that an objective assessment.

What have been some of the achievements of the space program in the past ten years? I think you already know most of them. You know that we have measured compositions and surface characteristics of the Moon; that we have determined the properties of our terrestrial environment and the interplanetary environment between the orbits of Mars and Venus; that we have measured the physical properties of the atmospheres of Mars and Venus; that we have discovered stellar X-ray sources; that we have obtained world-wide cloud cover maps and watched world-wide weather patterns continuously unfold; that we have placed automatic picture transmission devices in a satellite so that local weather forecasters could receive the cloud cover maps of their immediate surroundings; that we have communicated with a three-year-old spacecraft at a distance of 42 million miles using 10 watts of power; and that we have packaged 39,220 individual electronic parts into one 575-pound spacecraft. While it is true that these are formidable scientific and technical achievements, perhaps the greatest achievement of the past decade has been the creation of a unique national capability to undertake and solve large, complex, and difficult scientific and engineering problems. Consider for a moment the enormous technical capability represented by the 400,000 people in the government, university and industry team. The space program has been extremely fortunate over the past decade to have difficult goals which have attracted creative and dedicated people. The opportunity to explore the Moon, to study the planets, or observe stellar objects in unexplored regions of the electromagnetic spectrum has attracted some of the very best scientists and engineers in this country. In addition to being exciting, the program has been challenging. It has not been easy to design scientific experiments which will work unattended hundreds and sometimes millions of miles away, transmit the data through a telemetry system and a data processing system and still give accurate results. In short, we have developed what I believe to be a new, tougher, and perhaps more competent breed of scientist--a space scientist--whose impact will ultimately be felt in other areas of research. In addition, we have conducted the program in such a way that young people are continually entering the program. By conducting a major portion of the research in universities, we have steadily brought in new graduate students--young people with fresh ideas who, even in their graduate work, have begun to gain the experience that makes them space scientists.

Similarly, the engineering challenges have created a new breed of engineer--a space engineer-who must develop equipment which will operate for long periods of time in a remote and hostile environment and which requires a minimum of weight and power and which must work the first time it is launched.

Finally, the sheer size and complexity of operations such as Surveyor or Apollo has created a new breed of managers. Bringing together a spacecraft ready to launch at the Cape from systems and components which may have been developed in many of the 50 states, to see that it is all brought together at the proper time and that it can all be fitted together, will work, and be launched on schedule, and within the costs, has been a formidable management challenge.

Thus, as we look to the future, we know that there exists in NASA, in other government agencies, in the associated university community, and in industry, large numbers of people with the requisite training and with the kind of creative, imaginative drive that this country needs to keep it in the forefront of scientific and technological development.

If you will recall the space capability of this country ten years ago when there was only a small handful of scientific groups and very limited industrial experience, and then consider the goals which were established and the achievements made in the past decade, and then recognize the tremendous capability that we now have, I think you will agree that the future accomplishments of teams will exceed our most prophetic statements if we provide the same kind of relative challenge to that capability that an Orbiting Astronomical Observatory, a Surveyor, or an Apollo provided to that pioneering group ten years ago.

Given this competent team of government, industry, and university people what should our space science and applications program be in the future?

There are four major areas that we hope to be emphasizing in the early 1970's. First of all, we want to have a vigorous planetary program. Secondly, a major lunar exploration program using both manned and automated systems. Thirdly, a similarly vigorous program in astronomy; fourth, and most urgent, a rapidly increasing space applications program.

Now let me discuss each of these major areas in detail.

<u>Planetary Program</u>

The broad objective of the planetary program is to increase our understanding of the origin and evolution of the solar system, the origin and evolution of life and the dynamic processes that shape man's terrestrial environment. The first two of these are formidable problems of natural philosophy since they bear directly on man and on man's concept of his place in the universe.

The increase of our understanding of the dynamic processes which shape man's terrestrial environment is of vital, practical importance to us here on Earth.

Although Mars, the Earth, and Venus are similar in many ways, their atmosphere and surface structure appear to be vastly different. As we gain more knowledge about the properties of Mars and Venus, we will not only increase our understanding of the origin and history of these planets and their atmospheres, but we will also be developing a community of scientists knowledgeable in the fundamental forces which determine the nature of planetary atmospheres who will, in turn, be better able to understand what we may be doing to our atmosphere and perhaps prevent us from making serious irreversible changes in our environment.

I spoke of having a balanced program in planetary exploration--what do I mean by that? There are two dissimilar strategies that we could take to planetary exploration. We could select a single planet--say Mars--as the most interesting planet to study and concentrate all of our efforts on that single planet. Alternatively, we could decide to make preliminary studies of as many different planets as we can, without exploring any planet in detail at this time.

We firmly believe that neither of those strategies are sound and what we mean by a balanced strategy is one in which we do explore in at least some depth the planet which appears to be most interesting, but we do not do that to the exclusion of the study of all the other planets. We feel that a balanced program should have both elements in it and you will see that the program I describe to you does have both elements. We also feel that a good planetary program will use both large, complex spacecraft and small, versatile spacecraft with which we can respond very quickly to new discoveries or use for specialized experiments. Just as we have used the large Orbiting Geophysical Observatories, and the small Atmosphere Explorers to study our own planet, so do we feel that we will need a mix of planetary explorers; Mariner-size flybys and orbiters, and medium and large-size landers to explore the other planets.

(Figure #1)

The first slide shows the schedule of missions that we have flown to date; those which are approved and underway at the present time; and those which we have under consideration as potential flights in the future.

The planetary spacecraft that we have successfully launched have been eminently successful. Mariner II in

1962 gave us our first direct indication that the Venus atmosphere was extremely hot.

The Mariner IV flown in 1964 gave us our first close-up look at the surface of Mars and showed that the surface pressure was much lower than we had expected. Mariner V and the Russian Venera IV, together, gave us a much better understanding of the character of the Venus atmosphere and have verified the high temperature and the high pressure on the surface of Venus.

We are following these earlier exploratory flybys with the two Mariners in 1969 shown in the next figure.

(Figure #2)

Mariner '69 will give much higher resolution pictures of the surface of Mars together with infrared and ultraviolet data to improve our knowledge of the planet's surface and its atmosphere.

We are planning to follow those two flybys with a program of orbiters and landers similar to those used in the exploration of the Moon. You will recall that we used five orbiters and seven Surveyors in a concentrated effort to explore the Moon. In the case of the planets we have to follow a more measured pace because of the infrequent flight opportunities and the need to assess the data from a given flight before commiting ourselves to a particular mission too far in the future.

Therefore, in 1971, we are planning to launch two Mariner-class spacecraft to Mars as shown in the next figure.

(Figure #3)

These spacecraft will be inserted into complementary orbits around Mars. The first spacecraft will probably orbit Mars at an inclination angle of about 60° to the equator to provide mapping of about 70% of the surface, and to allow a close-up view of the mysterious wave of darkening that has been observed from Earth-based telescopes. The second spacecraft orbit is currently planned to be at about 80° inclination. Thus, the second spacecraft can concentrate on coverage of selected areas such as the polar caps; can take oblique views of broad areas of the planet; can take pictures of the moons of Mars; or can accomplish some combination of all of these activities.

We had planned to follow these orbiters with two more orbiters and two landers to Mars in 1973. Such a program was authorized by Congress; however, the need to keep expenditures at a minimum in 1969 has forced us to re-examine that mission. We could proceed with a combined orbiter-lander system as shown in the next figure, launched on a Titan III/D Centaur or we could proceed with only a lander system which might or might not be accompanied by separately launched orbiters. We are

(Figure #4)

still in the process of defining precisely how large and what kind of landers these will be and what payload they will contain. We would like to make full use of the time between now and 1973 and the full payload capability of the Titan III/D Centaur to make those first class missions. Whether we will be limited only by time and payload capacity or whether we will be limited by funding is a major question which only the new President and the new Congress can answer.

Those are all of the approved missions we have directed towards Mars at this time. It would be logical to continue the exploration of Mars with a larger lander of the Voyager Saturn V class in 1975, followed by perhaps even larger, more sophisticated landers or a sample return at the 1977 opportunity. The return of a sample from the surface of Mars would, very likely, require the addition of a nuclear-powered stage to the Saturn V. The question as to whether we will move on to that level of planetary program or whether we will continue with Titan/ Centaur class landers depends upon the importance and resources which the new administration allocates to planetary exploration.

We plan to send a Pioneer-class spacecraft as shown on the next slide out through the asteroid belt to fly by Jupiter.

(Figure #5)

Jupiter is a planet quite unlike Mars, Venus and the Earth. It has a magnetosphere like that of the Earth but much larger in extent and with much higher radiation levels. We want to explore that magnetosphere and we also want to determine the radiation levels so that we can design spacecraft to fly close to Jupiter, perhaps orbit and begin the systematic exploration of that planet. Those are all of the planetary missions we have approved and underway at this time.

(Back to Figure #1)

You can see that we are maintaining a balanced program. We are moving systematically ahead in the exploration of Mars and we are moving out to explore other planets.

We are considering small Explorer-class orbiters to Mars and to Venus at each of the opportunities beginning in 1972. We also have under consideration a Venus/Mercury flyby at the 1973 opportunity. That would be an exciting mission, one which would enable us to obtain photographic coverage of both Venus and Mercury on the same flight.

I show this next figure to remind you of the Solar System, the comparative size of the planets and their

(Figure #7)

orbits around the Sun. One of the most exciting opportunities to explore the outer planets, Jupiter, Saturn, Uranus, and Neptune occurs in 1977 and 1978. At that time it is possible to send a spacecraft out to Jupiter, on to Saturn, Uranus, and finally to the vicinity of Neptune. While we can use solar energy for power out to about the orbit of Jupiter, once we begin to move out beyond Jupiter we will have to depend on nuclear energy for power.

The Jupiter 1972 mission will give us needed information about the hazards of interplanetary space and give us much of the technological information we will need for this "grand tour." This is an exciting and unique opportunity, one which last occurred during the administration of Thomas Jefferson and which will not occur again for 179 years. We think it would be highly fitting and symbolic of the vigor of our society if, on the 200th anniversary of the founding of this nation, we could establish as a national goal sending a spacecraft out past these major planets to the outermost regions of the solar system.

The planetary exploration program that I have outlined is a very exciting one in the 1970's. It would, however, require an increase in the resources presently being expended for this endeavor. This year NASA is allocating approximately $80 million for planetary exploration. To accomplish this program that I have just outlined requires a budget over $200 million by 1972, and approaching $300 to $400 million by the mid-1970's.

Lunar Exploration

What are our plans for lunar exploration? The past feats of such spacecraft as Ranger, Surveyor and Lunar Orbiter are now a matter of history.

They have detailed the face of the Moon, revealed its far side, measured its bearing strength and gross chemistry and located landing sites for Apollo. Shortly, Apollo will commence the missions which will place man on the Moon's surface.

Lunar exploration is directed toward obtaining answers about the Moon, the Earth and the solar system to achieve some of the same objectives that I have just outlined for planetary exploration. The first manned lunar landing will return rock samples from the surface and deploy the same geophysical instruments to obtain data as the lunar interior and precise measurements of subtle changes in the size of the lunar orbit.

The answers to basic questions on the Moon's history, gross composition, and overall degree of chemical differentiation cannot come from samples collected in two or three relatively small areas on the Moon, particularly if chemical variations are large. Investigations of significant portions of the Moon's surface are necessary to obtain answers to fundamental processes. Studies of the surface are needed at several different locations where the contacts and structural relations between different mappable units are best exposed and at locations where features of special interest occur. In order to learn more about the deep interior of the Moon, additional passive seismology may be profitable. Measurements of heat flow from the interior of the Moon and will also provide essential information on the distribution of radioactive elements and the thermal history, including volcanism.

What kinds of flight programs would be required to obtain this and other information? We have several possible programs under study. They differ in degree and rate of achievement of scientific objectives. For illustrative purposes, I will briefly describe one of the more ambitious and hence, more interesting options.

After the initial landing of man on the surface of the Moon in late 1969, it is hoped that additional landings using the Apollo system can be undertaken to explore features of the lunar surface. These missions would have the same capability as Apollo and would deposit the Apollo Lunar

Surface Experiment Packages (ALSEP) and return lunar samples from several types of terrain in order to determine the degree to which the Moon is chemically differentiated.

Studies have indicated that upon the successful completion of several Apollo landings, an extended lunar module is desirable. Such an uprated system would permit up to three days on the lunar surface and would give the astronaut

(Figure #8)

additional mobility by means of a lunar flying unit in order for him to investigate interesting areas away from the immediate landing site. Additional instruments such as advanced ALSEP's and a surface drill could be carried.

One of the program options under study shows this

(Figure #9)

system evolving into what is called a dual launch mission by the mid-1970's. By using the Saturn V's, one to land cargo and the other to place man on the surface, stay times of the order of seven to twelve days could be achieved.

This would permit much greater surface mobility by

(Figure #10)

means of lunar flying units and also surface roving vehicles. In addition, scientific instrumentation capability would be increased substantially.

These systems would permit a reasonable accomplishment of the stated objectives. However, the resources that would be available for the lunar exploration program and hence, the rate of accomplishment will be dependent upon the relative amount of emphasis that the new administration places on achieving these objectives vis-a-vis the objectives associated with manned earth orbital workshops, space applications or planetary exploration.

Astronomy

I would now like to turn to the Astronomy Program.

Before I discuss the Space Astronomy Program, I want to remind you of the reasons why we think it is important to make astronomical observations in space. If you look back over the history of astronomy you cannot help but be tremendously impressed by the knowledge that has come from our observations of the stars. We have gained our understanding of gravitation and the nuclear processes taking place in stars. The results of the astronomers' work has changed our whole concept of man, of the Earth, of the place of the Earth in the solar system, and the solar system in the universe. You know that it was through the work of astronomers and physicists attempting to understand the nuclear processes in the stars which, together with the work in the laboratory, led to our ability to use nuclear energy.

As I am sure you are all aware, the whole field of astronomy is in turmoil today. New discoveries are made almost on a day-to-day basis. The discovery of quasars and the new pulsars all indicate that we are observing processes which are capable of generating almost unimaginable amounts of energy and which we do not yet begin to understand.

Sounding rockets have made the first contributions to our knowledge of the UV spectrum of the planets and a few of the brightest stars, and have provided low resolution UV and X-ray images of the Sun. In addition, an aircraft flying above 40,000 feet is providing low resolution infrared spectra of the brighter planets and a few stars.

(Figure #11)

The Orbiting Astronomical Observatory (OAO) is the largest, heaviest, and most complex satellite under development today. It will provide extended periods of precise observations of objects in the ultraviolet portion of the spectrum which is not observable from the ground. OAO-A2, with a launch scheduled for the Fall of this year, will map the sky in the UV and determine stellar energy distributions and emission line intensities of diffuse nebulae. Two more missions are to be launched in 1969 and 1970.

The three approved launches will carry progressively more refined telescopes up to one-meter aperture, but will fall short of diffraction-limited performance by an order of magnitude. Therefore, the next important step is to refine the performance to the diffraction limit, with versatility and reliability, probably enhanced by the occasional participation of an astronaut. Such a telescope system is being studied under the name "ASTRA." Although all of the details of the system are not yet defined, program development is paced so that the first ASTRA could be launched in the mid-1970's. Prior to this time, however, studies indicate a need for additional OAO missions.

From sounding rockets and the first four Orbiting Solar Observatories (OSO's), NASA's solar physics program has confirmed that the solar atmosphere during active periods is probably not in local thermal equilibrium, and has helped to establish that: (1) the physical scale of the solar atmosphere during active times is smaller than previously believed; (2) the soft and hard X-ray spectra are characterized by variability; and (3) the optical definition of a solar flare is inadequate, and correlations between optical, radio, and X-ray events are needed. OSO-III and OSO-IV, launched in March and October 1967, respectively, are still providing scientific data. The remaining OSO program, OSO's F, G, and H, will provide a further measurement of the variability of extreme UV and X-ray spectra over a portion of the solar cycle different from that during observations made by previous spacecraft.

(Figure #12)

The Apollo Telescope Mount (ATM) will allow man to make astronomical observations from a space platform for the first time in 1971. The first ATM will provide improved spatial and spectral resolution of 5 arc seconds observations of transient activity on the Sun. Under study for future ATM flights are X-ray, gamma ray, and UV stellar and planetary experiments.

In radio astronomy, sounding rockets have mapped the low frequency radio spectrum to wavelengths below the ionospheric cutoff. Experiments on the Orbiting Geophysical Observatory, geostationary satellites and the Interplanetary Monitoring Platform (IMP) satellites provide measurements of the galactic background at several low frequencies and fragmentary data on solar and Jupiter radio emissions. The radio astronomy Explorer-A, launched last July, will map our galaxy at various frequencies. Very large apertures (up to 10 kilometers) will eventually be necessary to achieve sufficient angular resolution in the one megacycle range in order to study individual sources. Because of the cost involved in launching these large radio telescopes or interferometers, they may have to be deferred until the 1980's.

Turning now to the space physics program, its objectives can be divided into three areas: Those associated with the Earth's environment, those associated with interplanetary and galactic space and those associated with the use of space as a physics laboratory.

A general description of the Earth's environment out to about 60,000 kilometers is already possible. Magnetic fields, particle types, energies, and densities are known, but the important electric fields have yet to be measured. Still unanswered are the basic questions about trapping mechanisms, possible acceleration of particles inside the magnetosphere, most of the factors controlling the trapping lifetime, and the mechanisms that produce sudden changes in particle population. Although we are not able to predict precisely which of these questions will be resolved by the mid-1970's, it can be predicted that a number of the important mechanisms can be identified by using results from such upcoming spacecraft as IMP, Small Scientific Satellites, Pioneers and atmospheric explorers.

Exploration of interplanetary space near 1.0 astronomical units has been performed with Mariner and Pioneer spacecraft. However, no spacecraft has yet explored the solar system inside the orbit of Venus or outside the orbit of Mars. The region to within 0.3 astronomical units from the Sun and out to the orbit of Jupiter can be explored by the mid-1970's. In the past, the exploration of uncharted regions has always led to unexpected discoveries that were more important than the planned investigations.

The flux of cosmic rays in the galaxy plays an important role in many models of galactic evolution. Since direct measurements outside of the solar system are not yet feasible, the actual galactic flux has to be deduced from measurements inside the solar system together with a knowledge of the gradient. A measurement of this gradient for protons and alpha particles between 1.0 and 5.0 AU are a high priority objective of the space physics program.

And lastly, the use of space as a Physics Laboratory is planned to capitalize on three of its unique properties: (1) the difference of gravitational potential between the surface of Earth and a synchronous orbit at 20,000 miles; (2) the zero G and high vacuum environment; and (3) the availability of cosmic rays with energies above 100 bev.

<u>Space Biology</u>

The objectives of space biology are to gain new fundamental biological knowledge by using space flight as a research laboratory. This new knowledge will find application in medicine, public health, and continuing space efforts.

In order to obtain these objectives, carefully selected and controlled experiments are being flown to provide a broad survey of biological effects from the space environment, preliminary to more detailed studies to determine the mechanisms of response and adaptation of organisms.

In the 3-day biosatellite, 13 experiments were flown under carefully controlled conditions. Two fundamentally important discoveries were made that will have far reaching importance. It was shown that there is a positive interaction between weightlessness and radiation. This interaction, depending on the organism used, varied between increasing the effects of radiation fourfold, to decreasing the effect significantly. The organisms tested included tradescantia plants, parasite wasps, flour beetles, vinegar gnats, mold spores, and bacteria.

Other experiments, designed to study the biological effects of weightlessness alone showed gravitational responses in wheat and pepper plants, and for the systems studied, confirmed the validity of a method of rotating plants on a clinostate on Earth to simulate zero-G conditions.

Experiments which are presently approved or assigned to approved missions through 1972 will assist in making broad surveys of the effect of space flight, especially weightlessness and circadian rhythms. The remainder of the present biosatellite program is planned for flight from 1969 to 1972.

(Figure #13)

The effects of 30 days of weightlessness will be studied on the central nervous, cardiovascular, and musculo-skeletal systems, and the behavioral and metabolic processes of a pigtail monkey. The biological effects of 21 days of orbital flight will be studied on the total body composition and circadian rhythms of rats. The effect of weightlessness will also be studied on human tissue culture cells and on the growth and development of a plant completing its entire life cycle in orbit.

Experiments on weightlessness and circadian rhythms of four different biological organisms have been assigned payload space for flight within the Apollo Applications Program. These experiments will help determine the effects of removing orga-nisms from certain periodicities associated with Earth's daily rotation.

The projects being considered through the mid-1970's include orbital flight experiments on additional biosatellites and manned earth orbital space laboratories, to continue the study of the effects of weightlessness, radiation combined with weightlessness, and of changed periodicities on circadian rhythms for various organisms.

Next I want to discuss our plans to apply the knowledge and technology to the solution of our practical problems here on Earth.

Space Applications

As I mentioned earlier, we plan to place increased emphasis on the Space Applications Programs. This effort is actually five different programs, consisting of Meteorology, Communications, Earth Resources, Geodesy, and Navigation and Traffic Control. The basic objective of the Space Applications Programs is to use space science and technology to assist in fulfilling basic needs and desires of society.

Since my time is limited, I will restrict my discussion here to the three discipline areas where we see the potential for the greatest payoff in the next decade: Meteorology, Communications, and Earth Resources.

I would like, first of all, to consider the Meteorology Program, consisting of Tiros, the Tiros Operational Satellite (TOS) which is operated and funded by the Environmental Science Services Administration of the Department of Commerce and the NASA funded Nimbus satellites and the meteorological experiments on the Applications Technology Satellites, otherwise known as ATS.

The ESSA's TOS System has been operational since 1966. The Tiros-M (shown in the next figure) under development

(Figure #14)

by NASA and to be launched in the second quarter of 1969 is designed as a prototype for an improved operational system combining routine day and night cloud mapping for global recorded data and for a direct readout to local users all in one spacecraft. Daylight capabilities alone have required two spacecraft up to now.

Meteorologists would like to be able to make more accurate, longer range weather predictions. In order to accomplish this for periods of up to two weeks, parameters needed for the general circulation model include atmospheric temperature and pressure, and the wind vector all as a function of latitude, longitude, and height. Present developments in the supporting research program and the Nimbus flight program have lead to the expectation that vertical profiles of atmospheric temperature and profiles of water vapor and ozone can be obtained by using satellites. The capacity for simultaneous measurements of the atmospheric density field must be developed through a broad-based supporting research program and Nimbus flight experiments in the early 1970's. Wind measurements at cloud levels are now being inferred from cloud field observations made with the ATS I and III satellites. Better techniques will be developed for cloud measurements from synchronous altitudes by use of the ATS F and G now under development. We expect to initiate development, in conjunction with ESSA, of an operational synchronous meteorological satellite to capitalize on the technology.

While we have already come a long way in the field of space meteorology there is a need to continue the Nimbus and the ATS programs through the 1970's to continually improve sensors and operational techniques. As these improvements are completed, they will be used in the operational systems of ESSA.

The next area where space technology has already had and will continue to have a large impact on society is in the field of communications. I will not go into detail as to the accomplishments in this field since they are probably well known to you. The capability for providing high quality satellite communications links for voice, television and data transmission between central ground stations has been developed, demonstrated and reduced to commercial operational practices.

In order to meet the rapidly increasing demands of this country and the developing nations of the world for advances in the communications aids to mass education, world-wide information networks and for the establishment of regional and national TV broadcast services, NASA has undertaken the development of the space technology that might serve some of these needs. We are developing the technology of higher powered satellite transmitters and high gain antenna that will be required to permit transmission of broad-band signals such as TV to even smaller and cheaper ground stations. We are exploring with the Indian government the possibility of conducting a cooperative experiment in which we would make our planned ATS-F satellite available to them for an extended period. They would establish all ground stations, including relatively ground receiving stations in thousands of villages and would develop and transmit instructional television programs by means of the satellite.

(Figure #15)

This research and development for improving communication capability will be conducted with future Applications Technology Satellites (ATS) type at synchronous altitude. ATS I and III are now functioning in orbit. The ATS IV mission failed due to a launch vehicle malfunction.

ATS E will be launched next year and F and G will be launched in 1972 and 1973. However, in order to accomplish these objectives, additional ATS's will be required at the rate of approximately one per year throughout the 1970's.

The next area of the Space Applications Program that I would like to discuss is the one that perhaps has the highest potential for improving the economic and social well-being of all mankind. I am speaking of the Earth Resources Survey Program. This program is really many programs grouped under one heading. It includes such disciplines as agriculture, forestry, oceanography, geography and cartography, geodesy and hydrology.

The photographs of the Earth taken from the Gemini spacecraft have demonstrated the capability of surveying Earth Resources from space. In addition, the data from Nimbus, ATS, and Apollo have demonstrated that multi-spectral observations from Earth-orbiting spacecraft will give man the ability to inventory the Earth and in addition to detect such incipient dangers as crop and forest damage, air pollution, water pollution and erosion.

The Earth Resources Survey Program activity thus far has emphasized development of the proper sensors to acquire this specialized data, interpretation of the sensor measurements in terms that the user requires and the development of the proper techniques and procedures for processing and disseminating the data.

This effort has been carried out under the supporting research program and by means of aircraft flights to test our sensors and obtain Earth resource data. However, as in most complex undertakings, you are not aware of all of the problems until you actually begin to experiment with a real system. Therefore, as the next step towards realizing the potentials of surveying Earth resources from space we hope to develop an Earth Resources Technology Satellite for experimental missions in the early 1970's.

Since this field of Earth resources is so broad and encompasses many different requirements, there may be a need for several such satellites by the mid-1970's, supporting the different needs of the many users. Such a totally new information system will truly revolutionize our understanding and management of the Earth resources.

Summary

In summary I feel the achievements we have made in the past ten years have been very impressive. We have developed an impressive capability, especially in terms of the competent and creative people who make up our government-university-industry team. This team is prepared to accomplish any goal in space exploration which the new administration may establish.

In the future we see a broad, balanced, Planetary Program emphasizing the exploration of Mars, but also moving out and examining such other planets as Mercury and Jupiter. Secondly, we expect a major Lunar Exploration Program in the 1970's, involving and making the best use of both man and automated systems since they are the keys to unlocking the many secrets the Moon has guarded for millions of years. Thirdly, we plan to have a similarly broad and balanced program in astronomy, covering not only conventional optical astronomy, but also the newly evolving fields of X-ray and gamma ray together with low frequency radio astronomy. Finally, and most important, we plan to place ever-increasing emphasis on our Space Applications Programs with major efforts toward exploring the potential of surveying the

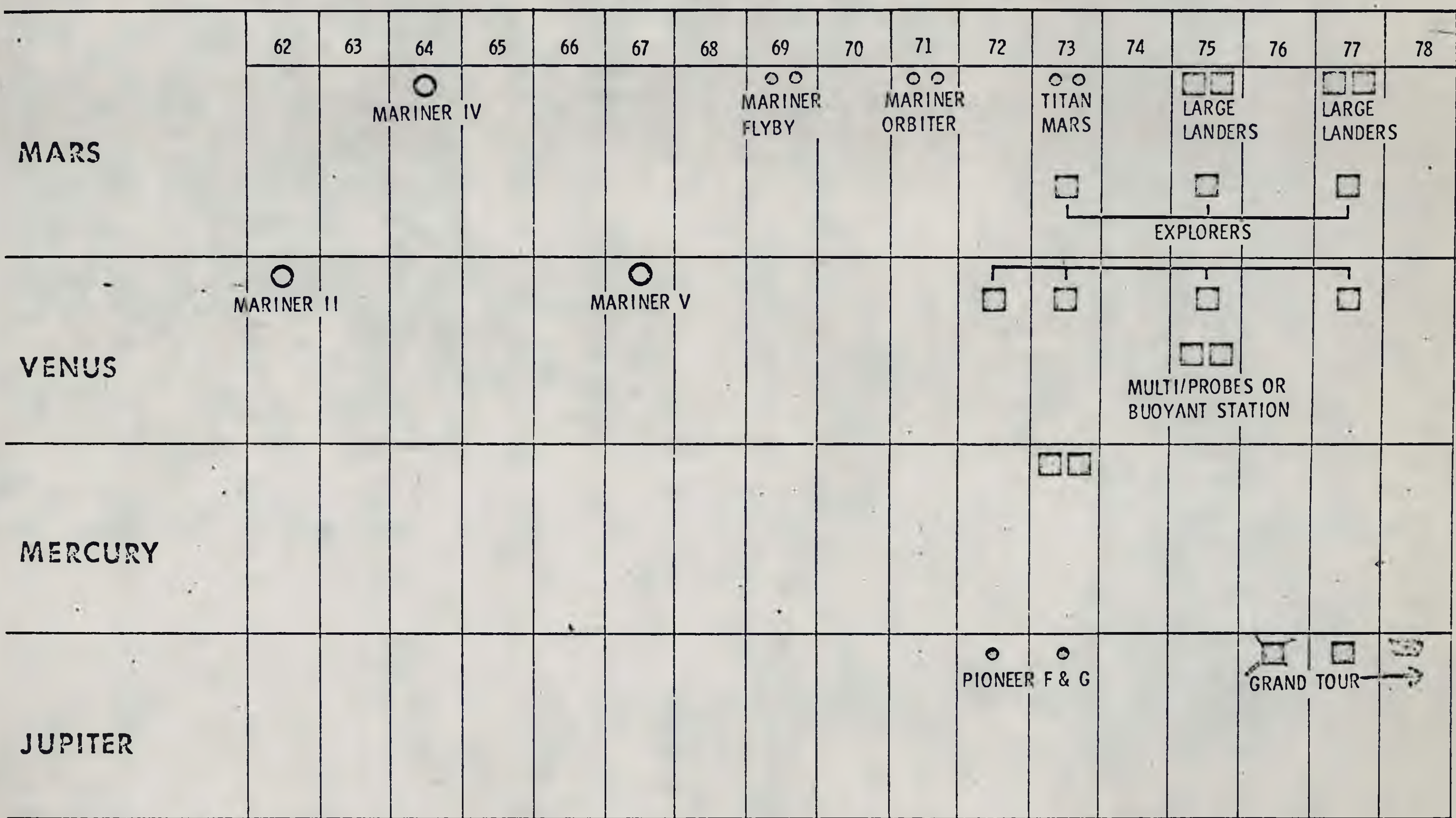
Earth's resources from space and continuing developments in the meteorology and communications fields.

We think our descendants will be proud of the achievements of the first decade of the space age. We think we have the capability and opportunity to make them even more proud of the achievements of the second and third decade. We think they will be very critical of us if we do not capitalize on this capability and these opportunities.

LIST OF FIGURES

(1)

PLANETARY EXPLORATION



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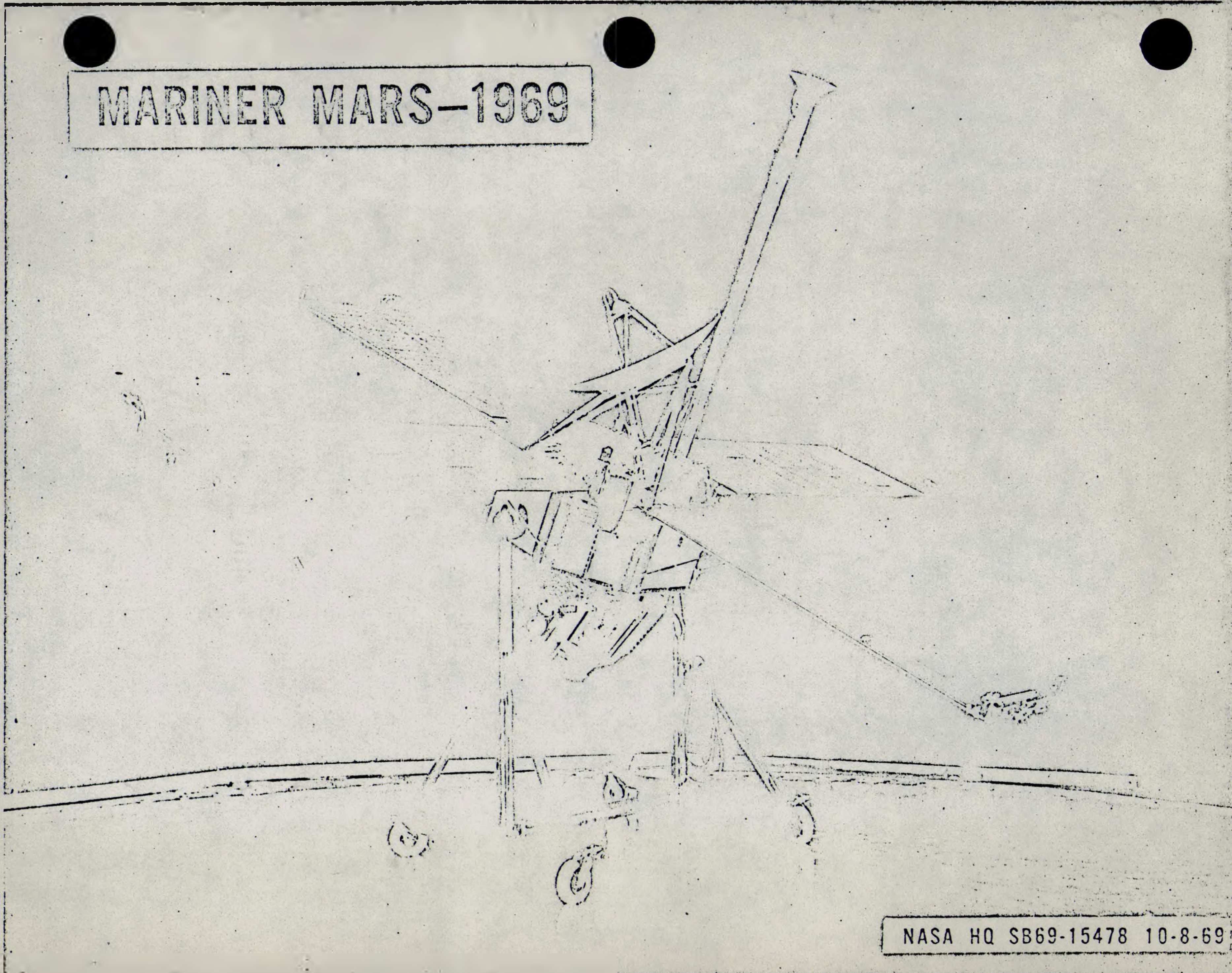
COMPLETED MISSIONS
APPROVED MISSIONS
POTENTIAL MISSIONS

MARINER MARS—1969



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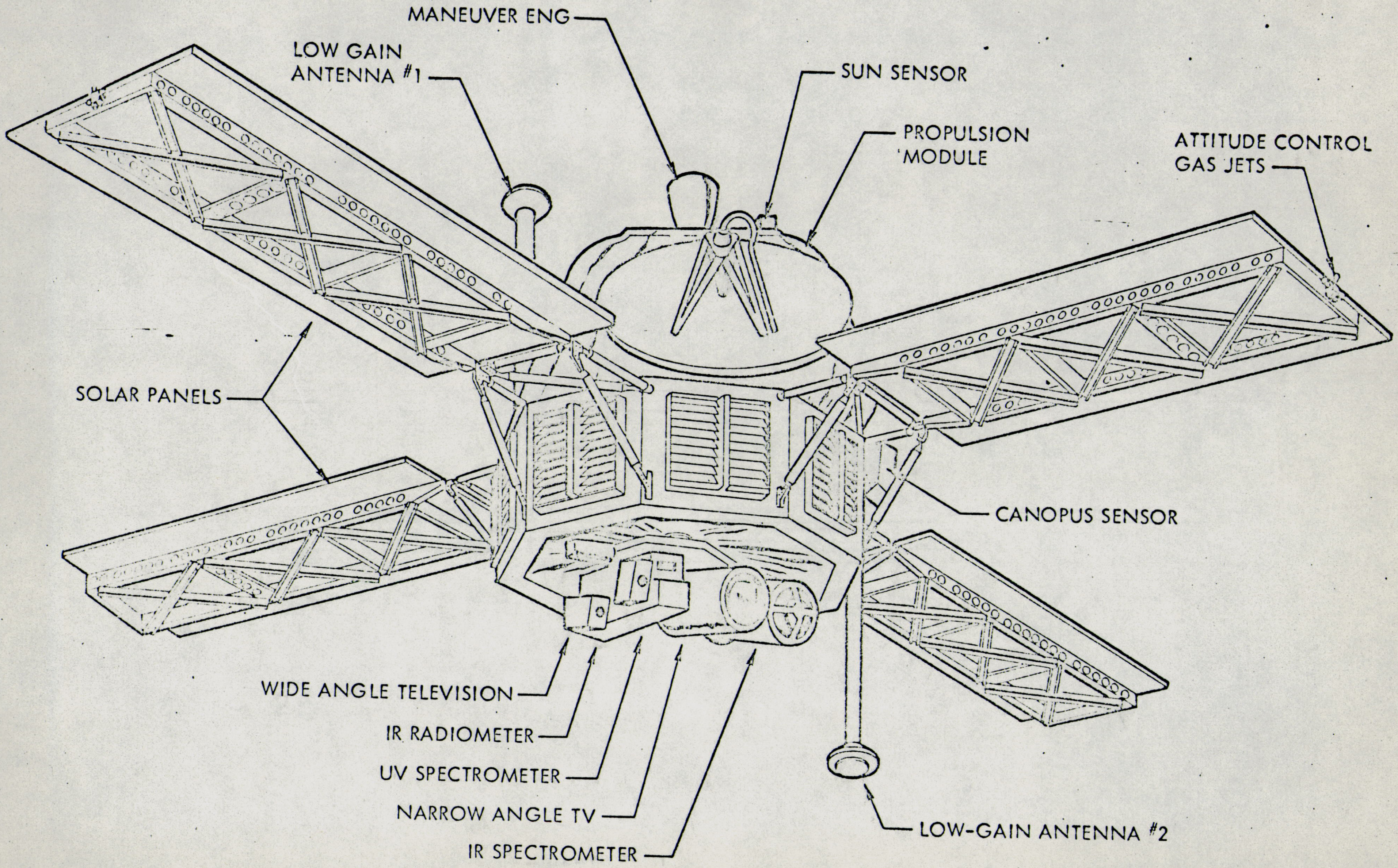
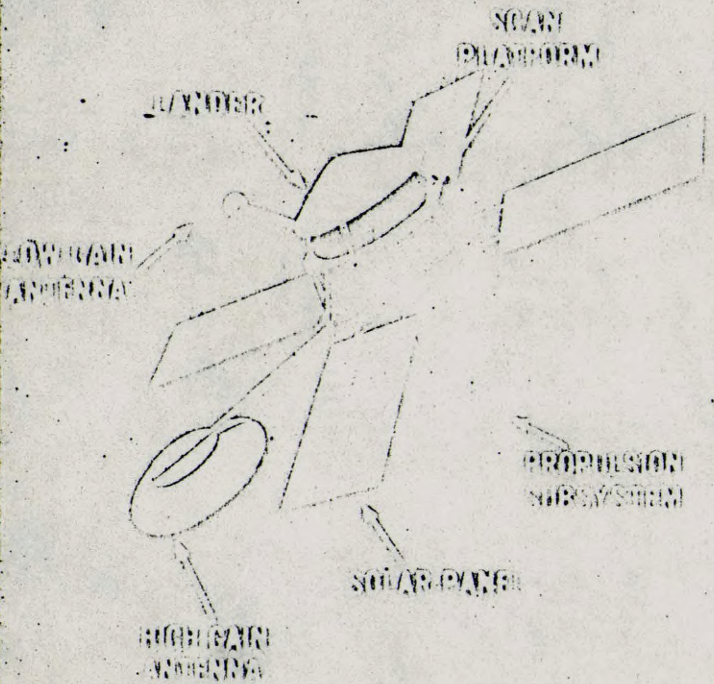

MANEUVER ENG
LOW GAIN ANTENNA #1
SUN SENSOR
PROPULSION MODULE
ATTITUDE CONTROL GAS JETS
SOLAR PANELS
CANOPUS SENSOR
WIDE ANGLE TELEVISION
IR RADIOMETER
UV SPECTROMETER
NARROW ANGLE TV
IR SPECTROMETER
LOW-GAIN ANTENNA #2

TITAN MARS 1973 ORBITER PROBE-LANDER MISSION

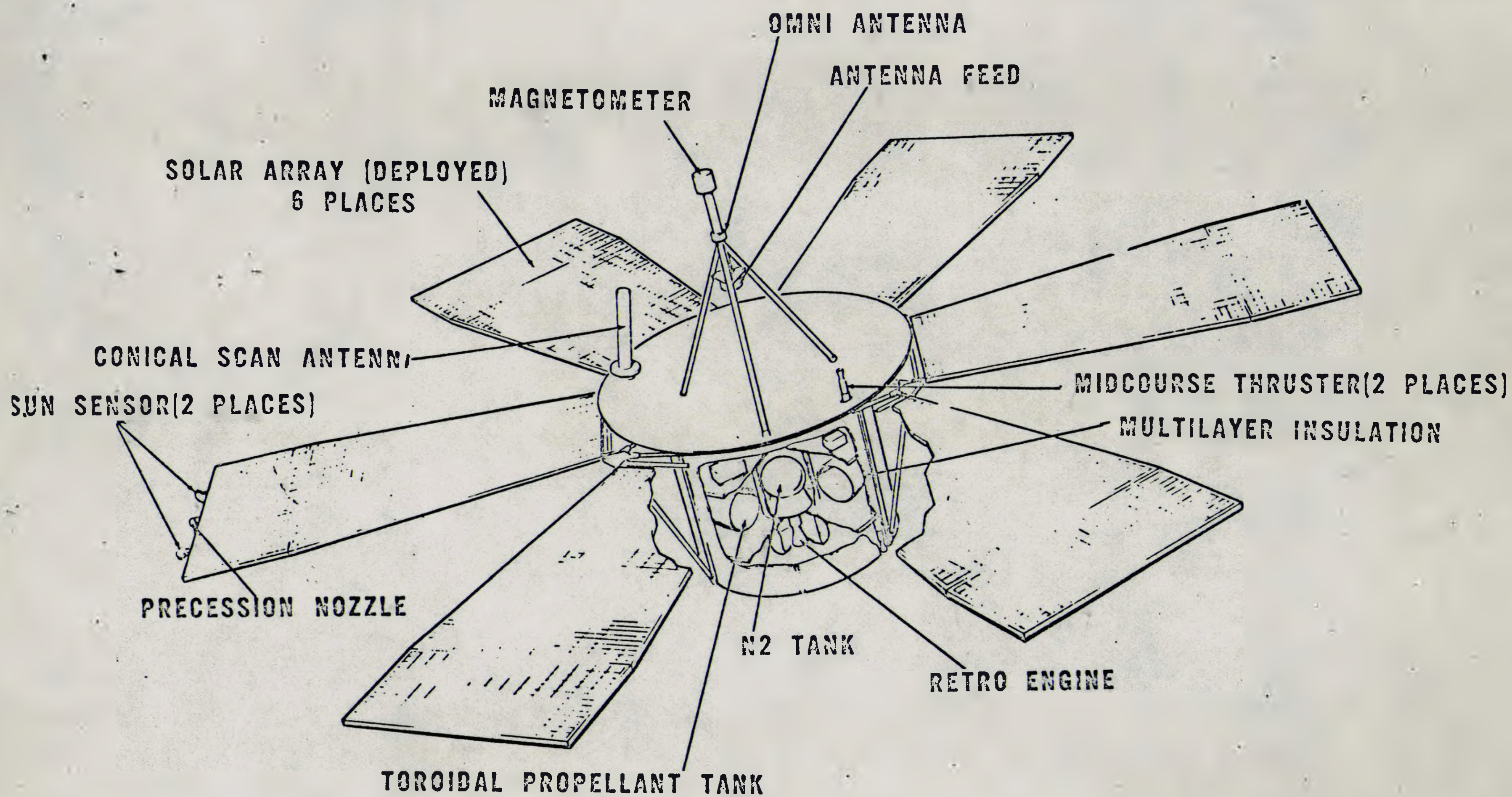
PRELIMINARY



	ORBITER	~~PROBE~~ - LANDER
GROSS WEIGHT IN ORBIT	[illegible] POUNDS	[illegible] POUNDS
SCIENTIFIC PAYLOAD	150-200 POUNDS	45 POUNDS ENTRY 20 POUNDS SURFACE
INVESTIGATIONS	TELEVISION IR RADIOMETER IR SPECTROMETER UV SPECTROMETER S BAND OCCULTATION CELESTIAL MECH- ANICS	ENTRY ACCELEROMETERS PRESSURE TEMPERATURE ATM. COMPOSITION SURFACE CAMERA ATMOSPHERIC COMPOSITION SOIL ORGANIC ANALYSIS LIFE DETECTION WATER DETECTION
POWER	400-500 WATTS	
STABILIZATION	3 AXIS	
DESIGN LIFE	180 DAYS CRUISE 180 DAYS ORBIT	ONE DIURNAL CYCLE
LAUNCH VEHICLE	TITAN III D CENTAUR	
LAUNCH	MAY 1973	

NASA SL68-576 Rev. 10-5-68

PIONEER ASTEROID/JUPITER



SPIN AXIS IN THE ECLIPTIC

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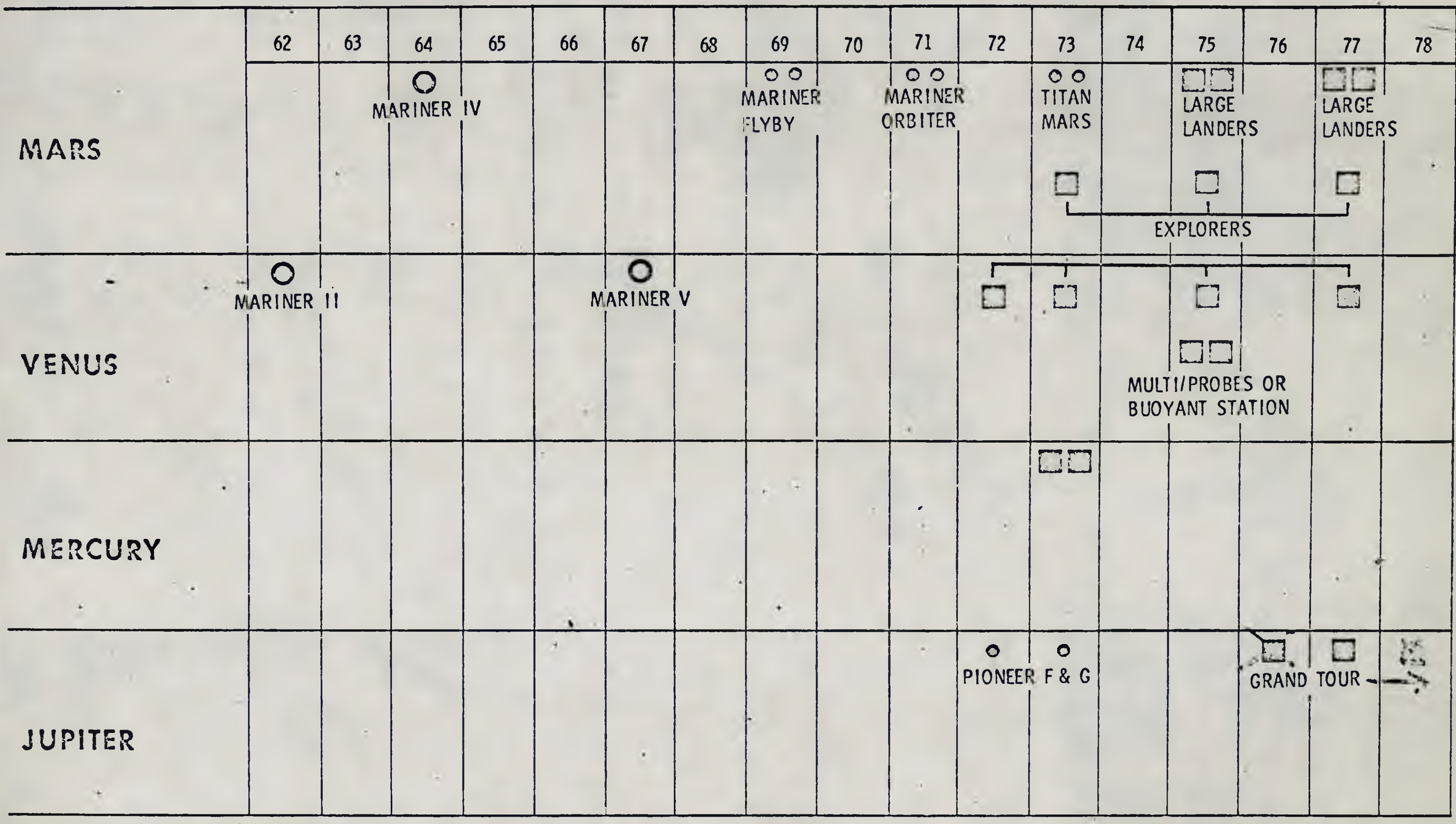
5-17-68

PLANETARY EXPLORATION



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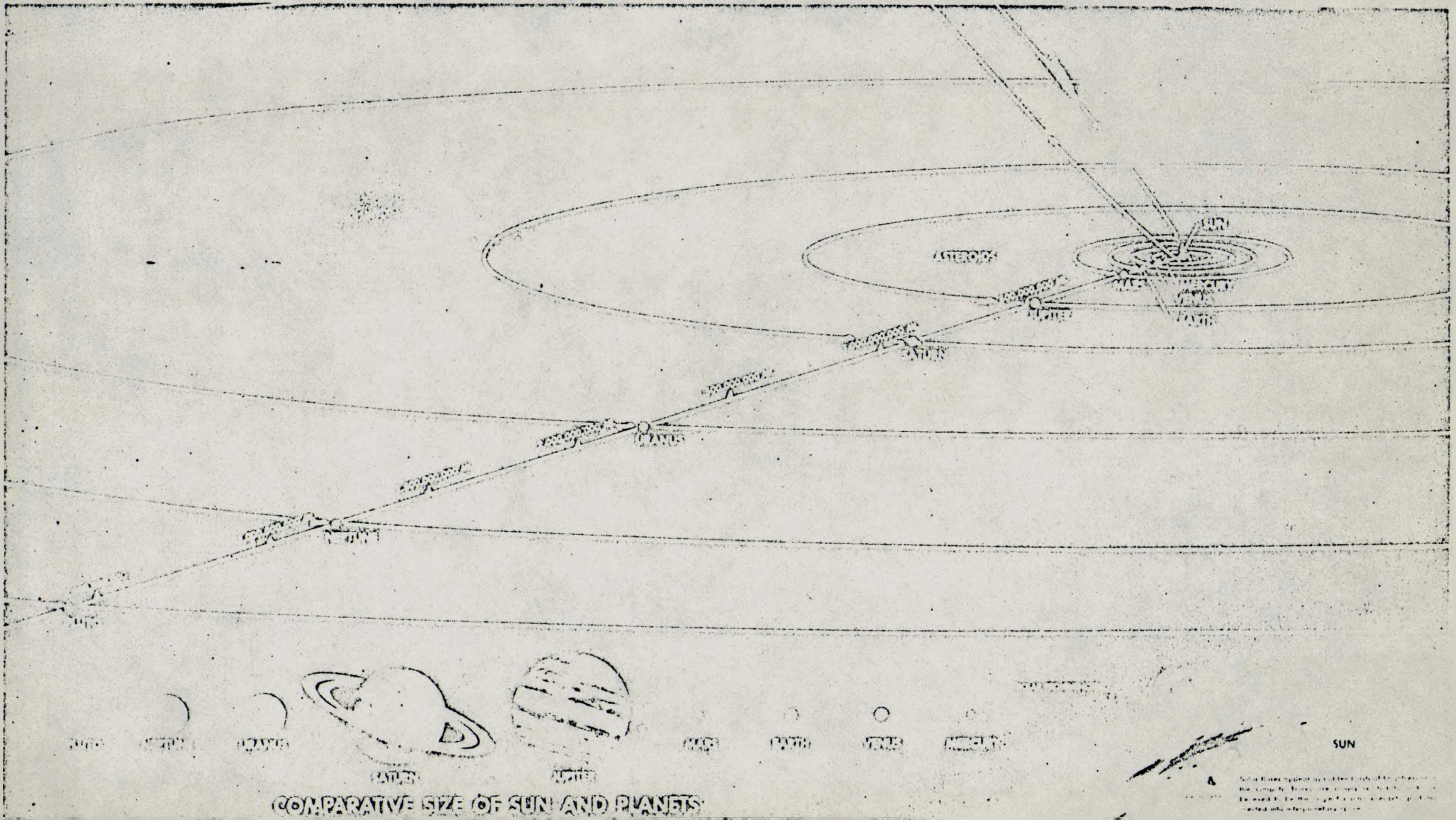
COMPLETED MISSIONS

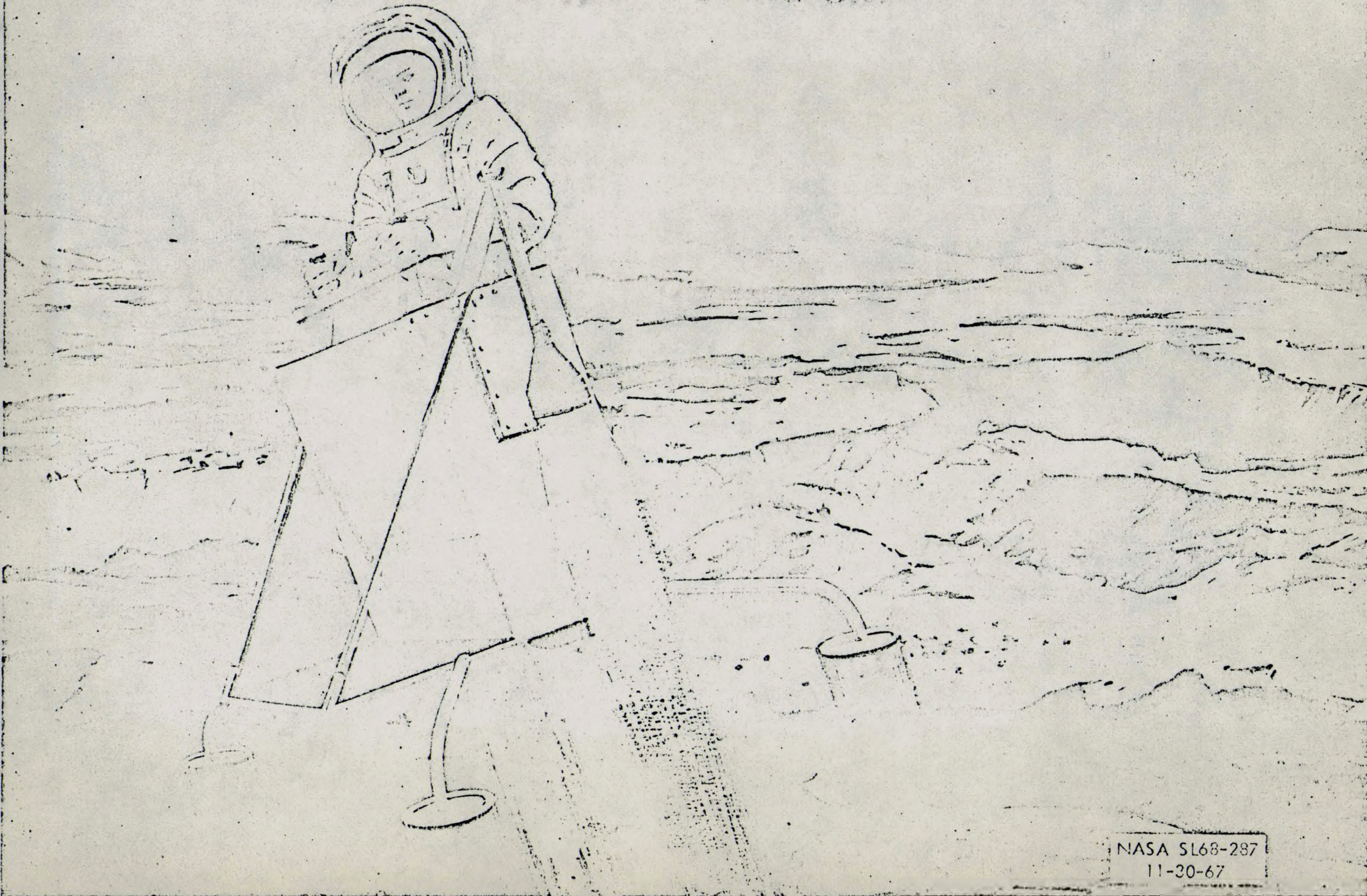
APPROVED MISSIONS

POTENTIAL MISSIONS

THE SOLAR SYSTEM



LUNAR FLYING UNIT



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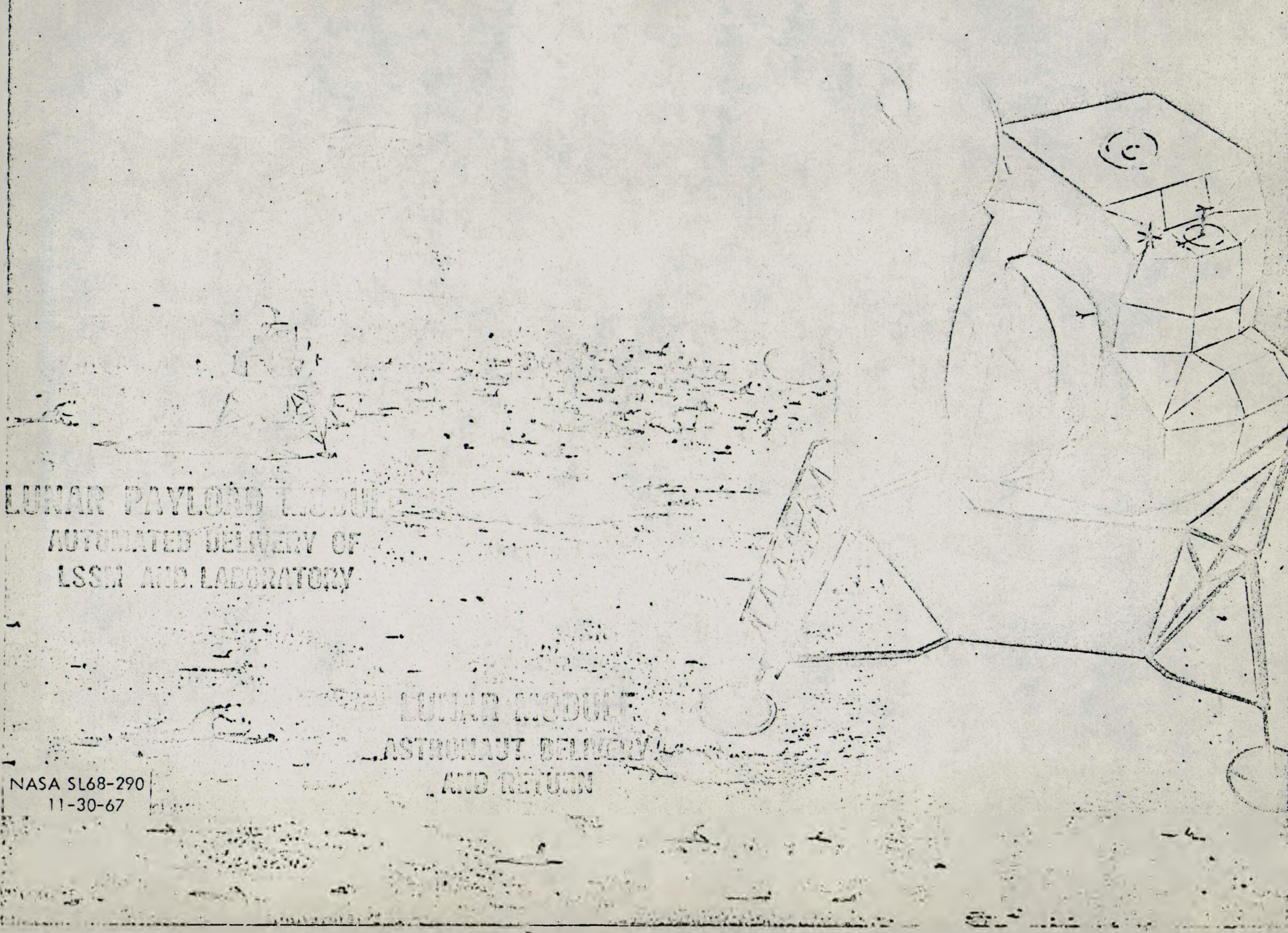
11-30-67

RENDEZVOUS ON LUNAR SURFACE



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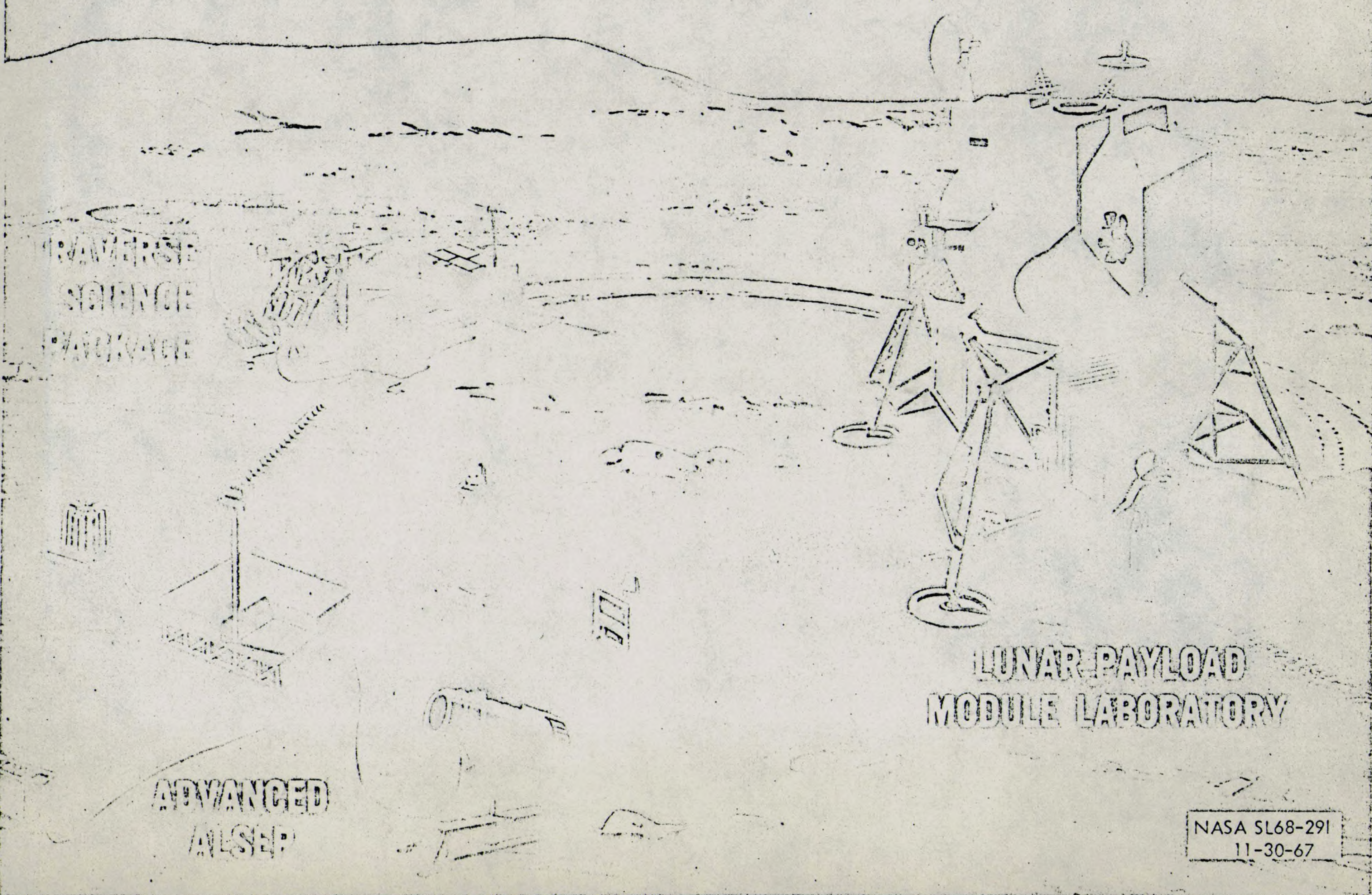
11-30-67

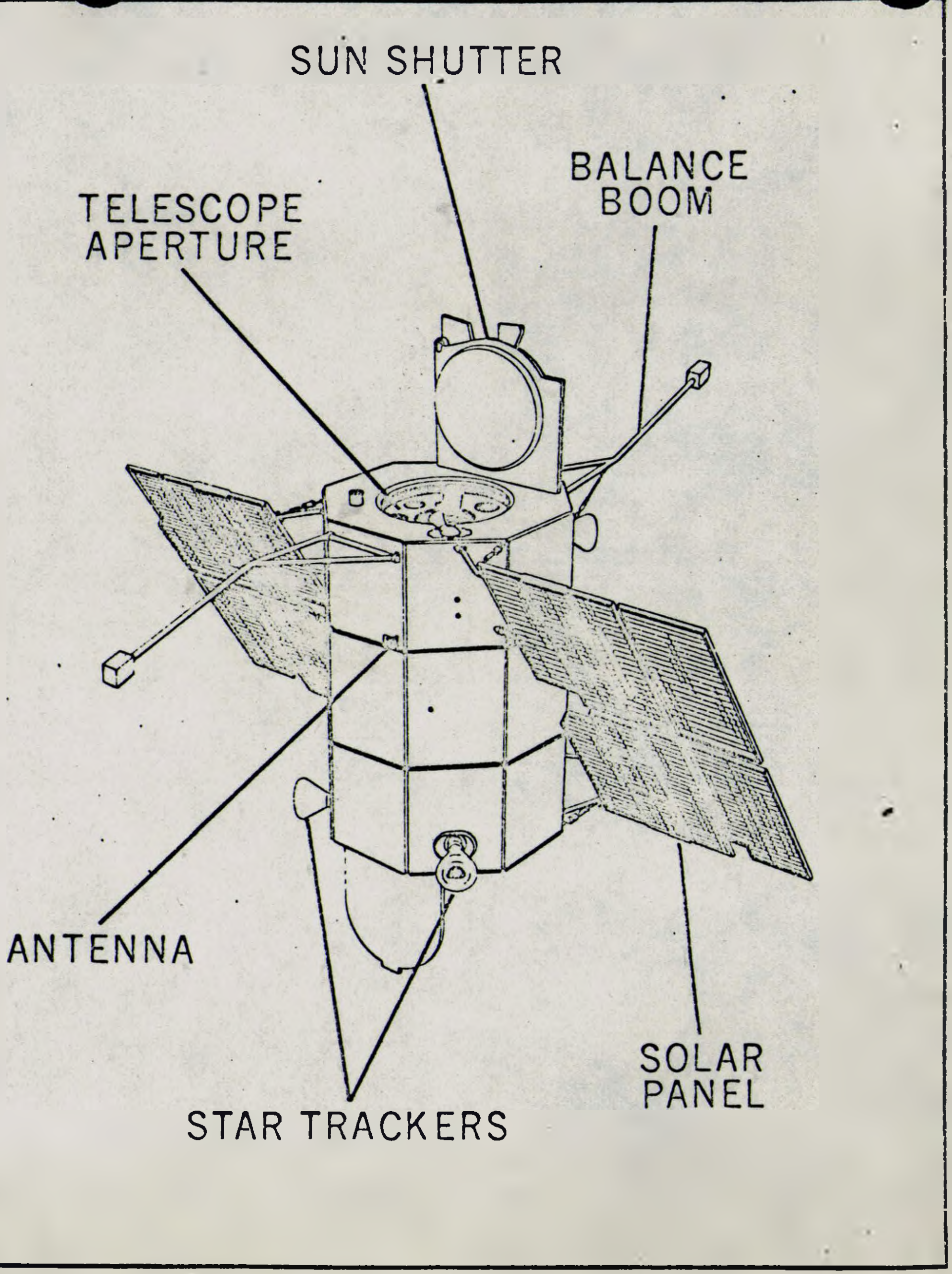
EXPERIMENTS ON LUNAR SURFACE



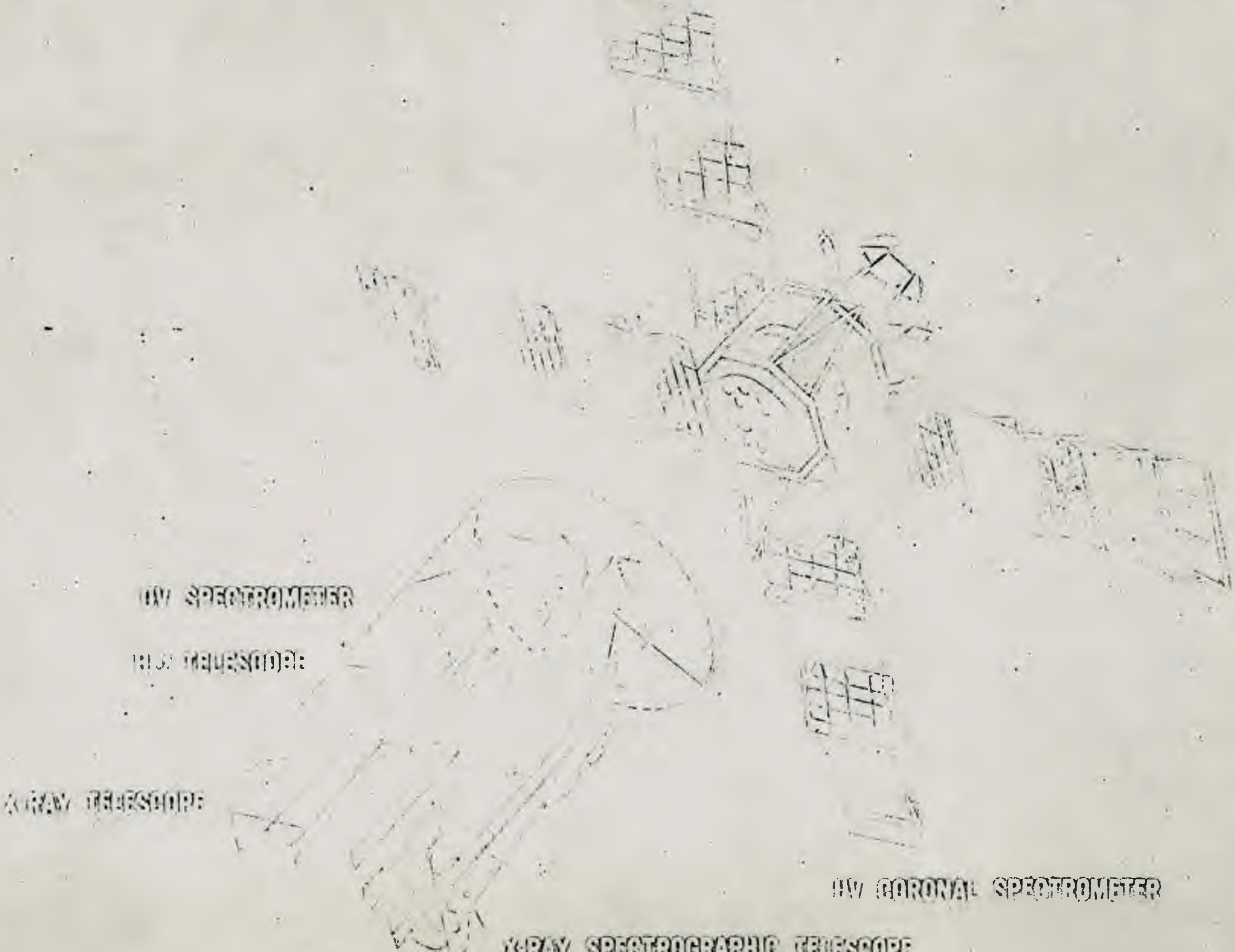
NASA SL68-291
11-30-67

ORBITING ASTRONOMICAL OBSERVATORY-A2

GROSS WT.	- 4,400 LBS.
INSTRUMENT WEIGHT	- 1,000 LBS.
INSTRUMENT PAYLOAD	- 11 TELESCOPES
STABILIZATION	- ACTIVE 3-AXIS (6 STAR TRACKERS)
POINTING ACCURACY	- 1 ARC MIN.
ORBIT	- CIRCULAR, 480 S. MI. INCLINATION 35°
LAUNCH VEHICLE	- ATLAS/ CENTAUR



SOLAR APOLLO TELESCOPE MOUNT
ATM-A



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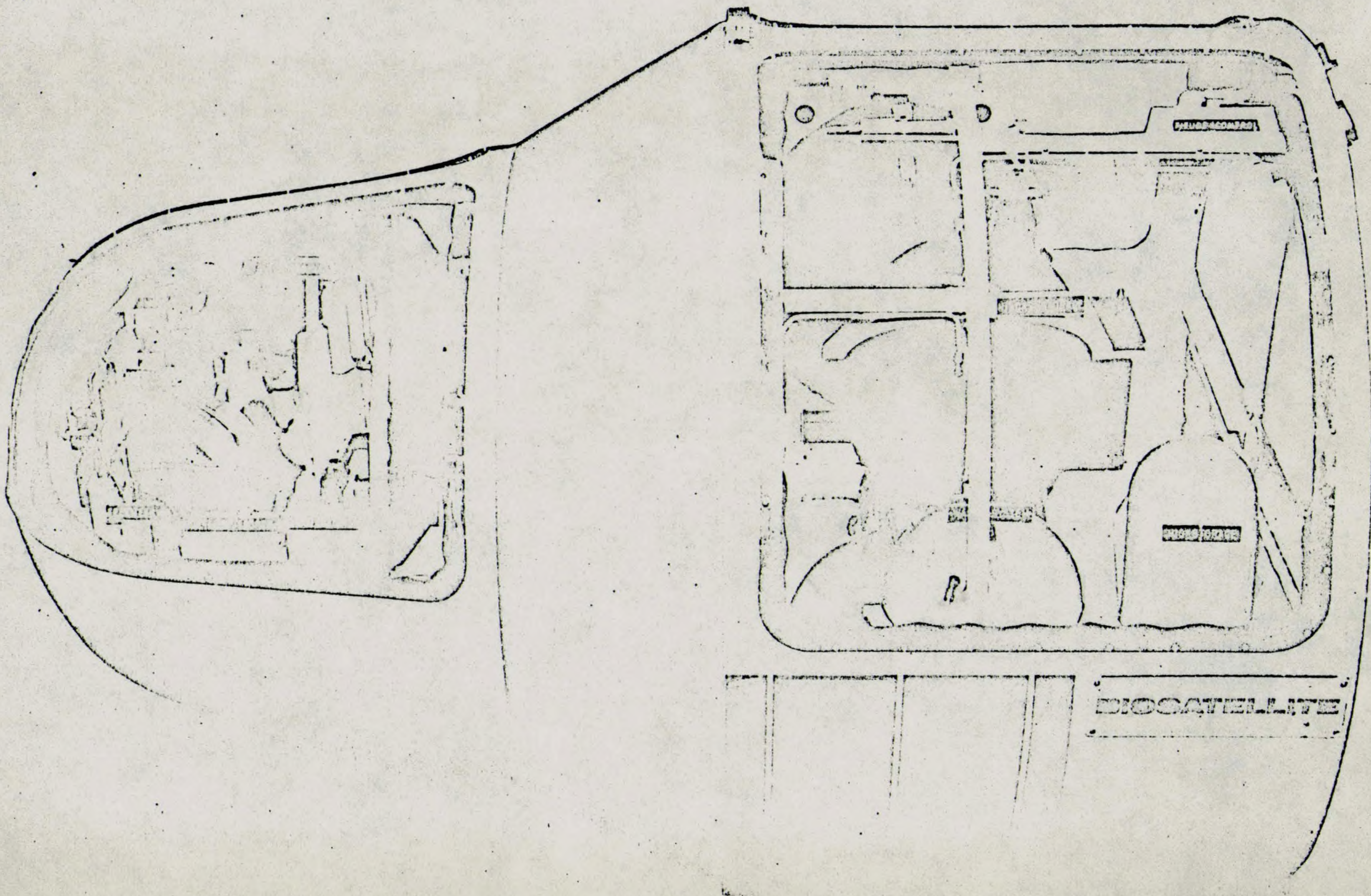
12-12-67

BIOSATELLITE / 30 DAY



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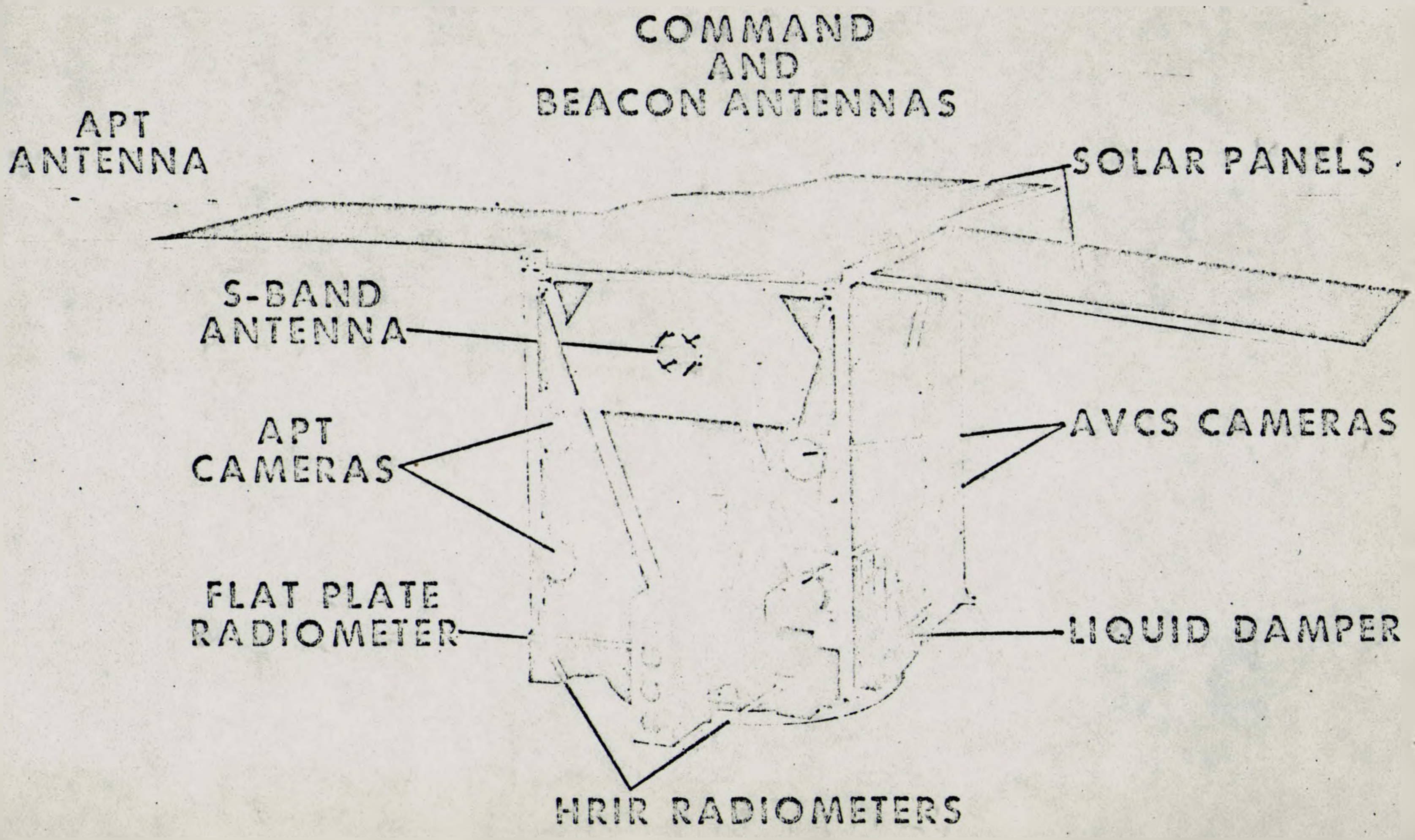
TIROS M (IMPROVED TOS) MODEL



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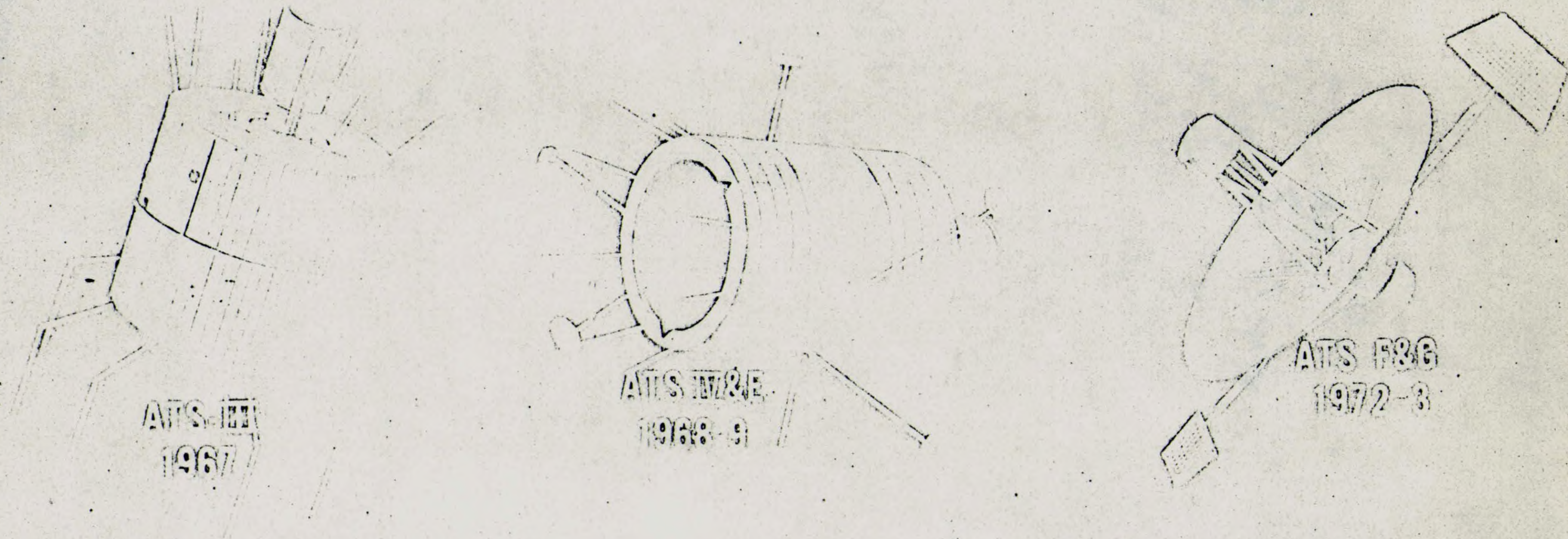
NASA APPLICATIONS TECHNOLOGY DEVELOPMENT



- DESPUN ANTENNAS
- VHF COMMUNICATION TECHNIQUES
- MULTIPLE ACCESS
- NORTH-SOUTH STATION KEEPING
- HIGH SPECIFIC IMPULSE PROPULSION
- SYNCHRONOUS ORBIT ENVIRONMENT
- GRAVITY GRADIENT STABILIZATION
- MULTIBEAM STEERABLE ANTENNAS
- LARGE SPACE ERECTABLE ANTENNAS
- ACCURATE ATTITUDE DETERMINATION
- ACCURATE ANTENNA POINTING
- MILLIMETER WAVES
- UP TO 1500 LBS IN SYNCHRONOUS ORBIT
- INTERFERENCE CRITERIA

NASA SA67-2368
REV. 9-4-68

B-11

APPLYING SURVEYOR AND LUNAR ORBITER TECHNIQUES TO MARS

BY

ORAN W. NICKS
DEPUTY ASSOCIATE ADMINISTRATOR FOR
SPACE SCIENCE AND APPLICATIONS
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C.

PRESENTED TO

AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

5 DECEMBER 1968 Wash DC

INTRODUCTION

THE SURVEYOR AND LUNAR ORBITER MISSIONS WERE PLANNED TO PROVIDE BROAD RECONNAISSANCE OF THE ENTIRE MOON, TO HELP SELECT SITES SUITABLE FOR APOLLO LANDINGS, AND TO MAKE IN SITU MEASUREMENTS IMPORTANT TO ANSWERING TECHNOLOGICAL AND SCIEN-
(1) TIFIC QUESTIONS. THREE LUNAR ORBITERS WERE PLACED IN LOW INCLINATION ORBITS TO PROVIDE SPECIFIC COVERAGE OF THE APOLLO ZONE AND REGIONS NEAR THE EQUATOR OF THE MOON. TWO LUNAR ORBITERS IN NEAR POLAR ORBITS, SYNCHRONIZED TO PROVIDE GOOD LIGHTING OVER MOST OF THE MOON DURING A ONE-MONTH PERIOD, PROVIDED COVERAGE OF SCIENTIFIC SITES AND ALLOWED MAPPING OF OVER 99 PERCENT OF THE MOON'S SURFACE.

FOUR SURVEYORS WERE SPACED ACROSS THE APOLLO ZONE TO EVALUATE THE SUITABILITY OF SITES FOR APOLLO LANDING MISSIONS. THE SPACING OF THESE WAS DICTATED PARTLY BY THE NEED TO ACCOMMODATE APOLLO LAUNCHINGS ON SUCCESSIVE DAYS OF A GIVEN LUNAR

PERIOD DURING EACH MONTH WHEN THE LIGHTING WOULD BE APPROPRIATE FOR LANDING. THE FIFTH SURVEYOR SITE WAS SELECTED NEAR TYCHO BECAUSE OF SCIENTIFIC INTEREST IN ONE OF THE YOUNGEST AND MOST PROMINENT CRATERS ON THE VISIBLE FACE OF THE MOON.

LUNAR ORBITER PHOTOGRAPHY ENABLED SURVEYOR MISSIONS TO BE PLANNED FOR LANDING SITES HAVING REASONABLY GOOD SURFACE PROPERTIES. HAD IT NOT BEEN FOR THE DETAILED LUNAR ORBITER LOOK AT THE REGION NEAR THE CRATER TYCHO, FOR EXAMPLE, IT SURELY WOULD HAVE BEEN A MAJOR GAMBLE TO ATTEMPT A SOFT-LANDING. AS IT WAS, ORBITER PHOTOGRAPHY ALLOWED THE PLANNING OF THIS SURVEYOR VII MISSION WITH SOME CONFIDENCE.

EXAMPLES OF ORBITER RESULTS

(2) THE TWO CAMERAS CARRIED BY LUNAR ORBITER SPACECRAFT WERE DESIGNED TO PROVIDE HIGH-RESOLUTION COVERAGE OF AREAS ABOUT 2 X 10 MILES IN SIZE, AND TO MAKE VISIBLE FEATURES AS SMALL AS ONE YARD IN SIZE. AT THE SAME TIME, THE WIDE-ANGLE CAMERA PROVIDED OVERLAPPING COVERAGE OF A SQUARE ABOUT 20 MILES ON A SIDE WITH 8 TO 10 YARD RESOLUTION. THIS COMBINATION OF HIGH- AND LOW-RESOLUTION COVERAGE ENABLED THE SELECTION OF SUITABLE APOLLO SITES FROM LARGE AREAS, AND THE CLOSE SCRUTINY OF REPRESENTATIVE FEATURES WITHIN THOSE AREAS.

(3) THE QUALITY OF THE PICTURES WAS SUCH THAT MANY-FOLD MAGNIFICATIONS WERE POSSIBLE AS ILLUSTRATED IN THE 10 TIMES ENLARGEMENT. THIS PHOTO INCLUDES A SCHEMATIC SHOWING THE SIZE OF THE SURVEYOR SPACECRAFT FOR REFERENCE.

(4) BECAUSE THE FARSIDE OF THE MOON IS NEVER VISIBLE FROM EARTH, IT IS OF MAJOR SCIENTIFIC INTEREST. EARLIER LUNIK PHOTOGRAPHS HAD GIVEN SOME INSIGHT INTO THE BACKSIDE FEATURES; HOWEVER, THE FIRST LUNAR ORBITER MATERIALLY INCREASED OUR KNOWLEDGE AS ILLUSTRATED IN THIS CHART. A COMPLETE MAP OF THE MOON'S BACKSIDE HAS BEEN MADE USING ORBITER PHOTOS WHICH IS AS GOOD AS ANY MAP OF THE NEARSIDE MADE FROM TELESCOPIC DATA.

(5) ONE OF THE SIGNIFICANT CAPABILITIES OF THE ORBITER WAS ILLUSTRATED BY A PHOTOGRAPH WHICH SHOWED THE HISTORIC SURVEYOR I ON THE SURFACE OF THE MOON. THIS CHART SHOWS A COMBINATION OF OBLIQUE, WIDE-ANGLE, AND HIGH-RESOLUTION PHOTOGRAPHS WHICH ENABLED THE PINPOINTING OF THE SURVEYOR.

(6) YOU WILL RECALL ONE OF THE FIRST STRIKING PICTURES FROM LUNAR ORBITER WAS THIS PREVIOUSLY UNSEEN PORTION OF THE BACKSIDE OF THE MOON AND OUR OWN EARTH IN THE DISTANCE ABOVE THE HORIZON. THIS PHOTOGRAPH WAS TAKEN VERY EARLY IN THE FIRST MISSION, PROVIDING CONSIDERABLE INSIGHT INTO THE CAPABILITIES OF THE LUNAR ORBITER CAMERAS FOR OBLIQUE VIEWS AS AN ASTRONAUT MIGHT SEE THE MOON FROM ORBIT.

THE OBLIQUE HIGH-RESOLUTION PHOTOGRAPH OF THE CRATER COPERNICUS TAKEN FROM 150 MILES AWAY SHOWS THIS RUGGED FEATURE, PRESUMABLY FORMED BY METEOR IMPACT. SOME WRITERS HAILED THIS AS "PICTURE OF THE CENTURY." WHAT HAD BEEN KNOWN AS A CIRCULAR FEATURE SUDDENLY BECAME A SERIES OF MOUNTAIN RIDGES AND VALLEY FLOORS. SUCH PICTURES STIMULATED SCIENTIFIC INSIGHT INTO THE FORMATION AND PROCESSES WHICH GOVERNED THE MOON'S HISTORY.

(8) ALMOST AS STRIKING IS THIS OBLIQUE VIEW OF THE MARIUS CRATER AND THE DOMED RIDGES BELIEVED TO BE VOLCANIC IN ORIGIN IN THE FOREGROUND. PICTURES OF THIS SORT WERE TAKEN IN MANY AREAS OF THE MOON TO HELP EVALUATE APPROACHES TO LANDING SITES AND TO PROVIDE COMPLEMENTARY DATA FOR SCIENTIFIC STUDY.

NEXT, I WOULD LIKE TO SHOW A SET OF PHOTOGRAPHS ILLUSTRATING THE COMBINED UTILITY OF THE SURVEYOR AND ORBITER. THE
(9) FIRST IS A MODERATE-RESOLUTION LUNAR ORBITER PHOTOGRAPH OF TYCHO SHOWING THE RUGGED NATURE OF THE CRATER. A SITE WHERE MATERIAL HAD BEEN THROWN OUT FROM THE DEPTHS OF THE CRATER WAS OF PARTICULAR INTEREST BECAUSE OF THE OPPORTUNITY TO PERFORM A CHEMICAL ANALYSIS OF SUBSURFACE MATERIALS. IN THIS CHART, THE TARGET AREA CHOSEN FOR THE SURVEYOR LANDING CAN CLEARLY BE SEEN.

(10) THE NEXT CHART SHOWS A HIGH-RESOLUTION VIEW OF THE REGION WHERE SURVEYOR LANDED WITH NUMBERS AND LETTERS TO IDENTIFY FEATURES ALSO RECOGNIZABLE ON A SURVEYOR VII MOSAIC. YOU CAN

SEE HERE THAT SURVEYOR VII LANDED NEAR WHAT APPEARS TO BE A SMALL LAKE OF DARKER MATERIAL. SINCE WE HAVE ONLY ONE SCREEN FOR VIEWING, LET ME CALL YOUR ATTENTION TO CRATERS A AND B, AND RIDGE D IN THIS VIEW, FOR YOUR COMPARISON WITH THE LAND-
(11) SCAPE SHOWN BY SURVEYOR VII IN THE NEXT VIEW.

THIS MOSAIC MADE BY SURVEYOR VII SHOWS A NUMBER OF FEATURES INTERESTING FOR SCIENTIFIC STUDY. THE ZOOM LENS ON THE SURVEYOR CAMERA ENABLED CLOSEUP LOOKS OF THE NEARBY CRATER IN THE FOREGROUND AND THE DEBRIS SCATTERED ABOUT ON THE SURFACE.

TO FURTHER ILLUSTRATE THE SCIENTIFIC USEFULNESS OF
(12) ORBITER PHOTOGRAPHS, WE SEE IN THIS LUNAR ORBITER PICTURE TRACKS MADE BY ROCKS ROLLING DOWN A SLOPE IN A CRATER. SIMILAR TRACKS WERE NOTED IN SEVERAL REGIONS OF THE MOON. FROM THEM, SCIENTISTS WERE ABLE TO DETERMINE THE BEARING STRENGTH OF THE LUNAR SURFACE AT DIFFERENT PLACES FOR COMPARISON WITH DIRECT MEASUREMENTS MADE BY SURVEYOR.

EXAMPLES OF SURVEYOR RESULTS

(13) THE COMBINATION OF A TV CAMERA, A SURFACE SAMPLER, AND AN ALPHA-BACKSCATTER CHEMICAL COMPOSITION ANALYSIS INSTRUMENT OPERATED REMOTELY FROM EARTH ENABLED MAN TO CONDUCT OPERATIONS ON THE MOON, MUCH AS IF HE WERE THERE WITH HIS OWN EYES AND

HANDS. THIS MOSAIC ILLUSTRATES TRENCHES DUG BY THE SURFACE SAMPLER WHICH WERE STUDIED TO DETERMINE THE PHYSICAL PROPERTIES OF LUNAR MATERIAL. THE SURFACE SAMPLER COULD OPERATE UP TO FIVE FEET FROM THE SPACECRAFT, AND ON VARIOUS MISSIONS PICKED UP AND WEIGHED ROCKS, DROPPED MATERIAL ON A FOOTPAD CARRYING MAGNETS, AND RELOCATED THE ALPHA-BACKSCATTERING COMPOSITION INSTRUMENT.

(14) WHEN NOT WORKING TOGETHER WITH OTHER INSTRUMENTS, THE SURVEYOR CAMERA WAS PHOTOGRAPHING THE LANDSCAPE AND OBJECTS OF INTEREST SUCH AS THIS ROCK FIELD. WITH ITS ZOOM LENS, IT COULD ALSO EXAMINE DISTANT OBJECTS AND FEATURES IN DETAIL.

(15) ON TWO MISSIONS, VERNIER ENGINES WERE FIRED TO STUDY THE EFFECTS OF THE JET EXHAUST ON THE LUNAR SURFACE. AT SOME TIME DURING A SHORT FLIGHT BY SURVEYOR VI, LUNAR MATERIALS WERE SPLATTERED AGAINST A COLOR CHART ON ONE OF SURVEYOR'S OMNI-ANTENNAS, CLEARLY SHOWING THE COHESIVENESS OF LUNAR SOIL.

PERHAPS THE MOST SIGNIFICANT RETURN FROM SURVEYOR WAS THE DETERMINATION OF THE MAJOR ELEMENTS OF THE SURFACE
(16) MATERIALS. IN THIS CHART, WE SEE TWO PHOTOGRAPHS OF THE ALPHA-BACKSCATTERING INSTRUMENT WHICH USED NEW TECHNIQUES FOR ELEMENTAL ANALYSIS. AS A RESULT OF THIS INSTRUMENT, WE HAVE A NUMBER OF MEASUREMENTS IN THREE AREAS ON THE MOON WHICH INDICATE ITS SURFACE COMPOSITION TO BE SIMILAR TO THE BASALTIC MATERIALS FOUND IN ABUNDANCE HERE ON EARTH.

ALTHOUGH TOO DETAILED FOR QUICK SHOWING, YOU SHOULD KNOW THAT MEASUREMENTS OF THE MAJOR ELEMENTS WERE DETERMINED
(17) WITH RESPECTABLE PRECISON. A TYPICAL SET OF RESULTS FROM THREE SURVEYOR SITES IS SHOWN TO GIVE SOME IDEA OF THE ABUNDANCES. YOU WILL NOTE THAT OXYGEN IS THE MOST PLENTIFUL WITH ABOUT 58 PERCENT, AND SILICON IS NEXT AT ABOUT 18 TO 20 PERCENT. FOR COMPARISON, WE HAVE SHOWN PERCENTAGES FOR A PARTICULAR TERRESTRIAL BASALT TESTED IN THE LABORATORY BY THE SAME TECHNIQUES.

(18) ONE OF THE MOST STRIKING PHOTOGRAPHS TAKEN BY SURVEYOR IS ITS OWN SHADOW ON THE LUNAR LANDSCAPE AS THE SUN SET. MANY SUCH MOSAIC PHOTOGRAPHS TAKEN AT DIFFERENT TIMES AND WITH DIFFERENT LIGHTING CONDITIONS WERE GENERATED AS ALL THE SURVEYORS TOGETHER PROVIDED SOME 85,000 PHOTOGRAPHS.

SURVEYORS OPERATED INTO THE LUNAR NIGHT TO CONDUCT ASTRONOMICAL EXPERIMENTS AND TO BECOME OUR FIRST TELESCOPES
(19) ON THE SURFACE OF THE MOON. THE SUN'S CORONA WAS PHOTOGRAPHED, AND THERE WAS A FIRST OPPORTUNITY TO RECORD FROM THE MOON AN ECLIPSE OF THE SUN BY THE EARTH. OTHER ASTRONOMICAL OBSERVATIONS OF PLANETS WERE ALSO MADE. ON ONE MISSION, A LASER EXPERIMENT WAS CONDUCTED IN WHICH SURVEYOR'S CAMERA WAS USED TO PHOTOGRAPH TWO SIMULTANEOUS LASER SOURCES ON THE EARTH'S SURFACE.

OUR KNOWLEDGE OF MARS

RELATIVELY SPEAKING, OUR FIRSTHAND KNOWLEDGE OF MARS IS CONSIDERABLY LESS THAN THAT OF THE MOON. UNLIKE THE MOON, MARS' DISTANCE FROM EARTH VARIES OVER GREAT EXTREMES, THEREBY MAKING EFFECTIVE TELESCOPIC OBSERVATIONS CYCLICAL ON A 26-MONTH BASIS, WITH A LONGER PERIOD OF ABOUT 15 YEARS SUPER-IMPOSED BECAUSE OF ITS ELLIPTICAL ORBIT AROUND THE SUN.

MARINER IV PROVIDED A FIRST CLOSE LOOK AT THE SURFACE OF MARS AND PRODUCED A TREMENDOUS SURPRISE WHEN IT SHOWED A CRATERED APPEARANCE LIKE THAT OF THE MOON. IN 1969, TWO MARINER FLYBY SPACECRAFT WILL OBTAIN ADDITIONAL SNAPSHOT VIEWS OF THE PLANET AND OTHER INFORMATION ABOUT ITS ATMOSPHERE AND ENVIRONMENT.

THE COMBINATION OF EARTH-BASED TELESCOPIC DATA AND THREE MARINER FLYBY MISSIONS WILL, IN SOME RESPECTS, CORRE-SPOND TO THE EARTH-BASED VIEWS AND THREE RANGER MISSIONS PRIOR TO LUNAR ORBITER AND SURVEYOR MISSIONS.

ORBITERS SURVEY DYNAMIC MARS

(20) THE TWO 1971 MARINER ORBITER MISSIONS CURRENTLY PLANNED WILL PROVIDE POWERFUL NEW TOOLS FOR OUR SURVEY OF DYNAMIC MARS. THEY WILL ARRIVE AT A TIME IN THE MARS CYCLE WHEN THE MOST STRIKING SEASONAL CHANGES ARE EVIDENT IN THE

SOUTHERN HEMISPHERE. A COMBINATION OF DIFFERENTLY INCLINED ORBITS WILL ENABLE GROSS SURVEYS OF THE ENTIRE PLANET, AND THE LIFE-TIMES EXPECTED FROM THESE ORBITERS WILL ALLOW OBSERVATIONS OF THE DYNAMIC CHANGES IN CLOUDS AND SURFACE FEATURES OVER A PERIOD OF SEVERAL MONTHS. FEATURES WILL BE MAPPED, REGIONS OF SIGNIFICANT MOISTURE CONTENT CAN BE SOUGHT OUT, VARIATIONS IN THE ATMOSPHERE NOTED, AND OTHER FACTORS IMPORTANT TO SELECTION OF LANDING SITES DETERMINED.

IN 1973, TWO ADDITIONAL ORBITERS CAN CONTINUE THE SURVEY OF MARS FROM A DIFFERENT SELECTION OF ORBITS, DURING A DIFFERENT MARS SEASON, AND WITH SUPPORT OF THE LANDING MISSION AS A PRIME REQUIREMENT. IN SOME MEASURE, THESE FOUR ORBITING MISSIONS WILL PROVIDE FOR THE INITIAL EXPLORATION OF MARS IN THE SAME WAY THAT FIVE LUNAR ORBITERS DID FOR THE MOON. HOW-EVER, I CANNOT OVEREMPHASIZE THE DIFFERENCES BETWEEN MARS AND THE MOON OWING TO THE FACT THAT THE MOON IS RELATIVELY CHANGELESS, WHILE MARS WITH ITS CLOUDS, ITS POLAR CAPS, ITS WAVES OF DARKENING, ITS DUST STORMS, AND OTHER SEASONAL CHANGES IS FAR MORE LIKE THE EARTH. THEREFORE, MARS WILL OBVIOUSLY REQUIRE MORE THAN FOUR ORBITAL MISSIONS TO DEVELOP A FULL UNDERSTANDING OF ITS CHARACTERISTICS.

SURFACE EXPLORATION OF MARS BEGINS WITH THE 1973 MISSION

(21) NEVERTHELESS, WE EXPECT TO PLAN WITH CONFIDENCE FOR SURVIVABLE LANDING SPACECRAFT DURING THE 1973 OPPORTUNITY. TYPICALLY, SUCH EARLY SPACECRAFT CAN HAVE THE CAPABILITY OF LANDING IN A ZONE 120 X 600 KILOMETERS. REGIONS FOR LANDINGS WILL BE SELECTED TO SEEK ANSWERS TO MAJOR QUESTIONS. IT IS LIKELY THAT REGIONS OF MAJOR INTERFACES OR THOSE EXHIBITING SIGNIFICANT CHANGES WILL BE IMPORTANT TO BROADEN AS MUCH AS POSSIBLE THE EARLY INFORMATION OBTAINED.

WITH COMPLEMENTARY ORBITAL SPACECRAFT PROVIDING CONTINUAL SURVEILLANCE OF ATMOSPHERIC VARIATIONS AND BROAD FEATURE COVERAGE, IT SHOULD BE POSSIBLE TO MAKE SIGNIFICANT STRIDES IN OUR KNOWLEDGE ABOUT THIS PLANET, AND TO RELATE FINDINGS FROM THE LOCAL SAMPLES OBTAINED BY LANDERS TO BROADER AREAS SURVEYED BY ORBITERS.

(22) ORBITERS AND LANDERS WORK AS A TEAM

AS IN THE 1971 MISSIONS, THE 1973 ORBITERS WILL OBSERVE THE WAVE OF DARKENING AND OTHER SURFACE CHANGES OVER A PERIOD OF TIME. MEASUREMENTS OF WATER IN THE ATMOSPHERE AND OTHER CHEMICAL CONSTITUENTS WHICH CAN BE DETERMINED FROM REMOTE OBSERVATIONS WILL INCREASE OUR KNOWLEDGE OF THE ENVIRONMENT OF THE PLANET NEAR ITS SURFACE, IN ITS ATMOSPHERE, AND IN

SPACE AROUND IT. THE ORBITERS' SENSORS WILL BE ABLE TO DETECT AND CHART THE STORMS OR ANY SIGNIFICANT CHANGES IN AREA WEATHER FOR MUCH OF THE PLANET.

AT THE SAME TIME, THE LANDER WILL BE MAKING LOCAL MEASUREMENTS OF PRESSURE, TEMPERATURE, HUMIDITY, ATMOSPHERIC CONSTITUENTS, AND OTHER METEOROLOGICAL PROPERTIES.

A CAMERA WILL PROVIDE IMAGES OF THE SURFACE AND THE TOPOGRAPHY AROUND THE SPACECRAFT SIMILAR TO THE TYPE OF COVERAGE PROVIDED BY SURVEYOR, BUT LESS EXTENSIVE BECAUSE OF THE DIFFICULTY IN RETURNING IMAGES FROM THE DISTANCE OF MARS. THE ORBITER CAN HELP TO INCREASE THE PICTURE RETURN BY PROVIDING A DATA RELAY COMMUNICATIONS LINK BETWEEN THE LANDER AND EARTH.

SIMPLE ANALYSES OF THE LOCAL SOIL COMBINED WITH THE MEASUREMENTS OF THE ATMOSPHERE AND THE ENVIRONMENT WOULD OFFER SUBSTANTIVE KNOWLEDGE FOR ANSWERING THE QUESTION AS TO WHETHER CONDITIONS SUITABLE TO LIFE MIGHT EXIST. IF THE WAVE OF DARKENING IS A RESULT OF LIVING ORGANISMS AS MANY HAVE SUPPOSED, IT MIGHT BE POSSIBLE TO CHARACTERIZE THE FORM AND BROAD CHARACTERISTICS OF THIS LIFE.

BURNING QUESTIONS OF IMMEDIATE CONCERN TO YOU AND ME WILL BE ADDRESSED BY USE OF OUR NEW TOOLS: "IS THERE LIFE ELSEWHERE? HAS LIFE EXISTED ON NEARBY PLANETS AND DISAPPEARED FOR ANY REASON? CAN NEARBY PLANETS BE MADE SUITABLE FOR LIFE?"

TOGETHER, ORBITERS AND LANDERS FORM A POWERFUL TEAM FOR THE STUDY OF MARS AND FOR SEEKING ANSWERS TO THESE QUESTIONS. TOGETHER, THEY WILL CONTINUE TO EXTEND OUR CAPABILITIES IN WHAT IS PROBABLY THE MOST CHALLENGING, OPEN-ENDED ARENA FOR EXPANSION OF SCIENCE AND TECHNOLOGY IN THE DECADE AHEAD.

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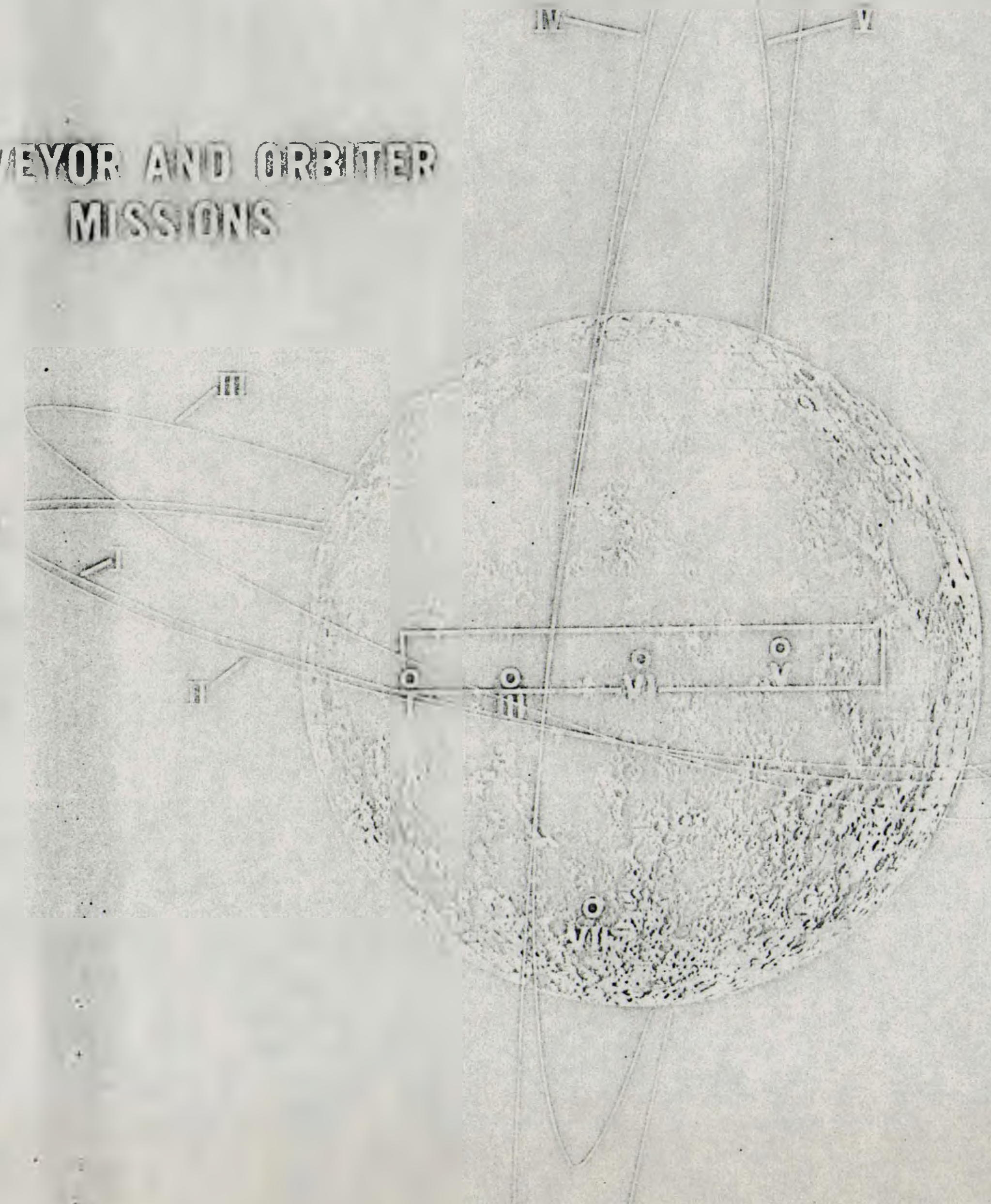
SURVEYOR AND ORBITER MISSIONS



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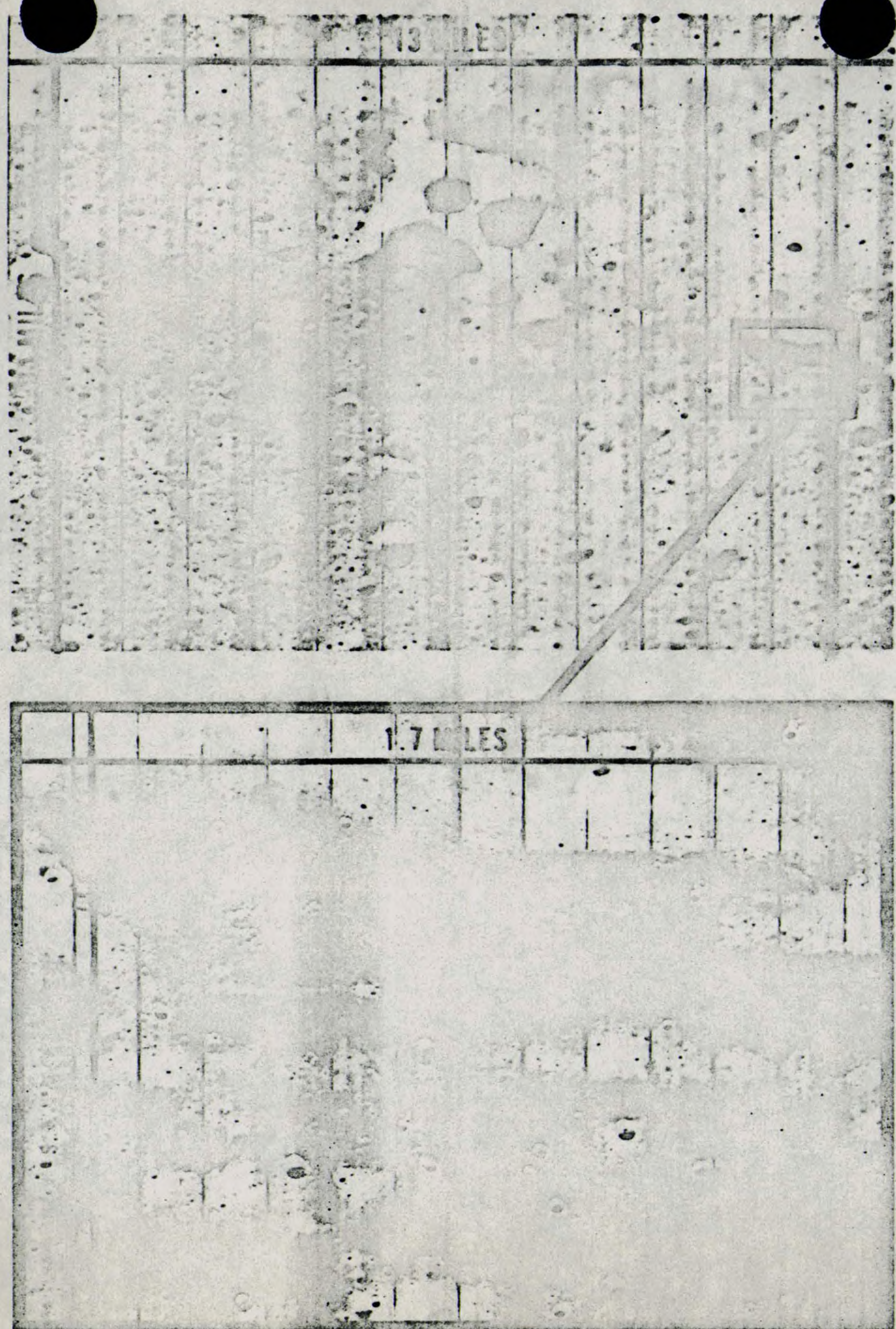

LUNAR ORBITER II
PHOTO QUALITY

WIDE ANGLE CAMERA
9 YARD RESOLUTION

HIGH RESOLUTION CAMERA
1 YARD RESOLUTION

NASA SL 67-894
1-11-67

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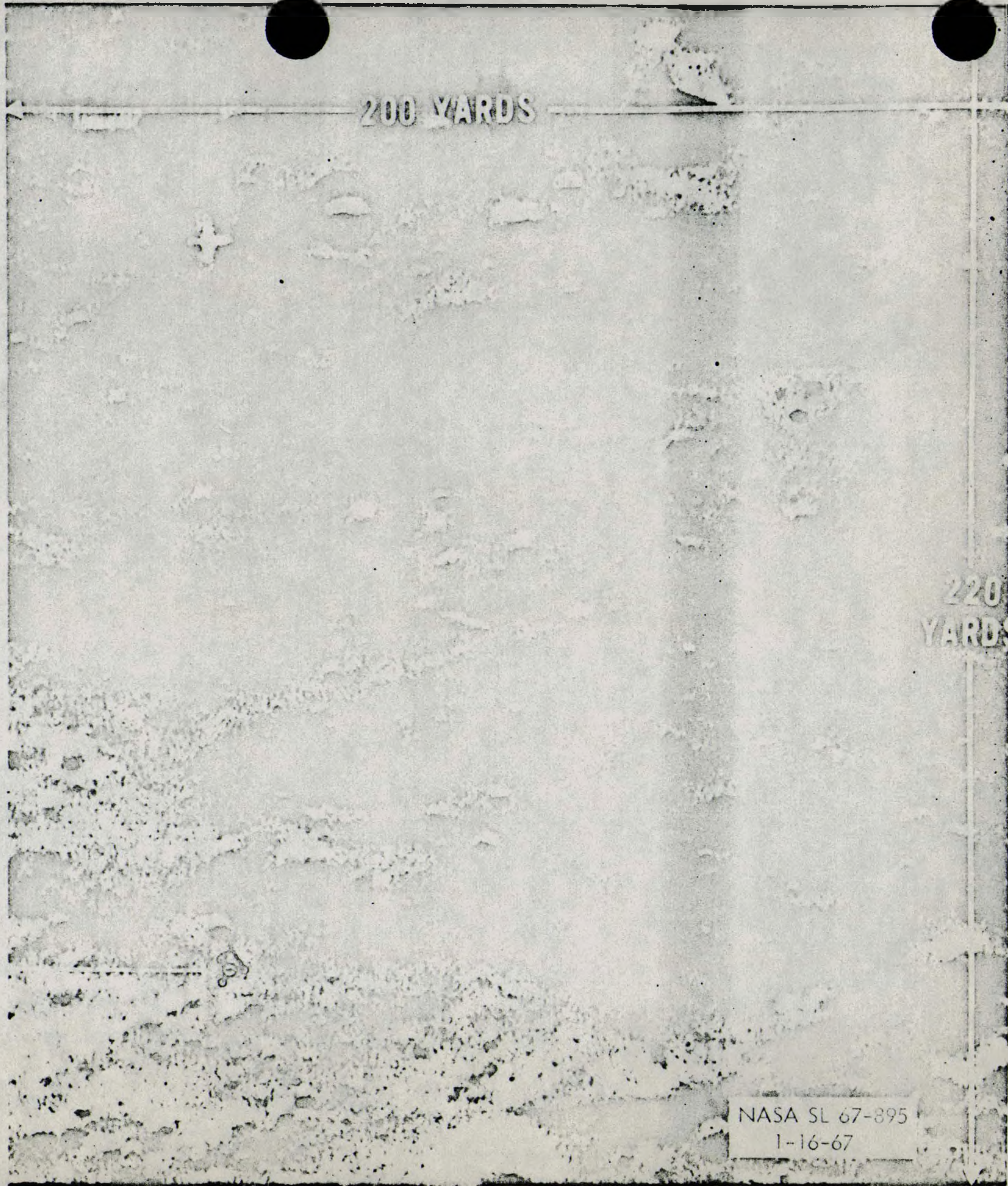
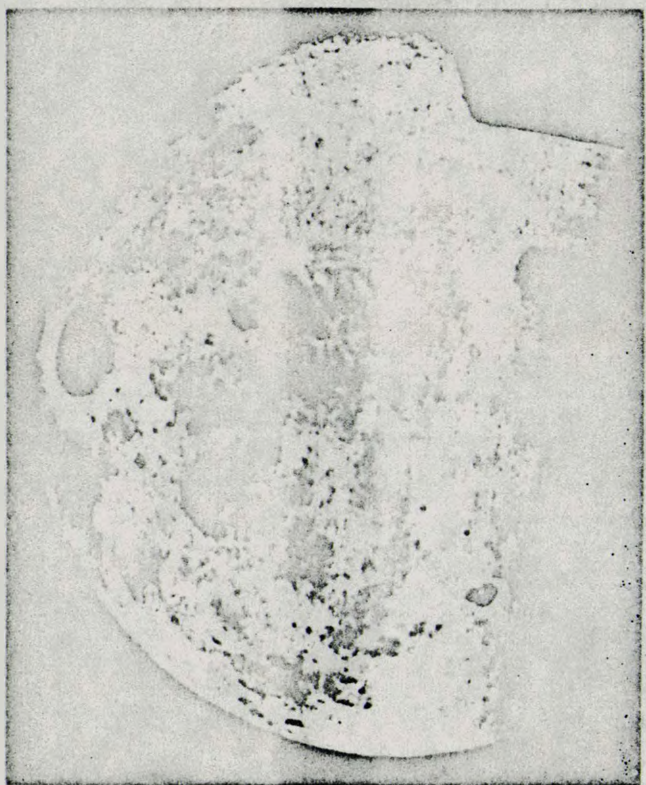
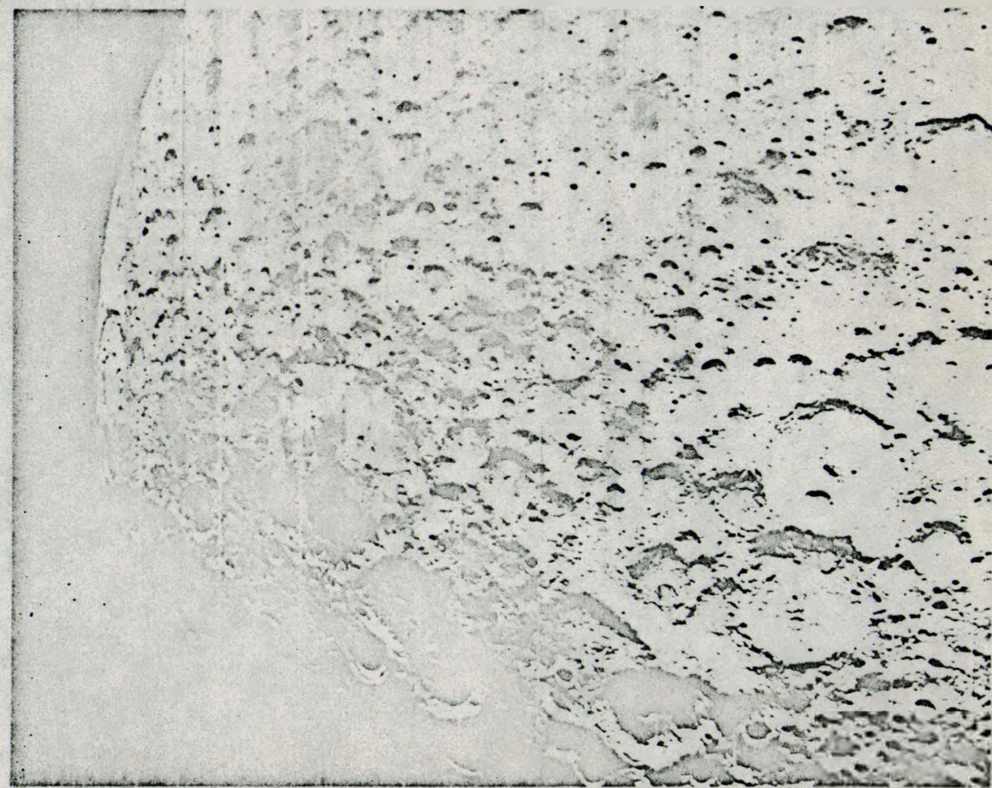
LUNAR ORBITER II

TEN TIMES ENLARGEMENT OF HIGH RESOLUTION PICTURE

SURVEYOR







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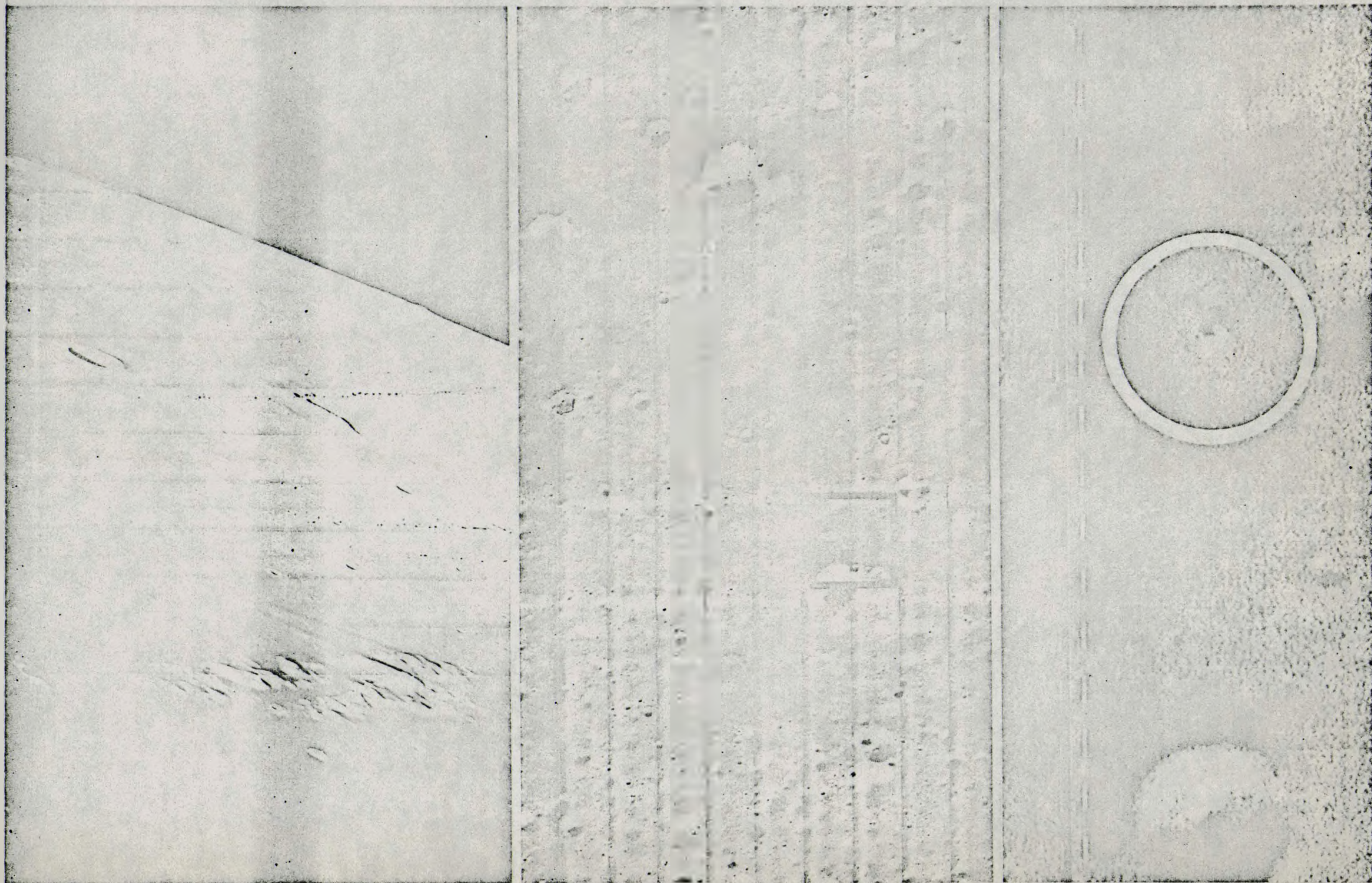
ORBITER III PHOTOGRAPHS OF SURVEYOR I



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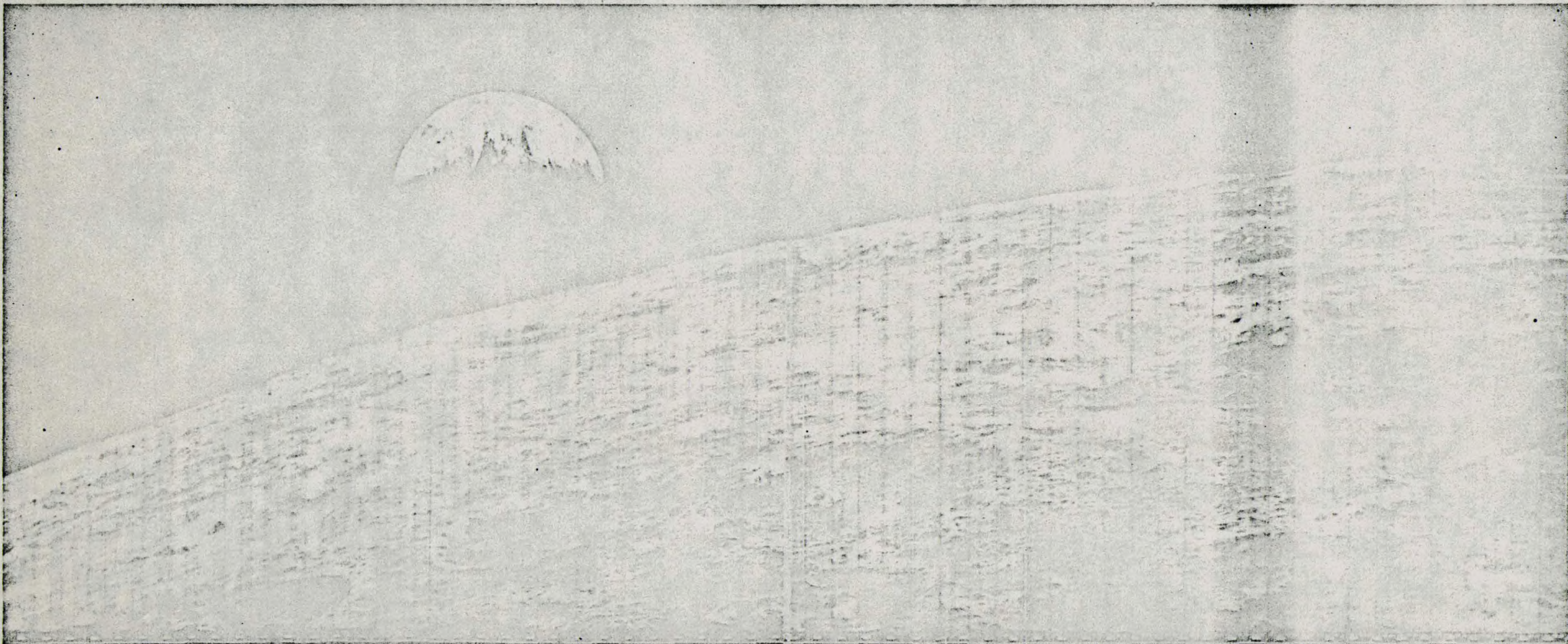
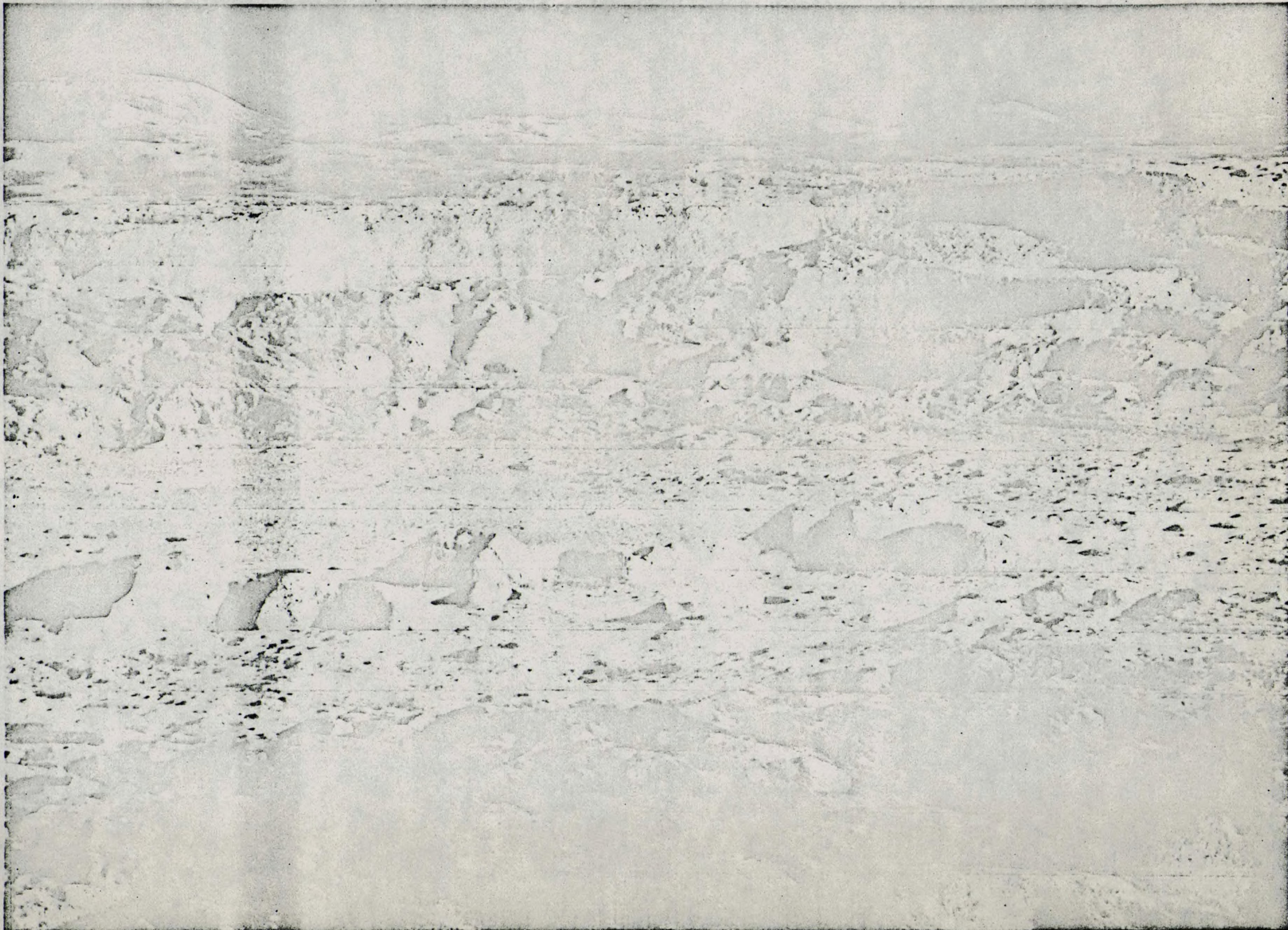
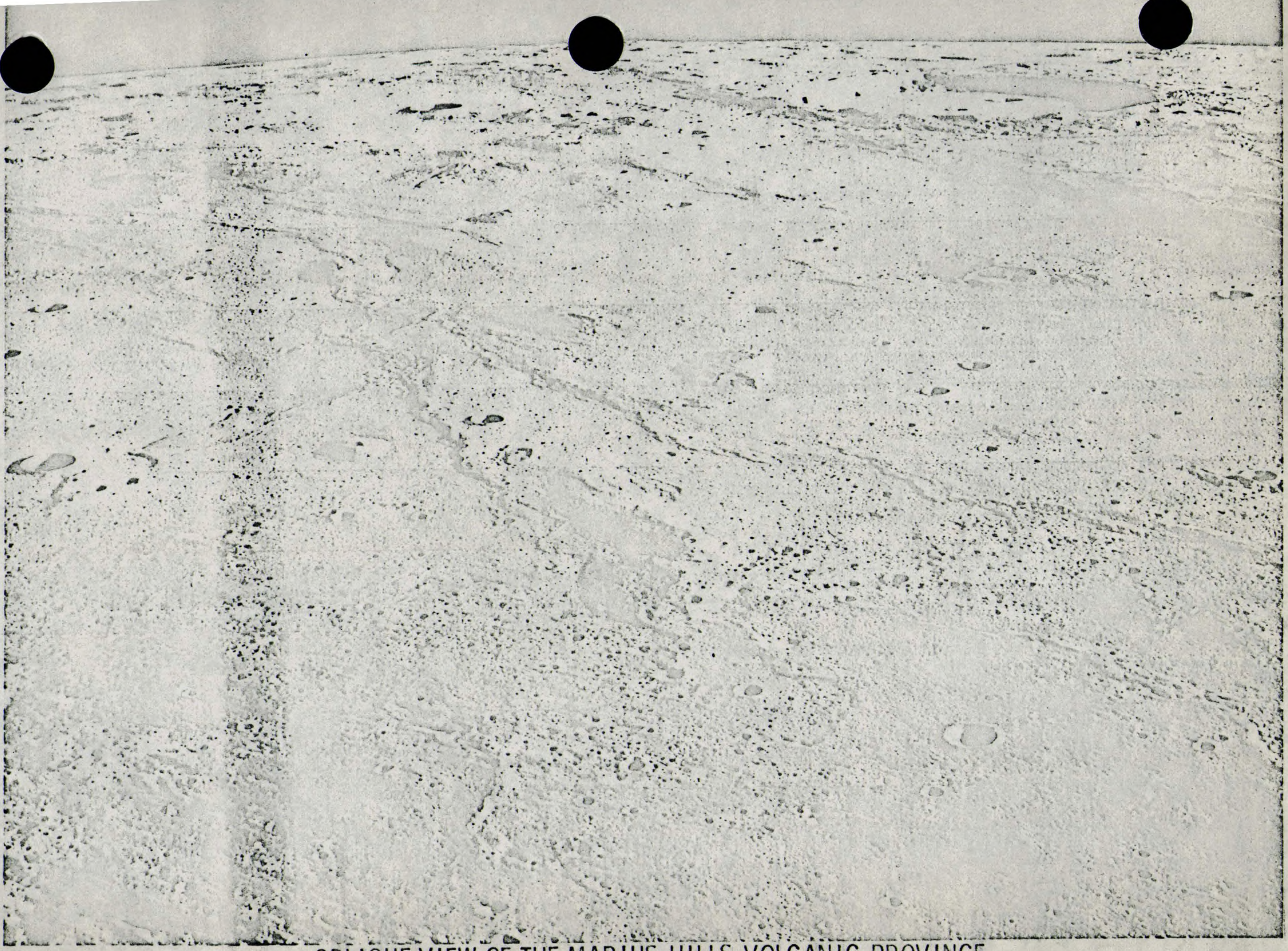
REV. 12-28-67





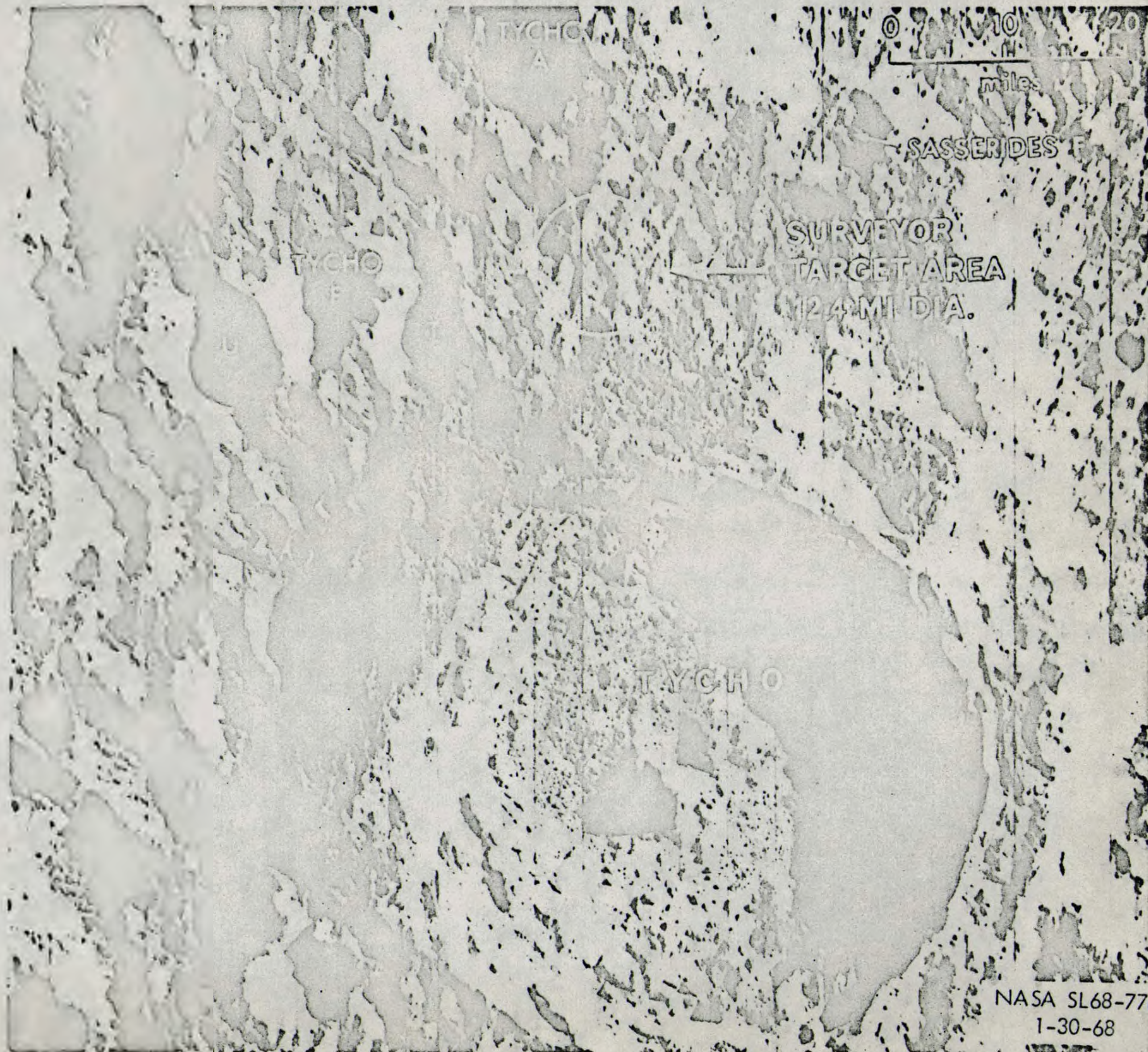


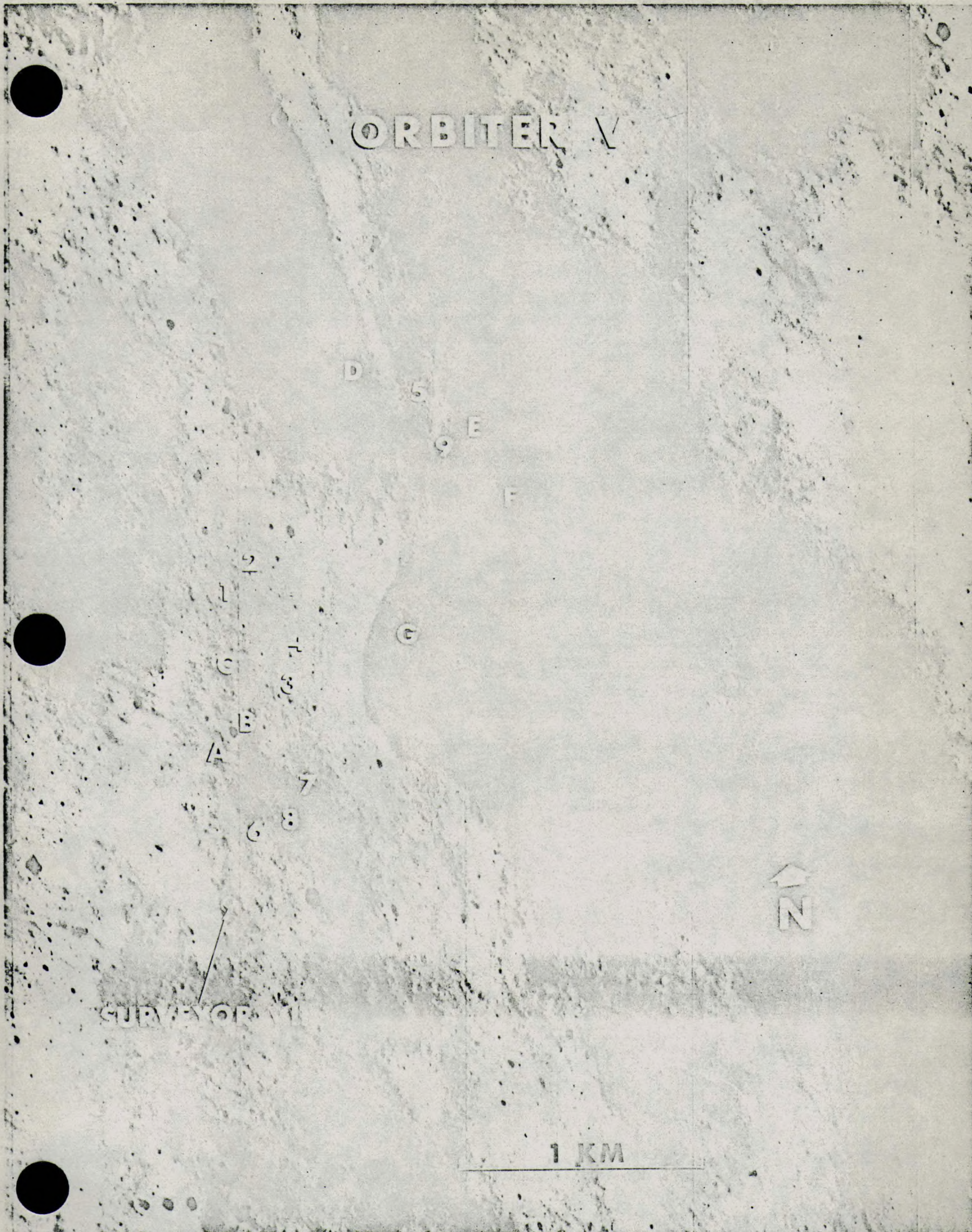
OBLIQUE VIEW OF THE MARIUS HILLS VOLCANIC PROVINCE

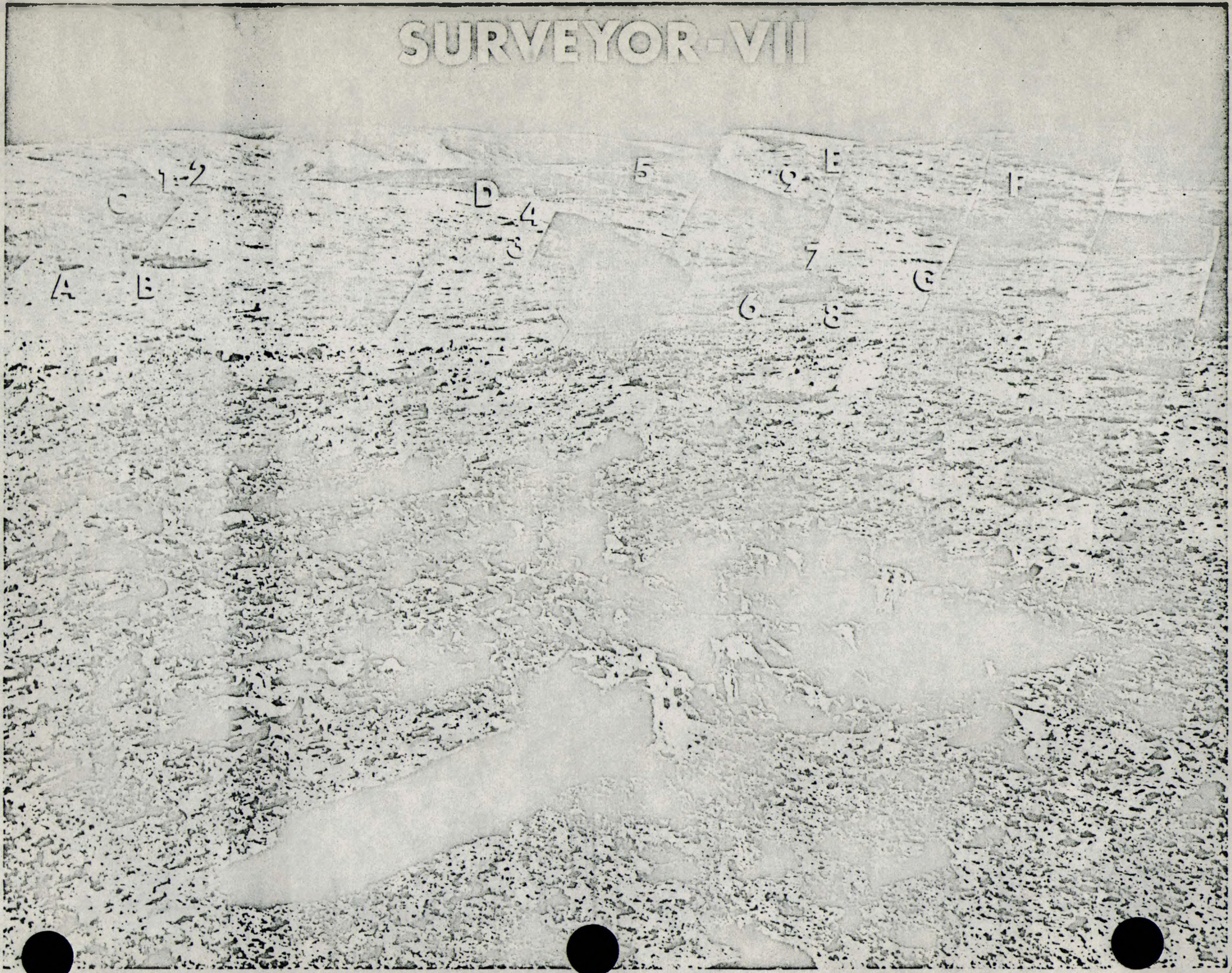
8

LUNAR ORBITER V

SURVEYOR VII
TARGET AREA
NORTH OF
CRATER TYCHO




ORBITER V
D
5
E
9
F
2
1
G
4
C
3
B
A
7
8
6
N
SURVEYOR
1 KM


SURVEYOR-VII
1-2
C
D
4
3
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E
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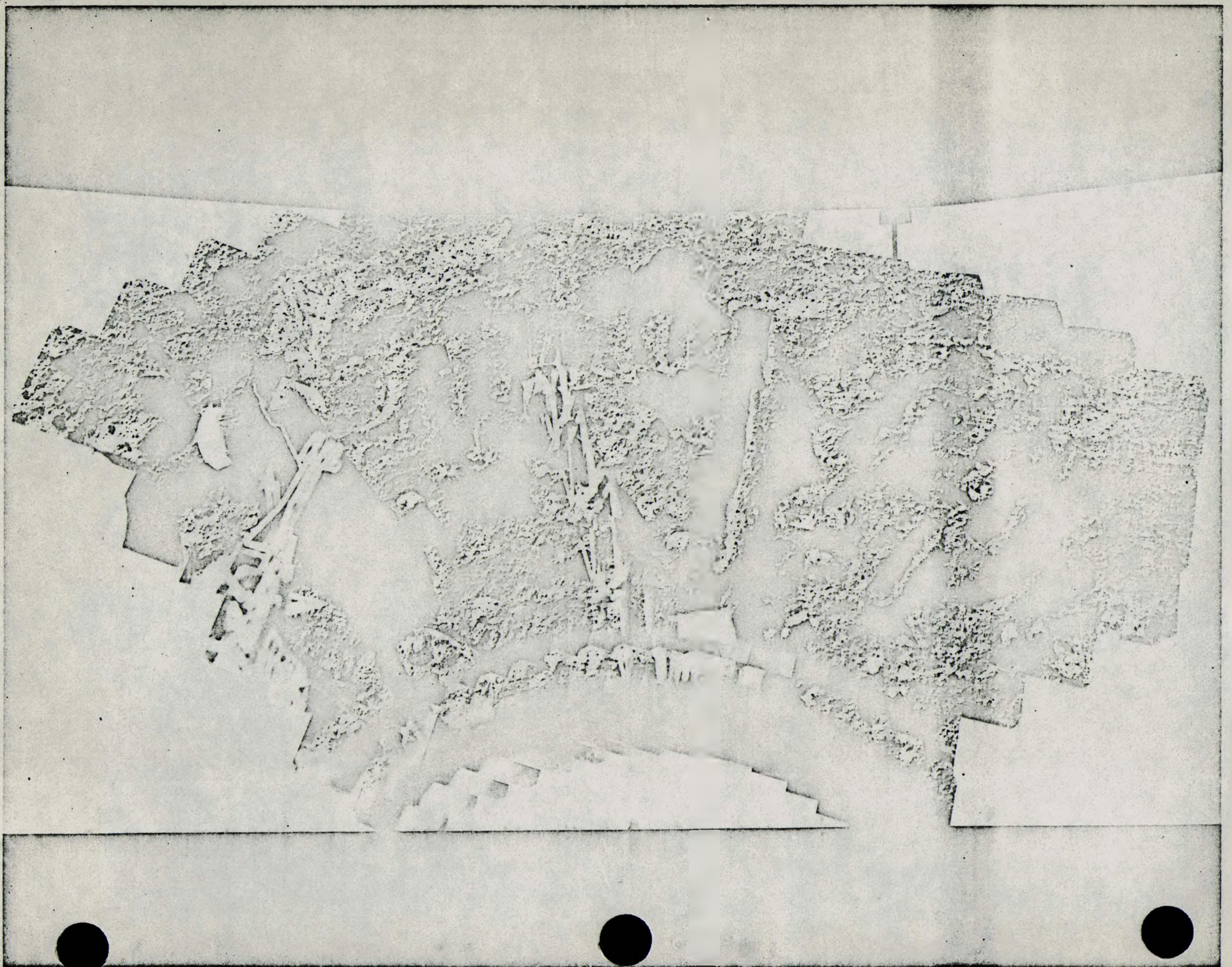
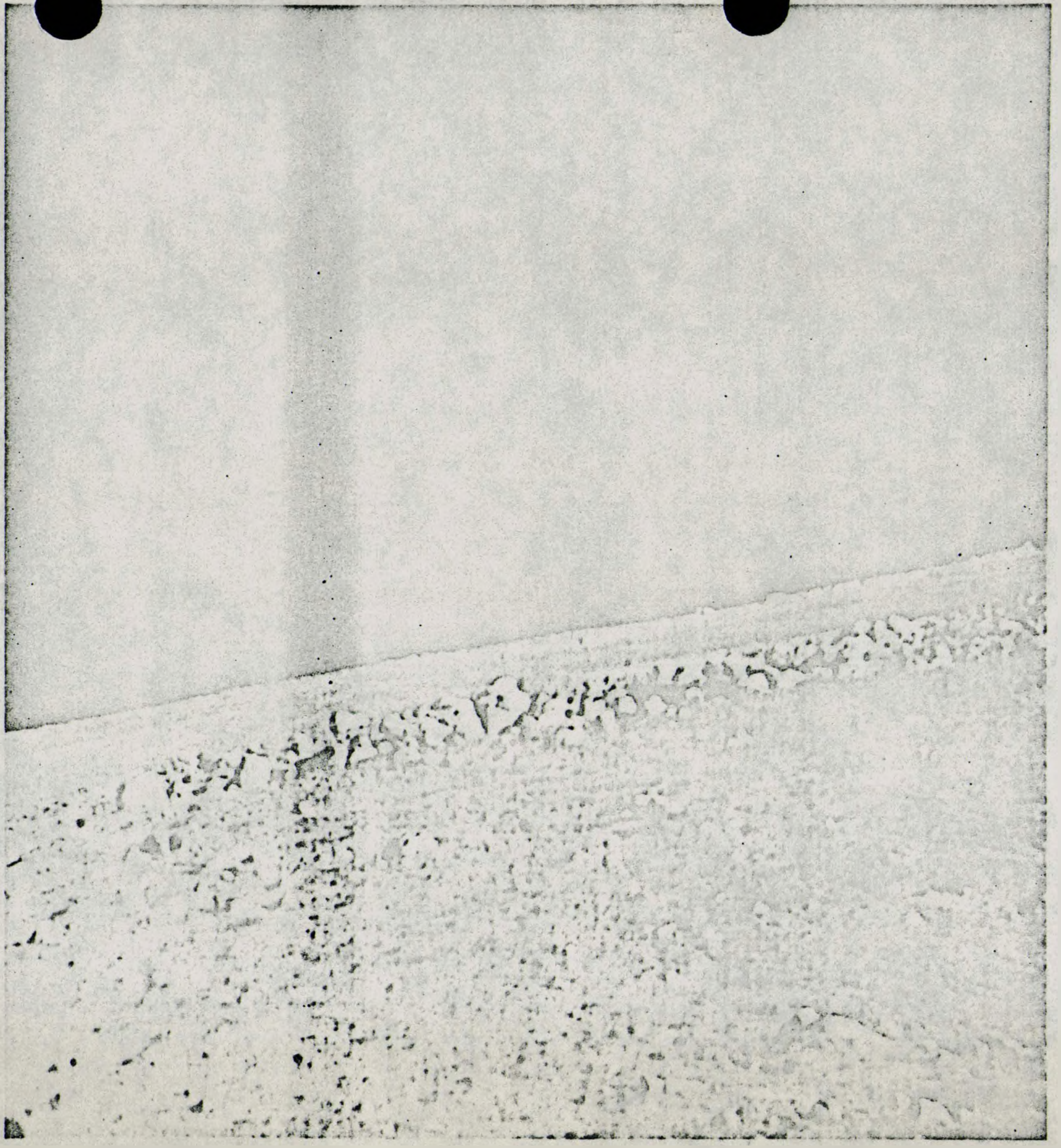
TRACKS OF DOWNSLOPE MOVEMENT OF BLOCKS IN CRATER VITELLO





SURVEYOR I
PHOTOGRAPH

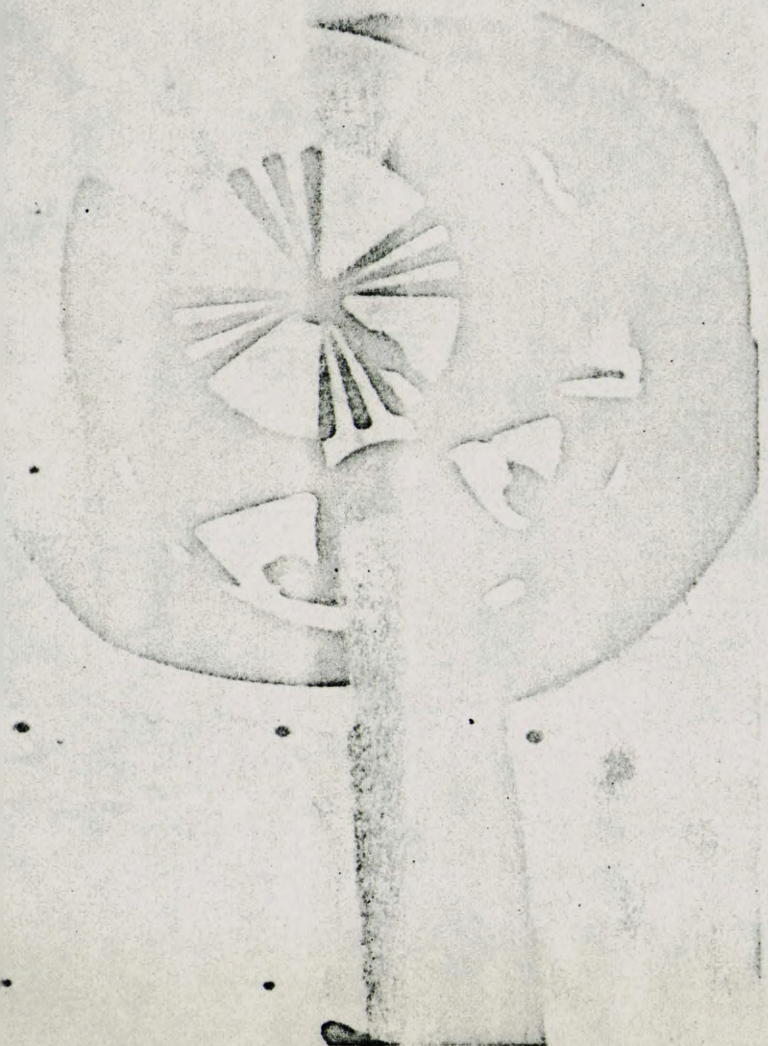
ROCK FIELDS ON THE MOON

NASA SL 67-655
11 15, 66

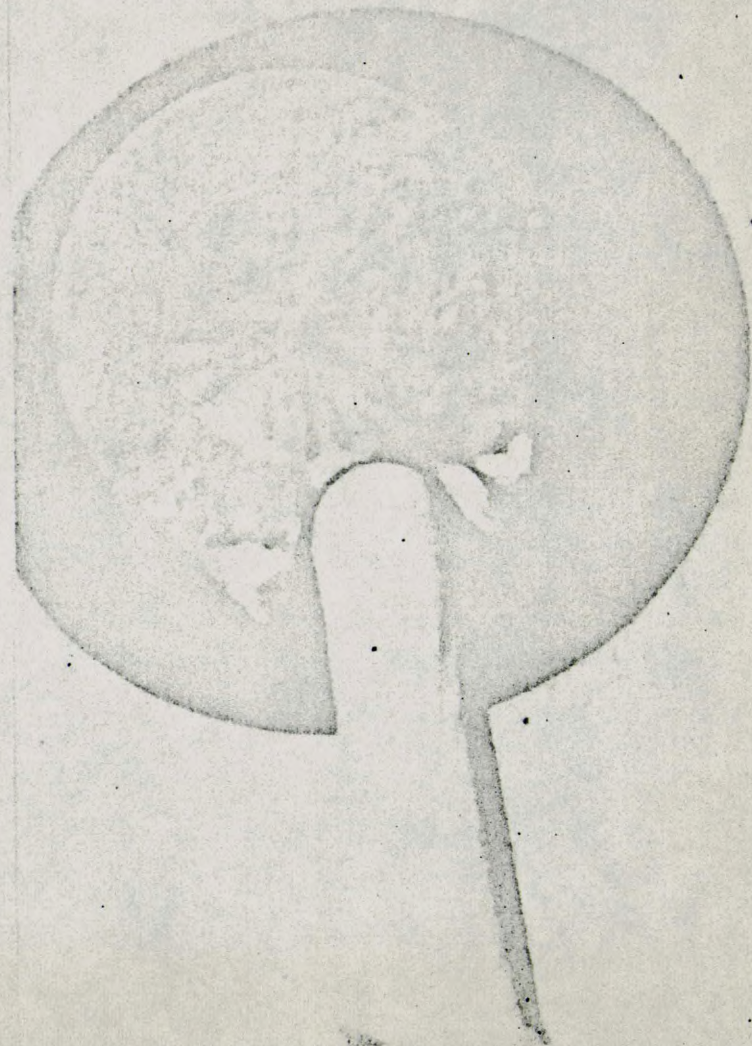
14

SURVEYOR V PHOTO CHART

CLEAN BEFORE VERNIER FIRING



DIRTY AFTER VERNIER FIRING



NASA SL68-689
1-15-68

15

SURVEYOR V

ALPHA BACK SCATTERING INSTRUMENT ON THE MOON

CHEMICAL COMPOSITION OF THE LUNAR SURFACE AT SURVEYOR V, VI, AND VII SITES (PRELIMINARY RESULTS) COMPARED WITH TERRESTRIAL BASALT

ATOMIC PERCENT

ELEMENT	BASALT (THOLEIITIC)	SURVEYOR V		SURVEYOR VI		SURVEYOR VII SAMPLE B	
CARBON	1	< 3		2		2	
OXYGEN	61.1	58	±5	57	±5	58	±5
SODIUM	1.6	< 2		2		3	
MAGNESIUM	3.5	3	±3	3	±3	4	±3
ALUMINUM	6.2	6.5	±2	6.5	±2	8	±3
SILICON	18.9	18.5	±3	22	±4	18	±4
CALCIUM	4.5	13 (Ca + Fe)	±3	6	±2	6	±2
IRON	3.7			5	±2	2	±1

SURVEYOR I's SHADOW ON THE LUNAR LANDSCAPE (MOSAIC)

NASA SL 67-679
11/15/66

SURVEYOR III

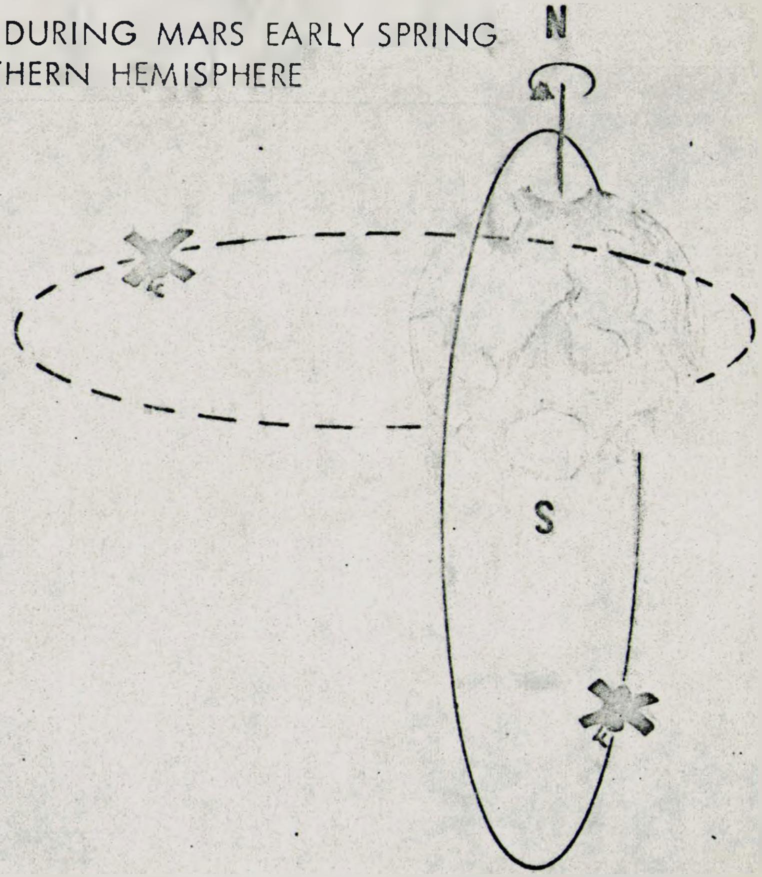
PICTURE OF ECLIPSE OF THE SUN BY THE EARTH

NASA SL 68-312
11-14-67

ORBITERS SURVEY DYNAMIC MARS

1973

ARRIVAL DURING MARS EARLY SPRING
IN NORTHERN HEMISPHERE



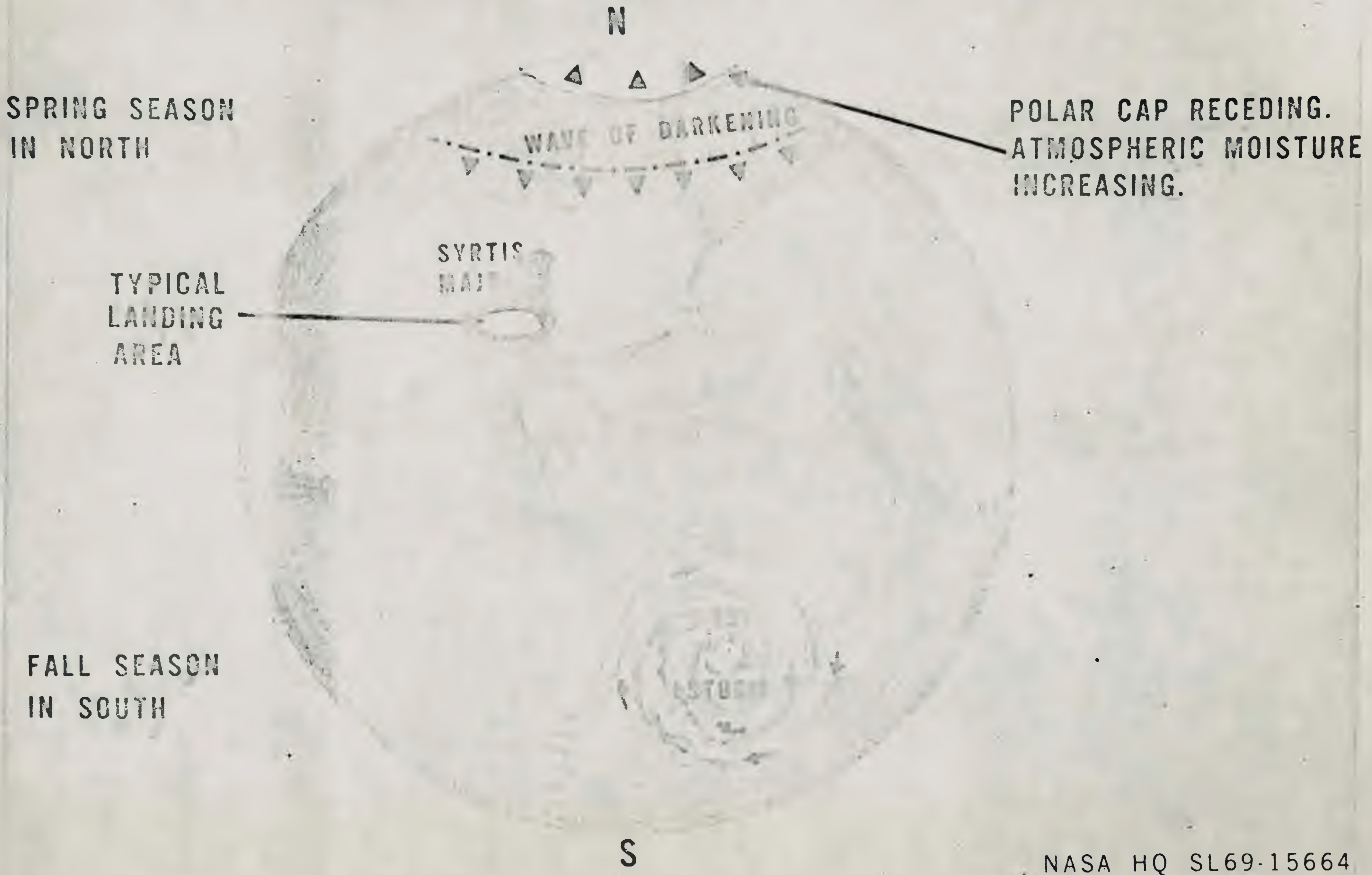
1971

ARRIVAL DURING MARS EARLY SUMMER
IN SOUTHERN HEMISPHERE

NASA HQ SL69-15663
11-25-68

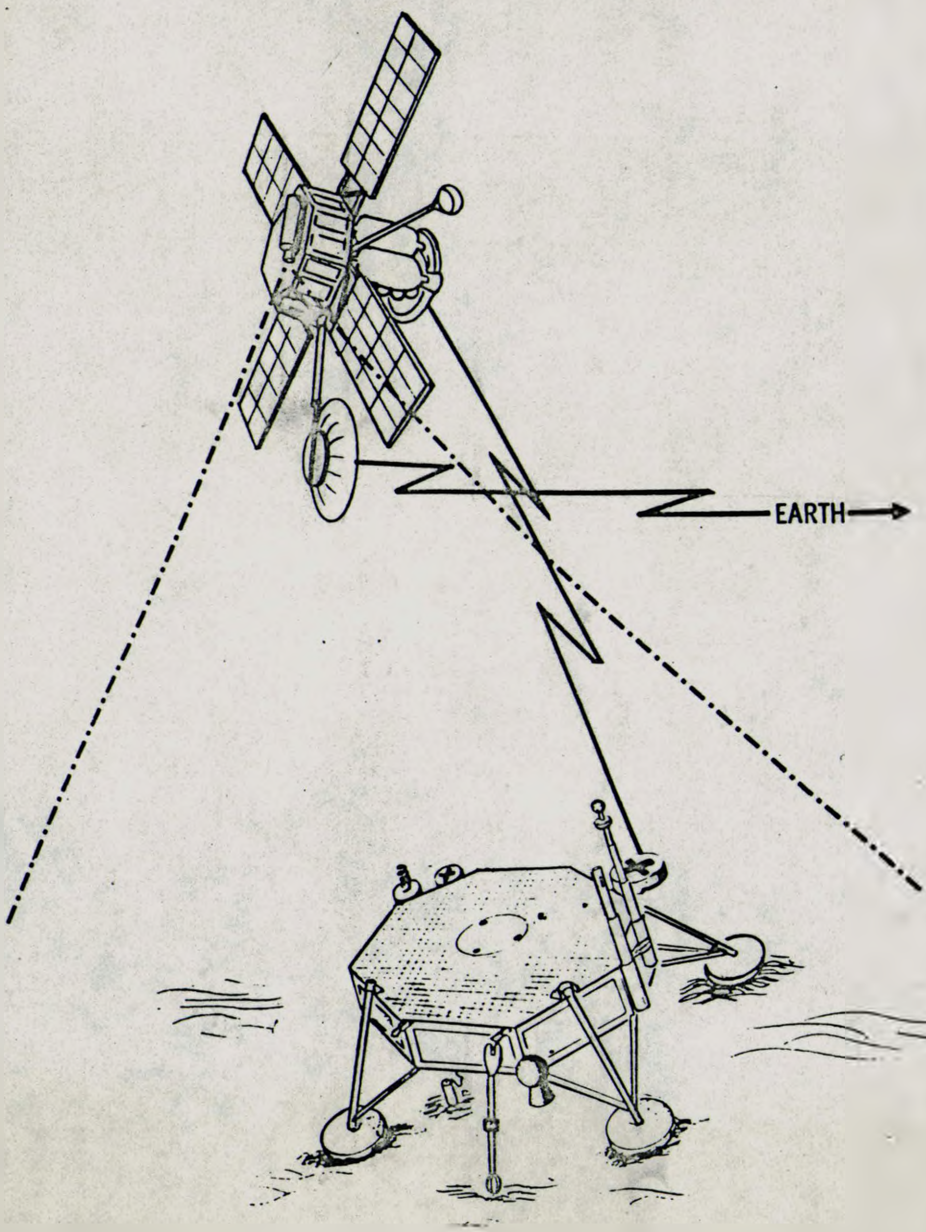
SURFACE EXPLORATION OF MARS BEGINS

1973 MISSION



NASA HQ SL69-15664
11-25-68

ORBITER AN ANDER WORK AS A TEAM



ORBITER

- OBSERVES WAVE OF DARKENING, SURFACE CHANGES
- MEASURES WATER IN ATMOSPHERE, COMPOSITION CHANGES
- DETECTS STORMS, AREA WEATHER

LANDER

- MEASURES LOCAL METEOROLOGY
- MEASURES SURFACE CHARACTERISTICS, CHANGES
- SEARCHES FOR BIOLOGICAL ACTIVITY

NASA HQ SL69-15662
11-25-68

B-12

Address by
General Jacob E. Smart, USAF (Ret.)
Assistant Administrator for DOD and Interagency Affairs
National Aeronautics and Space Administration
before the
Armed Forces Management Association
December 3, 1968

NASA/INTERAGENCY COORDINATION

In the ten years of its existence, NASA spacecraft have probed the space environment, taken photographs of the Moon and Mars and measured certain characteristics of the Sun, launched satellites which extend global communications and which map the weather of most of the Western Hemisphere every 20 minutes of the day and transmits it to Earth.

NASA has developed new materials, new products and processes and new techniques of management.

Our programs have enhanced the scientific competence of our universities and laboratories, and have trained scientists, engineers, astronauts, and military personnel to meet some of the Nation's future needs in aeronautics and space.

If plans materialize, American astronauts will travel to the vicinity of the Moon, circumnavigate it in low orbit some ten times, and return safely to earth before the end of this year. If all goes well, Americans will land on the lunar surface and return safely to the Earth before the end of next year.

In pursuing its spectacular and highly important programs, NASA has utilized the competence of American industry, business, university, and government. Only 10% of NASA's appropriated dollars have been spent in-house. NASA's endeavors required marshaling the strengths of the whole nation to achieve goals that are important to the whole nation.

I believe that NASA's experience in the past ten years points up some aspects of management of large and complex programs that will be important to managers who will direct the nation's important activities the next ten years.

Today I would like to identify some of the Nation's needs which can be fulfilled only by endeavors that are national in scope, and point up some of the features that my experience suggests could wisely be incorporated in the ever-evolving management system.

The marshaling of the Nation's resources to carry out a project that is national in importance and scope is not new in human experience.

The Great Wall of China, the vast irrigation systems of Mesopotamia, the pyramids of Egypt, are the products of early endeavors carried out on a national scale.

The razing and rebuilding of Paris; the construction of the transcontinental railroads in the United States; the Manhattan Project; the country's intercontinental ballistic missile programs, are later examples of large scale undertakings which were possible only at the national level.

Characteristically, each of these large and complex endeavors, whether it be the building of a king's tomb, a nation's capital city, or elements of a nation's defense system, entailed:

a. The concentration of large and diverse material resources;

b. Integration of efforts of large segments of the population;

c. The employment of the newest science and technology;

d. Centralized leadership and control by men who could organize and effectively utilize the strengths of individuals and of independent institutions.

The Nation is currently pursuing several endeavors that are possible only at the national level. The military and civilian space programs are two examples of highly costly and complex endeavors that require cooperation, coordination, and often integration of the efforts of separate independent agencies.

We are certain that foreseeable military, social, and economic needs will require pursuit of other projects that will likely be as costly and complex. Let us look briefly at some of the more obvious needs.

1. Perhaps first and most important is the Nation's security. This country must provide for defense against an ever-widening range of threats.

2. We have urgent need for an adequate national transportation system.

3. Our cities are overcrowded and persons everywhere are harassed with ever-increasing noise levels, and with polluted air and water.

4. To an increasing degree we are faced with the problems associated with age, and more recently with crime in our cities and social unrest in general.

5. And as pointed up by the President's Science Advisory Committee, this Nation is faced with the need to join and possibly lead international programs to cope with the imbalance between the growing world population and the availability of food.

These are but a few of the generally recognized needs.

The degree to which we succeed or fail in these important endeavors will directly affect our national security, our role in international affairs, as well as the continued well being of our people here at home. Meeting these needs, therefore, is a national problem.

But note, however, that the Nation's needs are not always amenable to solution through a national level program.

Many can be coped with effectively only at local, regional, or state levels. No single problem area falls within the authority and responsibility of any single department of government. Solutions to each can be achieved only by application of authorities vested in multiple agencies of Federal, State, and local governments.

All require the assemblage of strengths drawn from many sources: — scientists and scientific institutions of our universities and national laboratories.

All require the engineering and technological competence found in industry and government and universities, and the productivity of the national labor force.

All require multiple interfaces among a large number of independent agencies and a high degree of cooperation and integration of effort.

Methodology for managing large and complex endeavors has developed in this country over the years. Our managerial competence in government today is the product of an evolutionary process.

The DOD and the NASA currently manage the important, highly complex and costly programs for which they are responsible in a highly creditable manner, in my view.

The efficiency and effectiveness achieved in each of these endeavors are due in a large measure to the effectiveness of the interfaces the responsible lead agency maintains with the agencies of government, industry, and university that must support these endeavors.

These interagency relationships take many forms. There are Interagency Boards and Committees established by law, Executive Order, or other authority. Illustrative examples are:

1. The National Aeronautics and Space Council, established by the Space Act of 1958 to advise the President, composed of the Vice President as Chairman, with members from the Department of State, the Department of Defense, the Atomic Energy Commission, and NASA.

2. The Federal Council for Science and Technology, chaired by the President's Science Advisor, established to consider problems, issues, and developments in science, research, and technology: (1) affecting more than one agency; (2) concerning the overall advancement of the Nation's science, research, and technology; and (3) to recommend policies and other measures.

3. The National Council for Marine Resources and Engineering Development, created in 1966 by Act of Congress to intensify the study of the sea, and to exploit its practical benefits. The Council is chaired by the Vice President.

Another category of relationships exists for the coordination and integration of programs. Illustrative examples are:

1. With the Department of Defense — The Aeronautics and Astronautics Coordinating Board with its six Panels devoted to areas of endeavor in which DOD and NASA have common responsibilities.

2. With the Departments of Agriculture, Interior, Commerce, and Navy — The Earth Resources Survey Program Review Committee established to provide NASA with knowledge of requirements for information which might be gathered through observation of the atmosphere, earth, and oceans, so that NASA's R&D program in the field of earth resource surveys can be more effective.

3. With the Atomic Energy Commission — for the development of nuclear propulsion in space.

A third category relates to the exchange of personnel, services, equipment, and facilities. Illustrative examples are:

1. With the DOD — for the detailing of active duty military personnel with NASA; the provision of aircraft to NASA for R&D or administrative purposes; the provision of range support services to NASA; the performance of industrial security and contract services for NASA. Conversely, NASA provides special R&D support for DOD Southeast Asia operations, and uses its unique talents and facilities to assist DOD in the development of aircraft and missiles.

2. With the Department of Transportation — for research, development, and testing associated with the supersonic transport; for the development of high speed ground transportation; and for research and development on noise abatement.

3. With the Communications Satellite Corporation — for launch vehicle and other services.

4. With the Department of Commerce — for support of the Environmental Science Service Administration's operational meteorological satellite system.

And the fourth category relates to the utilization of technology acquired in the pursuit of each of these programs.

There are continuing interagency study efforts going on. They range from the accomplishment of a single task to the study of a national problem. Illustrative examples are:

1. With the Bureau of Standards — for study of the ramifications of adoption by the U. S. of the metric system.

2. With the Department of Justice — for applications in crime prevention and law enforcement.

3. With the Department of Health, Education, and Welfare — for development of criteria and techniques for prevention and control of air and water pollution, and for noise abatement.

4. With the Bureau of Reclamation of the Department of the Interior — for research on atmospheric water resources.

I am certain that our methods for managing large projects will continue to evolve — and to improve. There are certain characteristics that I would like to see adopted and incorporated into the management of new national endeavors.

Let me identify some of them -- briefly.

First, there should be general recognition that the major undertakings are truly national in character and in importance. The President or the Congress could wisely make a declaration to this effect, as was done by the Congress when NASA was created.

The Act that established NASA declared that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities.

In my view it would be completely appropriate for the President or the Congress to declare that it is the policy of the United States to improve the development and management of the resources of the earth and oceans as a means of providing needs of a growing world population, thus announcing to the general public, and particularly to governmental institutions that must participate, that the Nation will pursue a concerted program in these areas.

This has not been done in all important programs and the programs have suffered. A national program to fill a national need needs more to support it than its own merits and the enthusiasm of its director.

With Presidential and Congressional support and association, interagency cooperation comes more readily. Time and tempers of important people are saved.

Second, there should also be general acceptance of the fact that existing facilities and institutions will be utilized rather than creating new ones, whenever it is possible to do so.

The President or the Congress should designate one agency to serve as the lead agency to carry out the program or certain designated aspects of the program. At the same time, the major supporting agencies should be identified, and the President or the Congress should impose upon the Heads of these agencies some degree of responsibility for achieving success.

Where the Federal Government does not have control over the agencies that must participate, and this condition will prevail more often than not in major undertakings, the strength of the Office of the President or the Congress should be utilized along with the merits of the program to obtain public and institutional support.

To continue the analogy of earth and ocean resources, I believe it would be appropriate for the President or the Congress to charge NASA with exercising the lead in a national R&D program that is designed to learn how and to what degree science, engineering, and technology can be applied to help the Departments of Interior, Agriculture, Commerce, Navy, and others to fulfill their responsibilities for development and management of natural resources.

The scientific community promises great scientific and economic return from observation of the atmosphere, Earth, and oceans. But how this is to be done has yet to be demonstrated.

An extensive R&D program is required -- and such a program requires extensive support by a large number of important agencies and people.

National decision on whether we undertake development of operational space systems must await outcome of R&D. Issues will be more clearly identified and understood if the President and the Congress lend their interest and public support to a first class R&D program.

Third, there should be general recognition that future programs will likely be more important and also prove to be more complex, and that new knowledge, new competence, will be required to cope with them effectively.

I believe, therefore, that one of the objectives of every participant should be that of increasing individual and institutional competence.

This has been one of the policy objectives that has characterized NASA's endeavors during its ten years of existence. NASA has tried particularly to enhance the strengths of educational institutions.

The logic of this is inescapable. Our educational system has served as the primary means by which this Nation has developed the national competence we enjoy today. We can do no less than consciously try to improve the system that bears so markedly on the Nation's future.

In this connection, I want to assert that in my view our governmental educational institutions play a major role in enhancing the efficiency and effectiveness of governmental managers. I believe that the percentage of time devoted to continuing advanced education of government executives should and will increase. The National War College, the Industrial College of the Armed Forces, and the Service War and Staff Colleges, have paid for themselves many times.

There should be greater recognition of the role that our national laboratories and other facilities could play if called upon to do so.

The House Subcommittee on Science, Research, and Development, under the Chairmanship of Congressman Daddario, pointed up that existing laboratories should be regarded as national assets and are available for interagency use, as an alternative to establishing new laboratories.

This, of course, has always been done in varying degrees; however, for very obvious reasons, every agency would prefer to build its own facilities when time and resources permitted.

The unitary wind tunnel laws stemmed from appreciation by the Congress that complex, costly research, development, and test facilities are needed in limited numbers and must serve multiple agencies.

Increased multi-agency use of federal facilities connotes two concomitant actions that I believe deserve attention. First, that the facilities be supported adequately with equipment, manpower, and dollars; and second, that the agencies that must use these facilities in lieu of those they would build for themselves have adequate manpower and funds so that their own people can travel back and forth and, when necessary, remain in residence at the laboratory until the objective of the project is achieved. Some of the money that is saved by not building additional facilities must be considered available for timely modernization of equipments, upgrading competence of people, and for their operation for the number of hours necessary to meet their multi-agency workload.

National need for new or upgraded facilities for research, development, and testing is an important and highly complex matter, and one that in my view will require increased attention on an interagency basis.

Test equipment and facilities can be extremely costly and unless great imagination and foresight are used, a test facility is likely to have very limited utility both in terms of useful life and the variety of purposes it can serve.

Testing can be so costly that simulation is sought as a substitute whenever the attendant risk is considered acceptable.

The Aeronautics and Astronautics Coordinating Board has devoted considerable attention to future needs for test facilities.

There are two additional points that, in my view, deserve special consideration. They are somewhat different but related. I would like to discuss the two together.

The first is the generally held view that administration, maintenance, and operations are "overhead" — or fat without muscle; that these activities are generated by bureaucrats for their own support, and that expenditures for these can be attacked in public and pared at will.

The second is that each governmental agency that obtains support from another should reimburse that agency totally for the support rendered.

Inadequate funding of operations and maintenance forces efforts to obtain reimbursement at as high a price as the traffic will bear.

Haggling over reimbursable costs generates heat in interfaces where harmony is urgently and continuously needed. It takes engineers, technicians, and executives from more important matters. It requires the services of additional bookkeepers, auditors, and other administrative people.

Limited operations and maintenance funds and rigid rules on reimbursement tend to put our laboratories on a job shop basis. I do not believe that any thoughtful person believes that this Nation can stay near the forefront in science, engineering, and technology if scientists, engineers, and technicians in the Nation's laboratories must depend upon income from agencies that have discovered problems that need solution.

Our laboratories must certainly maintain the capability to solve problems brought to them, but this should be only a small part of their work.

The identification of a problem often points up that we are on the back side of a power curve.

Our laboratories must keep us in the forefront of science, engineering, and technology, and this can be had only through imaginative, aggressive, adequately supported research.

B-13

14 October 1968
pages 74-76

U.S. News & World Report

Interview With Wernher von Braun, Director, Marshall Space Flight Center

—USN&WR Photo

HAS U.S. SETTLED FOR NO. 2 IN SPACE?

With Project Apollo about to resume at full tilt, the big question is: Can U. S. still beat Russia to the moon? And what happens after that?

Here are answers from Dr. Wernher von Braun, a driving force in the space program. In this interview, held in the conference room of "U. S. News & World Report," he warns of grave shocks ahead.

Q Dr. von Braun, is the U. S. going to beat Russia to the moon?

A I am beginning to doubt that we will. It is very important that we are there first, but in view of the spectacular performance of the Soviet spacecraft Zond 5, in late September, I am beginning to wonder. It will undoubtedly be a photo finish.

Q Where are we behind?

A We haven't done certain things that they have already demonstrated with their flight around the moon. On the other hand we have flown a more powerful rocket, our Saturn V. It won't be long, however, before the Russians have a more powerful rocket flying, too. So, as I said, it will be nip and tuck.

Q People wonder why, after we've spent billions of dollars on space, we are still lagging. What is your answer?

A All our information indicates clearly that the Russian program is richer than ours. To put it bluntly, the Soviets are spending more money than we are. They are spending approximately 30 to 50 per cent more in terms of man-hours per year than we spend. You cannot possibly translate from dollars into rubles very directly, but when you ask the question, how many people are on the job there and how many people are on the job here—it's between 30 and 50 per cent more in Russia. Or to put it still another way: They are spending almost 2 per cent of their gross national product on space, while we spend less than 1 per cent.

Q Are there important defense implications in space? Is that what is motivating the Russians?

A There are defense implications, yes. Space, just like air or water or land, is a place rather than a program, and you can conduct military activity in a place. However, I would say that defense is by no means the most important motivation. The peaceful use of outer space for both scientific and economical applications will turn out to be far the more important.

Q What is likely to be the effect of the recent cutbacks in the U. S. civilian space budget?

A We have gone down and down and down for the last three years. I see very great danger in it, because there is no indication whatsoever that the Russian program is undergoing similar cuts. On the contrary, there is every indication that for the last few years it has gained at least 10 per cent a year, probably more. So, while we are virtually scrapping much of the capability that we have built up as a result of the lunar-landing program, for instance, the Russians are continuing to build up.

Q Does the U. S. have no program beyond a moon landing?

A It may surprise you to hear this, but for the last two years my main effort at the Marshall Center has been following orders to scrub the industrial structure that we had built up at great expense to the taxpayer, to tear it down again. The sole purpose seems to be to make certain that in 1972 nothing of our capability is left. That's my main job at the moment. And we haven't even put a man on the moon yet.

Q How do you account for the diminishing support for the space program?

A The first is, of course, conflicting trouble areas in the world. There is a war in Vietnam, there are riots in the cities, and so forth. All these things have detracted from interest in space. Another equally important thing is that we haven't flown any astronauts since the last Gemini flight nearly two years ago. If they don't read about something for two years, people just forget about it. We've been out of the headlines for a long time. In addition, the Russians also have not flown people for a long time, so this feeling of being in a race with them has disappeared. I think a vast majority of people in this country believe that we are way ahead in this game anyway, so why run if we're ahead? That just isn't so. We aren't ahead.

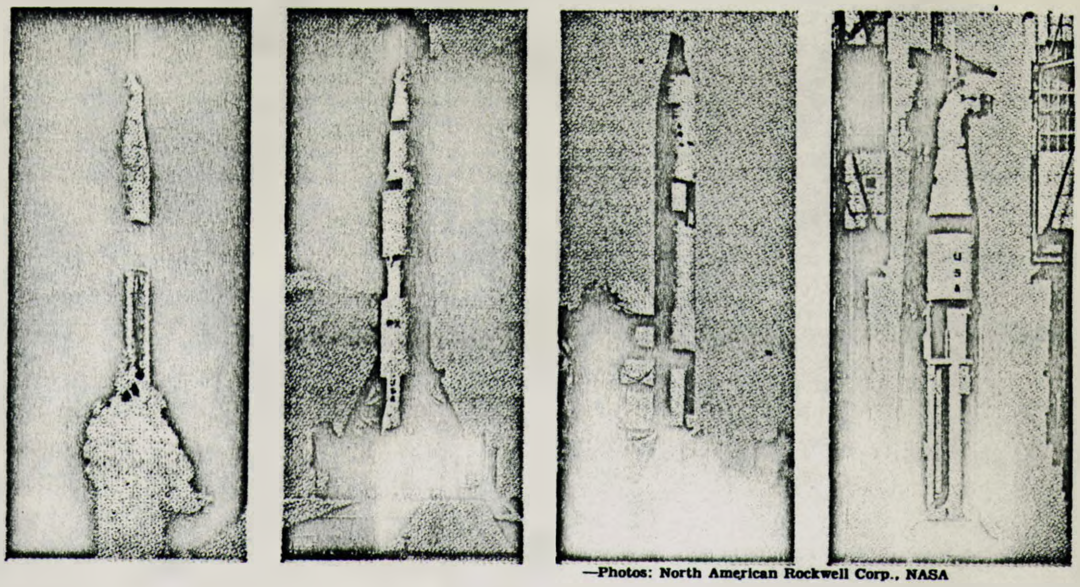
Continued on page 6

6

From Page 5

U. S. NEWS & WORLD REPORT

Dr. Wernher von Braun, 56, [illegible]e key man behind the [illegible]moth rockets that will send U. S. astronauts to the moon. For more than three decades—in his native Germany and in his adopted America—Dr. von Braun has been a pioneer in rocketry. He is now director of the Marshall Space Flight Center of the National Aeronautics and Space Administration at Huntsville, Ala.



—Photos: North American Rockwell Corp., NASA

Q Does it really matter who is first on the moon?

A The fact as to who will be there first will not go unnoticed on earth. The respect for the scientific status and the technological quality of the two countries will be compared in these terms for many years, perhaps for generations to come. After all, who remembers the *second* man to fly the Atlantic Ocean?

Q What might this country have done over the past few years to have insured being first?

A From my own point of view, I can only say this: It is an awfully difficult thing for anybody participating in our lunar program to try to run as fast as he can if the environment is one of building down rather than building up. It is like being ordered to disarm while the war is still on.

[illegible] In practical terms, what are you doing—laying off [illegible]ers?

A Yes. By the thousands. Let me give you some figures: At the peak, the Apollo program employed approximately 300,000 people throughout the industry. We are now down to little more than one half that figure, which means something like 135,000 people have already been laid off. And by the end of 1969, we will be down from our original 300,000 to 162,000 for that program.

Where the thing really begins to hurt is when the engineers, the scientists and the special skills—when they are laid off also, because you just dissipate the capability that you have built up, and as a result you are depriving yourself of the real payoff of your initial investment.

I must agree with the statement of Mr. James Webb, the chief of the National Aeronautics and Space Administration, when he said: "The Soviet Union will retain a commanding lead in space exploration for years to come because of repeated budget reductions."

Q You seem to be warning that this country may be heading for a great shock, greater than the first Soviet Sputnik. Is that so?

A Yes. I'm convinced that, unless something dramatic happens, the Russians are going to fly rings around us in space in a period of five years.

Suppose the Russians establish—which they undoubtedly will—an orbital station manned by a couple of dozen people to do all kinds of activities in outer space. They may use such a station for all kinds of research—astronomy, meteorology, biology, medicine, space manufacturing techniques. But they may also use it for earth-related activities, such as oil and mineral prospecting from orbit, crop surveys, navi[illegible]onal aids to shipping and aviation, and for communica[illegible] purposes ranging from entertainment to educational TV [illegible] political propaganda. They may also use it for military applications.

I'm not necessarily talking of orbiting H-bombs, but, for instance, for military observations. From such a space platform, they could keep an eye on the entire world. We will have a situation within a decade where such big Russian space stations are, as a matter of routine, flying over United States territory. If we keep cutting back our own space effort, all we'll be able to do is just sit here and say, "Well, we are not participating in the space program."

It would mean, to all intents and purposes, our abdication as a first-class power. I don't mean this solely in military terms. We would be abdicating our role as leader in world technology by not responding to the greatest technological challenge of our times. It would be comparable to not participating in aviation 50 years ago.

Q What must be done?

A What must be done? Some of my friends have told me: "Apparently, you can get the best performance in this country only if everybody realizes we are No. 2 and we had better run like hell."

The trouble is that most people seem to think that in space we are No. 1, which we aren't.

What we really need is sustained support of this space program over a great number of years. We must stop blowing hot and cold. This thing is for the long haul.

Q Will it require a lot more money?

A A program on the order of 5 to 6 billion dollars a year, sustained over a number of years, would at least enable us to pull even with the Russians. Programs on the order of 3.5 to 4 billion dollars—which we have this year—simply guarantee our falling back. I stress not only remaining in second place, but falling further behind.

Q What has the U. S. received for the money spent in space in the past decade?

A I would say that if 30 billion dollars has been spent in this decade, about 60 billion dollars has been returned to the economy in one way or another.

It is, of course, not possible to put a price tag on each single contribution that space makes to the economy, because the process is also one of enriching science and enriching technology, and the spin-offs are, in many cases, not quite that visible.

Let me give you an example: When we negotiate a contract with industry, the requirements for our space program are usually so stringent that they are always moving at the edge of our technology. In other words, we have very demanding requirements and we continuously move into the unknown, into new areas, in order to meet our basic requirements. As a result, space has become a kind of cutting edge for progress in many of the related sciences and technologies. This progress then flows back into the rest of the economy.

If we need a material that can stand conditions that no known material can stand, and finally a company comes up with such a material that meets our requirements, then

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HAS U. S. SETTLED FOR NO. 2?

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other applications for that same material will soon be found in commercial goods. We end up with better commercial goods that are either more durable, require less maintenance or can take conditions that previous materials could not. In other words, it spins off back into the economy. There is no way to put a price tag on that.

U. S. TIMETABLE IN SPACE—

Q Exactly what is the status of the moon race? What is our timetable—and that of the Russians?

A I will tell you our plan first.

On October 11, we will have sent up three men for the first time in an Apollo spacecraft. It has flown several times on unmanned missions, and we have felt it ready for a manned flight. The rocket is the Saturn I-B. That has been tested several times also. The plan has been to put this Apollo spacecraft into an orbit around the earth where it would stay, hopefully, for something like 10 days, slightly more than the equivalent period of a flight to the moon and back.

The purpose of the flight? To have the crew tell us that there's nothing wrong with flying this vehicle with three men. They will have tested all spacecraft systems after three days, but it will also be good to know how things go for the full 10 days.

Then in December we have another flight planned, the same Apollo spacecraft on our big Saturn V rocket. The Saturn V is big enough to push this spacecraft, plus the lunar module—a separate lunar-landing vehicle—all the way to the moon with enough fuel to get back.

This bigger Saturn V rocket has already flown twice, unmanned. The first mission was flawless, and on the second mission we had a few anomalies that we are quite confident have been straightened out. So we now want to fly the same spacecraft on this bigger rocket.

Q Is it possible that the shot in December will make an orbit of the moon with three men aboard?

A We are providing several options for this flight in December, which we may take up if the flight in October is judged very successful. One of the options is what you might call an all-out option, which means we would, indeed, drive the spacecraft all the way out to the moon and into an orbit around the moon in which it can then stay for a day.

Then it would drive itself out of orbit for a return flight. The hardware has the capability of doing that. It would be, however, very premature to say that this is our firm plan. It is far more likely that a less ambitious mission profile will be selected for the December flight.

Q If all goes well, what are the next steps?

A We would then have another Saturn V flight in the first quarter of 1969, a manned flight around earth, with the entire equipment—the command and service module, and the lunar module—and we would fly a simulated profile of a landing on the moon and a takeoff for home.

Then we will probably have another flight farther away from earth, with another set of activities simulating certain phases of the moon flight.

The fifth manned shot—again a couple of months later—would go with the same complete Apollo "stack," carried in the nose of a Saturn V, into an orbit around the moon. We would actually have two men transfer into the lunar module to fly a kind of simulated landing on the moon in the lunar environment. They would sweep down to a few miles above the lunar surface but make no landing, and finally rendezvous again with the moon-orbiting Apollo spacecraft and return home.

Q Does that mean our first American on the moon would not land until the sixth manned shot?

A That's right. If this whole program clicks as presently planned, we could make a lunar landing in the fall of 1969. But it could just as well be the very end of 1969.

Q There doesn't seem to be much margin for error—

A There may not be much of a time margin, but there's more margin for error for equipment failure than most people realize. For example, there are very few of what we call single-point failure sources in this entire Saturn-Apollo system. By that, I mean if any one component fails—say, a switch or a relay or even a valve—this will not jeopardize the entire mission. We have redundancy in the system, just like in an airplane with several engines and several sets of navigation instruments. If you have a failure in one system you can always go to another. We have spent a great deal of effort removing as many single points of failure as possible. Of course, there are always some left. But then you have some left even in an airplane. If an airliner loses a wing, then that's a single-point failure. But if it loses an engine, it isn't.

SOVIET MAN ON MOON: WHEN—

Q What is Russia's timetable to the moon, as you see it?

A There is, of course, quite a bit of speculation in this, but I would expect the following: My guess is that the Russians will fly a crew on a loop around the moon before this year is over. They will not deboost their spacecraft into an orbit around the moon and stay in that orbit for any length of time, as we plan to do. They will simply fly a loop around the moon, just like they did with the Zond 5, on a so-called free-return trajectory.

In other words, they will fly a kind of slingshot trajectory around the moon, and use the lunar gravitational field to throw them back toward the earth. Their Zond 5 launch rocket seems to limit their spacecraft weight to a relatively modest deep-space propulsion capability—not enough to go into orbit around the moon, but enough to make mid-course corrections, so that they can re-enter the atmosphere under the proper conditions for safe aerodynamic braking and landing. All this they have done with Zond 5, and I expect them to repeat this with a crew before the year is out.

Zond 5 was clearly a dress rehearsal for a manned operation. Had the Soviets' sole purpose been to recover a film cassette from a loop around the moon, they would have chosen a steep re-entry into the atmosphere with a bone-crushing 40 or 50-G deceleration [placing a pressure equal to 40 or 50 times the force of gravity on objects in the capsule]. That's a much simpler task.

Instead, they selected a shallow, low-G re-entry which requires extremely precise approach guidance and very extensive recovery preparations over a large potential landing area.

My guess is that if all goes according to plan, both sides will finish this year in essentially an even position. We may have, under the very best of circumstances, orbited the moon with men; they will, with a higher probability, have looped it with men.

Carrying the Russians into 1969, I think that they might land a man on the moon in the summer, possibly before us. I don't believe that anyone can predict clearly who will definitely be there first because we need a lot of good luck, and so do they. In a race of this kind, a lot depends on details. I mean, a single man who errs can foul up the entire timetable. [END]