file David Morrison (we should have a separate file for him in our general corresp. section, Carol.)

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546

Reply to Attn of:

File under Morrison

SL-4

July 21, 1978

Dear Colleague:

Summer heat has come to Washington, but we are busy at NASA Headquarters preparing our inputs to the FY 1980 budget. Also, the FY 1979 budget is still under consideration by the Congress, so we do not have any firm information on our operations for the upcoming fiscal year. Nevertheless, there are some news items I felt I should communicate.

Dr. Adrienne F. Timothy has recently been appointed Assistant Associate Administrator for Space Science (Science), filling the position vacated in January when Ichtiaque Rasool moved to the Office of Space and Terrestrial Applications. As most of you know, Adrienne has been working in the Solar Terrestrial Division, most recently as Advanced Planning Manager, and before that as Chief of Solar Physics. Her training is in physics, and before joining NASA, she worked with Skylab experiments as an employee of American Science and Engineering Co.

On May 20 the first of two Pioneer Venus launches was successfully accomplished from the Kennedy Space Center, and the Pioneer Venus Orbiter has encountered no problems to date in its trip to Venus. The Pioneer Venus Multi-probe will be launched in August. Enclosed is a short note on the mission and a listing of experiments on both spacecraft.

Also enclosed is a short report from the Mars Science Steering Group, chaired by Arden Albee, outlining their proposed strategy for future Mars exploration. This report was presented to Headquarters in late June.

Following are items for your calendars for the next year or so:

Aug 7	Pioneer Venus Multi-probe launch window opens
Oct 31-Nov 3	Tenth Meeting, AAS Division for Planetary Sciences/Caltech
Dec 4-8	AGU Fall Meeting/San Francisco
Dec 4	Pioneer Venus Orbiter injection at Venus
Dec 9	Pioneer Venus Probes arrive at Venus
Jan 15-18	Second International Colloquium on Mars/JPL
Mar 5	Voyager 1 Jupiter encounter
Mar 6-10	International Asteroid Conference/Tucson
Mar 19-23	Tenth Lunar & Planetary Science Conf/LPI
May 28-Jun 1	AGU Spring Meeting/Washington
Jul 9	Voyager 2 Jupiter encounter
Sep 1	Pioneer 11 Saturn encounter

I hope you have all received by now the "Dear Colleague" letters discussing opportunities in the Mars Data Analysis Program and the Planetary Geosciences Programs for FY 1979. Also, we expect to have the book Asteroids: An Exploration Assessment in the mail to you shortly.

Sincerely,

David Morrison
Staff Scientist
Planetary Division
Office of Space Science

Enclosures

P.S. Please note that planetary science is specifically included in the recent SPACELAB and LDEF announcement of opportunity (AO-OSS-2-78). There is still time to submit Letters of Intent to propose.

June 15, 1978

FY78 MARS PROGRAM

STEERING GROUP CONCLUSIONS

During FY78 the objectives of the Mars program were to study various vehicle and mission options for the continued exploration of Mars, to estimate the cost of a "minimum" sample return concept ("grab" sample) and to synthesize the options and concepts into program possibilities. These objectives have been met. We have considered orbiters, landers (hard and soft), penetrators, entry vehicles, airplanes, balloons, rolling balls, and rovers (teleoperated and autonomous) and analyzed their technology status, design requirements and potential mission usages. The results of these studies are reported elsewhere. We have designed two minimum Sample Return missions, one utilizing Mars orbital rendezvous and a sample transfer, the other landing the entire return vehicle on Mars for a "direct" return to Earth. The cost of either of these concepts (not including launch vehicle, sample analysis or back contamination costs) is estimated at approximately (within 20%) one billion dollars in fixed year dollars. Additions above these minima are being estimated and various options associated with increased intelligence in sampling, more sample sites, mobility and complementary science are under analysis.

From the many program possibilities we have considered this year the Steering Group finds there is no way to avoid the reality that the next phase of Mars exploration is intensive science with many diverse objectives. There is no scientific prioritizing possible which will enable small steps to accomplish these objectives. It remains for a programmatic commitment to be made, and for guidelines to be established so that mission(s) and systems design can be conducted within these guidelines. To aid NASA in making their decision about the programmatic choice to make we offer the following conclusions reached by the Mars Steering Group:

1. Future Mars exploration must be attacked by a cohesive program which addresses the objectives stated by the Mars Science Working Group on May 15, 1978 (attached).

2. Missions and projects within the total program remain to be chosen and defined based on celestial mechanics, performance, technology readiness, cost, cost-effectiveness, institutional and appeal factors. However, it is now timely and appropriate to undertake a Mars sample return and such sample return should be the major element of the next Mars project.

3. An appropriate name for the Project is ARES* - Automated Return of Extraterrestrial Samples

4. The so-called "minimum " or "grab" sample return concept has been analyzed and found to be not a cost-effective Mars mission. The potential for a disappointing scientific return is large while the costs for avoiding that appear to be relatively small. No precursor mission to a sample return is needed, but certain capabilities are required to ensure intelligent and effective sampling. These include:

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*The Greek name for Mars, pronounced Arēs.

(i) At least local mobility - sufficient (to be defined) to ensure comprehensive and representative sampling. It is noted that a mission profile cannot be recommended without further study as to options for sample acquisition and selection, targeting accuracy and complementary science;

(ii) Site characterization observations (remote and <u>in-situ</u>);

(iii) Site selection utilizing both <u>a priori</u> analysis of Viking data (see Item 5) and orbital data prior to landing, there is a trade between adaptability for site selection and surface mobility;

(iv) At least 3 distinct landing and sampling sites. The first three (with the third being a backup to the first two) will probably be in recent volcanic plains and ancient cratered terrain. Different sites may impose different mobility requirements and this will affect the sequence of siting choices. A later site might, if the engineering is feasible, appropriately be a North polar site.

5. Viking data, especially orbital imaging and IR observations, continue to yield significant information. A complete data analysis program should be carried out, not only for the direct scientific return, but to be employed in the design of Project ARES.

6. Remote and <u>in-situ</u> measurements are required, beyond those connected with sample return, in order to carry out the Mars program. Incorporating some or all of these into ARES needs further programmatic study. In this connection, we note:

(i) Polar orbiter observations may logically be done in a sample return mission, depending upon performance limitations (see Item 10);

(ii) Network science, especially seismology and meteorology, is required but the means for its accomplished depend on ARES project guidelines (see Item 7);

(iii) Long range mobility is a desirable element of the Mars program but not necessarily of Sample Return (see Item 4(i)). Its obvious use is for traverse science, especially geology.

7. The airplane offers significant scientific potential for the Mars program and introduces a new element of excitement into Martian exploration. It appears feasible, but needs further study. The penetrator is a more technologically mature concept which may offer the most cost-effective means to gain seismologic and meteorologic data. The use of these or of hard landers in the Mars program can only be determined when general Project ARES guidelines are established. We therefore recommend continued work (at approximately present level of effort) on these vehicles for the next six (approximate) months.

8. We have found little support for the Rolling Ball concept, although it must be recognized that its principal defect may turn out to be its present technological immaturity.

9. We are particularly interested in the potential for:

(i) Terminal descent imaging - for site characterization, location, and terminal guidance;

(ii) Terminal guidance for hazard avoidance;

(iii) Guided entry for reducing landing errors;

(iv) The technique of aerobraking for orbit capture;

(v) High resolution orbital imaging on film with film return;

and urge further consideration of these.

10. Mars Orbit Rendezvous seems to be the preferred mission mode for sample return, over Direct Return, on the basis of mission design flexibility. This appears to rule out (for Project ARES) further consideration of On-Orbit Assembly of IUS stages but demands continued evaluation of:

(i) Multiple Shuttle launches in one or more opportunities,

(ii) Use of solar electric propulsion,

(iii) Space storable propellants, and

(iv) Aerobraking for orbit capture.

11. Planetary protection (Mars and Earth) is an integral and proper part of a sample return mission design. Consideration of appropriate procedures is a responsibility of the ARES project in cooperation with, and with review by, the NASA Life Sciences Division. We agree with the Science Working Group that Planetary Protection issues must be addressed early (within the Mars program) to assess and establish their interfaces (and consequent design and cost implications) with mission analysis, science, engineering and management.

12. The Sample Return mission does not end at Earth capture. Additional study of the following is recommended in the coming year.

(i) Analysis of recovery procedures of the returned samples.

(ii) Assessment of facility requirements (including orbital, transport, and surface) for sample handling, analysis, and storage).

(iii) Determination of scope and level of at least the first "cycle" of sample analyses.

(iv) Consideration of science participation options and organization for Mars Sample Return.

13. Finally, it is recognized our project recommendation is extra-ordinary and is not done lightly. We note, with some passion:

(i) That the state of planetary science as it evolves over the remainder of the twentieth century demands intensive science at Mars and that this objective can probably not be implemented in the traditional sense of NASA/OSS projects; i.e., it requires broader support.

(ii) That a Mars Sample Return will not only provide a most valuable advance in knowledge in the space sciences, but it will also provide a significant and most defensible goal for the Nation's Space Agency.

(iii) That the cost, far from being excessive, provides a bargain. The yearly expenditure is small, by any reasonable comparative analysis, and the return will last in its significance for generations.

(iv) That broad, incisive and active support, both public and governmental, needs to be promoted. Films, lectures, pictures, and public participation are all required and must be actively participated in by Mars program personnel. The program should be designed from the onset to provide maximum public involvement in the mission.

(v) It is time now to begin the "selling" of ARES. This should be done carefully, not by overselling, but with judicious broadening of support. An FY82 start is sought but the recommendations above are independent of temporary political or programmatic perceptions.

SCIENTIFIC OBJECTIVES OF MARS EXPLORATION

(listed without order of priority)

1. Characterize the internal structure, dynamics and physical state of the planet.

2. Characterize the chemical composition and mineralogy of surface and near-surface materials on a regional and global scale.

3. Determine the chemical composition, mineralogy and absolute ages of rocks and soil for the principal geologic provinces on Mars; determine the interaction of the atmosphere with the regolith.

4. Determine the chemical composition, distribution and transport of volatile compounds that relate to the formation and chemical evolution of the atmosphere.

5. Characterize the dynamics of the atmosphere on a global scale.

6. Characterize the planetary magnetic field and its interaction with the upper atmosphere, solar radiation, and the solar wind.

7. Characterize processes that have produced the landforms of the planet.

8. Determine the extent of organic chemical and biological evolution of Mars and elucidate how the history of the planet constrains these evolutionary processes.

WHY MARS?

The next logical step in the exploration of Mars must involve intensive study and be focused on the return of samples to Earth laboratories. Apart from NASA programmatic considerations, the basic reasons for the above position are scientific. Only by a program of intensive study that involves sample return can a significant increase be made in our understanding of Mars. But such a program will cost approximately two billion dollars. Why should NASA commit almost half of its planetary exploration budget for the next decade to the intensive study of a single planet, and why should that planet be Mars?

Why Concentrate on a Single Planet?

It takes a tremendous amount of information to begin to understand a planet. We need to know its surface morphology and the composition of its atmosphere if it has one. We need information on the chemistry and mineralogy over the entire surface of the planet. Just to obtain these data requires flyby and orbiting spacecraft. The ages at which rocks were formed are needed to develop the chronological framework for the planet's evolution. Detailed studies of the chemical composition and mineralogy of its rocks and soils are essential to unravel its formation and internal evolution, and the formation and evolution of its atmosphere. This detailed chemical and mineralogical information must be complemented with data that can provide insight into the structure of the planet's interior, its critical third dimension. To obtain all of this information requires orbital spacecraft with remote sensing instruments, probes into and through the atmosphere, networks of instruments placed on the surface of the planet, analyses performed on the surface, and, of most significance, samples returned to Earth for analyses. These are just the suite of measurement techniques from which our understanding of Earth has been derived. It should not be surprising that they also are necessary for the basic understanding of the terrestrial bodies of our solar system.

The required data base is so extensive that it is impractical to assume that every planet can be covered in the same detail. A balanced planetary exploration program must therefore include intensive study of selected planets and less detailed survey studies of a greater number. Surveying all of the major planetary objects is in the best tradition of science - it is the reconnaissance of the unknown. The more detailed studies balance this by establishing the firm foundation of planetary science from which derives general understanding. The planets selected for detailed study must, therefore, be those that are intriguing as entities, that provide the best basis for comparison and extrapolation and that have raised a broad range of fundamental questions.

Mars: The Next Planet for Intensive Study

Two factors make Mars the next choice for intensive study, its variability and accessibility. These two factors provide the opportunity for addressing the broadest spectrum of planetary science available on any planet. Mars has, or had in the past, all the major divisions of a planet;

a differentiated and tectonically active solid body; a dynamically active atmosphere; a hydrosphere; an ionosphere with particles and fields; a potential for organic chemistry and life. A significant aspect of the processes occurring within these divisions is that in many cases they are either simpler or driven by different forces than similar processes on Earth. For example; the Martian atmosphere is less complex than Earth's and is not affected by ocean heat transport that is so important in the circulation of Earth's atmosphere; although modification of Mars' crust has occurred it has not been so extensive as to obliterate early formational processes. Consequently Mars is a key link in understanding Earth processes and the formation and evolution of the terrestrial planets.

As a result of Viking we know the atmosphere composition and the surface morphology of Mars relatively well. However, fundamental sets of data that bear on the formation and evolution of Mars as a planet are yet to be obtained. These data sets include the internal structure, composition (major element, trace element, and isotopic), mineralogy, absolute ages, geometry of the magnetic field, and high resolution gravity field surveys. Although Viking biology experiments did not produce positive evidence for life, Mars is still the prime target for exobiological searches in the solar system.

Mars' environment permits extended activity on its surface and its tenuous atmosphere allows measurement of its surface chemistry and mineralogy from orbit. In contrast, Venus, which like Mars has many similarities to Earth, presents us with a dense atmosphere and a hostile surface environment that precludes any but the briefest surface activity. The technology is available to take advantage of this natural accessibility and deliver the types of spacecraft and instruments to Mars that are required for its exploration. This includes polar orbiters, penetrators, hard landers, and vehicles for acquiring and returning Mars material to Earth.

Timeliness

It is always difficult to argue that some planetary exploration program must be done now instead of sometime in the future. An intensive Mars exploration program offers no exception. However, several points can be made that suggest an intensive Mars exploration program focused on sample return should begin now.

During the next decade there will be an increasing demand for hard facts to test developing hypotheses and concepts of the formation and evolution of both Mars and the solar system. So far the intensive studies of Earth, the Moon and meteorites have formed the tie points for our understanding of the planets. These studies - in which laboratory analyses of samples have played a key role - have formed the foundation of new concepts put forth as rather sparse data has been gathered from other bodies in the solar system. An ever increasing need will develop to supplement data from these intensive studies with similar data from Mars.

Mars is located at a different heliocentric distance than either Earth or its Moon, and may, thus, be representative of a different temperature, pressure and chemical composition regime of the early solar nebula. It is intermediate in size to the Earth and the Moon and, thus, provides an important comparison for planetary evolution. Consider briefly several key questions that can be addressed with satisfying certainty if sufficiently detailed data are obtained; data that can only be obtained from the laboratory analyses of returned samples. Absolute ages provide the time framework for volcanic activity, a major factor in a planet's chemical and thermal evolution. They would provide a calibration to the cratering rates that is important to establishing a time sequence to the evolution of Mars. Moreover it would allow the population of early solar system bodies to be estimated - which has important implications for the growth and composition of planets - in the region of Mars and compared to that in the region of Earth. A time scale would yield insight into the time and rate of climatic change. Detailed compositional information would provide an important "second point" at a different heliocentric distance then the Earth-Moon system from which to evaluate nebular condensation models.

Planetary science may provide the next major conceptual framework for understanding Earth. Past developments that have led to major breakthroughs in our understanding are the recognition of the existence of a geologic record, the ability to put this record into a time framework, the definition of the internal structure of Earth, and the unifying concept of plate tectonics. The ocean floors held the clues for plate tectonics that has provided the framework for understanding the present dynamical processes of the Earth's crust. Planetary science may well provide the clues for developing the conceptual framework of how these dynamical processes began. Lunar studies have certainly provided new perspectives for considering crustal formation and the generation of basaltic melts. Mars, with its similarities to Earth, has the potential for increasing our understanding of the planet on which we live. That potential that can only be realized with an intensive Mars exploration program.

The lead time required for sample return is eight to ten years. This means that we must begin now to provide data by the early nineties. Even with the earliest possible new start for sample return, the decade of the eighties will not benefit from the impetus of sample analyses that the lunar experience provided during the seventies.

By 1986 spacecraft will have flown past all of the planets in our solar system except Neptune, Pluto and possibly Uranus. After VOIR, reconnaissance of the terrestrial planets will have been completed. It is time to begin the next phase of planetary exploration, that of the intensive study of selected planets. The next choice is Mars. The intensive study of Mars can provide the focus to NASA's planetary exploration throughout the decade of the eighties and well into the nineties.

PIONEER VENUS MISSION

Introduction

Pioneer Venus 1, NASA's fourth probe to the planet Venus, was successfully launched on May 20, 1978. The launching took place only 0.7 seconds after the launch window opened. Pioneer Venus 1 will arrive at Venus on December 4, 1978, and will be placed into a 24-hour eliptical orbit. The periapsis will be less than 200 km above the surface of Venus.

The Spacecraft's trajectory will take it outside the Earth's orbit for the first 82 days of its journey to Venus. Shortly after it crosses inside Earth's orbit it will be joined by its sister spacecraft, Pioneer Venus 2, the multiprobe spacecraft. The multiprobes will arrive at Venus on December 9, 1978, targeted for polar and equatorial latitudes and day and night sides. The spacecraft bus will deploy three small probes and one large probe about 20 days before the Venus encounter. The four probes will require about 30 minutes to descend to the surface, but they are not expected to survive impact. The bus itself will be used as an upper atmosphere probe, taking data on ionospheric constituents from 200 km down to about 115 km. Depending on the exact angle of approach it will either skip out of the atmosphere or burn up as it descends.

Pioneer Venus is an atmosphere-intensive mission. The 30 scientific investigations carried aboard the six spacecraft (counting the bus) will be used to study the physical, chemical and dynamical properties of Venus' atmosphere. In addition, the orbiting spacecraft carries a radar altimeter to map the surface at approximately Earth based resolution over most of the planet. It also carries a gamma burst detector, which has already detected one burst from a galactic source.

The duration of the nominal mission is 243 days, or one Venerian year.

Orbiter Experiments

The orbiter carries a cloud photo-polarimeter, similar to the one flown on Pioneers 10 and 11 to Jupiter. The photo-polarimeter is being used for whole Earth photometry during the cruise phase of the mission, providing us with our first comprehensive phase angle coverage of the integrated light of the planet Earth. At Venus, it will be used to study the vertical distributions of clouds as well as their dynamical properties. An infrared radiometer, whose heritage comes from Earth weather satellites, will be used to sound the atmosphere, measure the localized albedo and map water vapor above the cloud layers. An ultraviolet spectrometer, similar to those flown on earlier missions, will be used to study air-glow phenomena and to map the hydrogen corona of Venus.

Neutral and ion mass spectrometers will be flown on the orbiter as well as the bus spacecraft, while neutral mass spectrometers will be included on the four probes. The orbiter mass spectrometers are designed to operate above 150 km, covering mass ranges from 1-46 amu for neutral species and 1-56 amu for ion species.

The putitive magnetic field of Venus will be measured with a flux-gate magnetometer with a dynamic range of 25 to 50 gamma and resolutions of .1-.2 gamma. This device will also be used to study ion current systems. The interaction of the solar wind with the planet's ionosphere will be studied with a plasma analyzer and an electric field detector. Additional information will be obtained from the retarding potential analyzer, which is primarily designed for measuring ionospheric plasmas, but will be useful in the 400-500 km range, and an electron temperature probe.

As in the past, a variety of radio science experiments will be performed using the S- and X-band signals available from the orbiter and multiprobe spacecrafts. These studies include celestial mechanics studies for determining the shape and interior structure of the planet, dual frequency radio occultations to probe the atmosphere, and measurements of small scale turbulence within the atmosphere.

<u>Probe Experiments</u>

The multiprobe bus contains neutral and ion mass spectrometers which are similar to those flown on the orbiter. The primary difference in their application will be in the altitude range which they operate, 150-115 km. The bus will not survive below the upper atmosphere of Venus.

Atmospheric composition measurements from the large probe will be made by a neutral mass spectrometer and a gas chromatograph. The mass spectrometer has a range from 1-208 amu, and employs a variable energy ion source so as to take advantage of energy dependent cracking patterns. It will obtain approximately 60 mass spectra between 67 km and the surface. The gas chromatograph will obtain samples at 53, 44, and 24 km. It will determine the abundances of Ne, H_2, N_2, O_2, Ar, CO, CH_4, Kr, and CO_2, and will be able to identify NH_3, H_2O, HCl, H_2S, COS, and SO_2. Also on the large probe, the cloud particles will be characterized by a particle size spectrometer which will categorize the particles in 34 different size ranges between 1 and 500 microns.

Two experiments are flown on allfour probes, providing uniform data over much of the planet and allowing cross calibration of some of the simpler experiments flown on the small probes. The atmospheric structure experiment, similar to those flown on the Viking mission, measures the temperature, pressure, and acceleration environment of the probes as they descend. The nephelometers measure the aggregate properties of the cloud particles. Used in conjunction with the cloud particle spectrometer, they will enable us to better understand the nature of the clouds, while their independent use will allow us to characterize the nature and extent of the cloud layers at different locations on the planet.

Both the large and small probes also contain net flux radiometers which will measure the net deposition and flow of energy within the atmosphere.

Differential Long-Base-Line Interferometry will be used to measure the transverse motions of the four probes as they enter and descend through the atmosphere. Three DSN stations will simultaneously track the four probes and the bus, which serves as a ballistic reference. Analysis of these data will enable us to understand the general circulation and winds on Venus. In addition, radio propogation and turbulence experiments will be performed.

Management

The Pioneer Venus project is the last of the series of Pioneer spacecraft managed by Ames Research Center at Moffett Field, California. Charles F. Hall is the Project Manager and Larry Colin is the Project Scientist. At NASA Headquarters, the Pioneer Venus program falls within the Planetary Division of OSS, with Fred Kochendorfer as Program Manager and Robert Murphy as Program Scientist.