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THE JOHNS HOPKINS UNIVERSITY

DEPARTMENT
OF
PHYSICS

TECHNICAL SUPPORTING STUDIES PLAN
Revision A

NASA/MSC Contract NAS 9-11528

Task I. Principal Investigator Services

Submitted by

Wm. G. Fastie
Principal Investigator

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To: Distribution

From: Wm. G. Fastie, Principal Investigator

Subject: Technical Supporting Studies Plan, Revision A,
MA-091T, NASA/MSC Contract NAS 9-11528.
Task I. Principal Investigator Services.

We submit herewith a revised draft of the subject plan. The revised plan reflects the changes requested in Mr. Clyatt's letter of November 5. The current revision has been discussed with Mr. Hardee's office.


Wm. G. Fastie
Principal Investigator

WGF:eb

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Technical Supporting Studies Plan

Revision A

DRD #MA-091T Contract NAS 9-11528 Task I

I. Introduction.

The following description of the proposed supporting studies for the Apollo 17 UV Spectrometer includes our current ideas on the type of research which should be done to give maximum scientific support to the flight of Apollo 17 and to the analysis of the data received from the Apollo 17 UV Spectrometer. However, it should be recognized that some of the items proposed herein may be logistically impossible and, as the studies develop and further Apollo flights are accomplished, new ideas will evolve which should be studied to enhance the Apollo 17 mission. Therefore, the plan presented herein represents a guideline rather than a final program.

II. Summary.

The following technical supporting studies are currently planned for the UVS experiment. The studies and their objective are more fully described in subsequent sections.

1. Analytical studies of existing data and theory to construct models for the lunar atmosphere. The influence of the solar wind and its accompanying magnetic field, solar flares, lunar volcanoes, and past and current lunar landings will be considered in this analysis.

2. The acquisition of information about the UV albedo of the moon in the spectral region 1175 to 1675 in order to make it possible to roughly predict the observed signal during the Apollo 17 UVS observations of the lunar surface.
3. Analysis of engineering performance data from a pre-prototype of the Apollo 17 UV spectrometer obtained in a separately financed experiment (NASA grant NGR 21-001-001) in an Aerobee rocket which is scheduled for a May 25, 1971 launch.
4. Correlation of the UV absolute calibration studies financed by the above grant with the calibration of the Apollo 17 spectrometer.
5. Study of Data System and Data reduction program interface with lunar atmosphere analysis program and reduction and analysis of flight data.

III. Analytical Studies

As this is written, no information about the results of Apollo 14 that may affect our knowledge of the lunar atmosphere has been studied. However, as noted below, the Apollo 12 cold cathode gauge results have impacted our proposed experiment. We intend to study the data from Apollos 14, 15 and 16 for information which may suggest changes in our experiment and/or provide guidelines for our theoretical work.

We propose to continue analysis of the interaction of the solar wind with the lunar surface and the generation of atomic constituents, particularly hydrogen, by this interaction. This study will include the effect of the geotail which reaches beyond the moon during full moon and which alters the solar wind in the vicinity of the moon. These theoretical studies will also include analysis of ionization of atmospheric species by solar extreme ultraviolet radiation and the mechanism by which the ions thus produced can escape.

The above analytical studies will be strongly impacted by the scientific results obtained on the lunar surface by Apollo 12. The cold cathode gauge experiment of Johnson et al. (see Apollo 12 Preliminary Science Report, NASA SP-235) provides strong evidence that the lunar atmosphere is perhaps an order of magnitude denser than the upper limit of 10^7 atoms/cc determined by radio occultation experiments performed with Surveyor. On the other hand, the UVS experiment was designed to measure in the density range from 10^{10} atoms/cc to 1 atom/cc. One atom/cc represents the smallest density of hydrogen atoms which analysis indicates could result from solar wind interaction at the surface. Analysis also indicates that atomic hydrogen density from any source could not also exceed 10^4 to 10^5 atoms/cc. Thus, the Apollo 12 results indicate that atomic hydrogen is a minor constituent of the lunar atmosphere and that heavier gases, particularly xenon, which can be detected in the

range 10^3 to 10^9 atoms/cc, will predominate. The Apollo 12 results also open the possibility that the density of the lunar ionosphere will permit detection by the UVS of several ionic constituents. If the density of the lunar atmosphere is as much as 10^8 per cc, several molecular species may also be in the range of detectability of the UVS. In summary, the Apollo 12 results have limited the range of total lunar pressure and permit the calculation of more precise lunar atmosphere models. This capability in turn affects the design of the experiment (for example, the spectral scan rate and the spectral resolution) and the data reduction and analysis plan. The above studies will be conducted in cooperation with the co-investigators (C. A. Barth and G. Thomas, University of Colorado; T. M. Donahue, University of Pittsburgh; and R. Henry, The Johns Hopkins University). The cooperative program will be accomplished by conferences, seminars, individual studies by the investigator, and the direction by the investigators at The Johns Hopkins University of graduate student research theses. Funds required for this phase of the supporting research activity are restricted to support of the graduate students and travel expenses for the investigators.

The first phase of this study will be completed by Dr. Thomas in early 1972. Dr. Thomas' work will be largely an analysis of the interaction of solar wind protons with the lunar surface. Dr. Thomas will also conduct a literature survey.

Dr. Donahue will analyze Apollo 14, 15 and 16 data as available before the Apollo 17 flight to provide the latest information for quick analysis of the Apollo 17 UVS data.

The largest effort in this area, of course, will follow post flight data reduction, and will be conducted by all members of the UVS team. In the event that the flight data indicates analysis is required in an area such as surface chemistry, for example, we will make the data available to experts in other fields for analysis. This work will continue until the end of the present contract period, namely December 31, 1973.

IV. Lunar Albedo Studies

One of the primary modes of operating the UVS to measure the lunar atmosphere is to point the instrument at the lunar surface and to scan the sunrise and sunset terminators. When the sunlit surface is observed, the signals received are probably large but not calculable because the lunar albedo in the UV is unknown. The UVS experiment will determine this albedo and its variation on the lunar surface as an incidental result of the lunar atmosphere experiment.

From an instrumental standpoint, it is highly desirable that knowledge of the lunar albedo in the far UV be obtained in advance of the flight of Apollo 17. This information will make it possible to tailor the electronics so that overexposure of the detector will not occur. It will also make it possible to prepare the real time data display to present this large signal which immediately follows or precedes the weak terminator signals containing

atmospheric information. In addition, it will make it possible for us to conduct quantitative studies of the UVS photomultiplier tube recovery time after exposure to the lunar signal. This information will be invaluable in determining whether the lunar surface signal might disturb the observation of the atmospheric emission signal after terminator crossing during Mode I operation and may thus demonstrate the need for UVS protective door closing during Mode I operation after spacecraft sunrise and before spacecraft sunset. This work will be completed as soon as possible and no later than June 30, 1972.

Accordingly, we will formally propose to NASA headquarters that we be provided with existing lunar dust samples. We have determined that the required information has not been acquired and that current lunar sample experimenters do not possess the necessary equipment to make the required measurements.

The most important preflight aspect of these studies is their impact on the planning of the experiment. However, in the post-flight period, we anticipate that we will be interested in correlating the in-flight albedo measurements with laboratory measurements of samples acquired by the Apollo 17 landing party. We, therefore, will formally request through NASA headquarters Apollo 17 lunar dust samples. We would plan to study the samples with the spare flight instrument installed in the Calibration Test Equipment

or with other existing laboratory equipment. We anticipate that the Apollo 17 lunar dust sample study will be complete by December 31, 1973. Dr. Henry, assisted by Dr. Schaeffer and Mr. Fastie, will conduct the lunar sample albedo study and flight data correlation analysis.

In the event the UVS observes fluorescence or phosphorescence on the dark side of the moon, we will also conduct post-flight laboratory studies on lunar samples to determine whether such emissions are caused by solar x-rays, solar UV or cosmic rays.

V. Absolute Calibration.

As discussed in our proposal and in our preliminary study report, it is essential that the UVS be calibrated preflight and inflight in order to make it possible to extract from the flight data the information needed to analyze the results in terms of density and scale height of the lunar atmosphere. For the past decade, this laboratory has continued studies in the techniques of far ultraviolet calibration under NASA Headquarters grant support, (NGR21-001-001, which is currently funded.) In addition, one of the responsibilities of the principal investigator as a co-experimenter on the UVS experiment on Mariners VI and VII was to assist in absolute calibration of the instrumentation. Consequently, the technology, experience

and the laboratory facilities required for this work exist. However, in order to apply the calibration techniques to the Apollo instrument, considerable effort will be required in the area of training personnel and in a comparison of the Apollo detectors with Apollo reference standards, with laboratory reference standards and with NBS standards. More specifically the following work will be necessary.

1. Acquire two NBS calibrated photodiodes.
2. Compare these diodes with existing laboratory standards.
3. Determine sensitivity of Apollo 17 photomultiplier tubes with the above standards.
4. Map the variation and sensitivity of the Apollo 17 photomultiplier tubes as a function of position on the tube face.
5. Recommend to the Applied Physics Laboratory the tubes which should be chosen for flight and their proper orientation as determined in #4 above.

This work will be under the direction of Prof. H. W. Moos who is also responsible for absolute calibration of our UV rocket spectrometers. He will be assisted by Dr. Schaeffer and by a graduate student.

6. Measure polarization properties of sample gratings from the master grating used to produce the flight replica gratings.
7. Analyze the detailed information obtained from the laboratory calibration of the flight spectrometers to determine the absolute sensitivities of the flight instruments.

The studies for items 1 through 5 above will be completed as required by the scheduled work on the qual unit, flight spectrometer and the spare spectrometer. Items 6 and 7 will be completed before the Apollo 17 launch so that the technical information thereby obtained will be available for analysis of flight data.

VI. Aerobee 350 Pre-prototype.

Although the Apollo 17 UVS is based on an instrument which has been flown on rockets, satellites and interplanetary vehicles, the design incorporates new features which improve the light gathering capability, scattered light rejection, and photoelectron detection capability. More specifically, the conceptual design includes:

1. A pair of exit slit mirrors which provides 2.5 times the photon signal at the detector as was available from previous instruments.
2. A multiple angled external entrance slit baffle which has an extremely high rejection ratio for solar UV radiation and diffusely scattered solar UV radiation from the illuminated lunar surface. This baffle is essential for observing the radiation from the illuminated lunar atmosphere against the background of the unilluminated lunar surface just beyond the sunset and sunrise terminators.

3. A photoelectron pulse counting system which rejects noise pulses, counts photoelectron pulses for 100 milliseconds and presents the accumulated counts to the command module data system as a 16-bit word.

Our continuing NASA Grant NGR 21-001-001, which has funded our work in rocket UV spectroscopy for the past decade, has recently provided special funding which has made it possible to build a rocket UV spectrometer which includes most of the conceptual design features of the Apollo 17 UVS, and specifically incorporates the three major features described above. More particularly the slit mirror assembly closely follows the dimensions of the current Apollo 17 design; the external entrance slit baffle will, in fact, be a test model of the Apollo 17 design, and the electronic system will use the proposed Apollo 17 detector (EMR542G photomultiplier tube). HV power supplies, pulse detectors, and storage and transfer registers, which are similar to those proposed for the Apollo 17 UVS.

The Aerobee 350 experiment includes several other instruments in an integrated experiment to study the twilight ionosphere to an altitude of 350 kilometers, at which altitude the UVS spectrum will be similar in brightness at some wavelengths to the spectrum anticipated from the Apollo 17 experiment.

The data from this experiment will be received in a format which

can be easily converted to be identical to the Apollo 17 format. Thus, we will have spectra and flight tapes which will be invaluable in planning the format for the real time display and for training for the real time phase of the Apollo 17 operation. This data will also be important for writing and testing analytical computer programs for the lunar data. In fact, this latter advantage represents an economic advantage in excess of the total cost of the 350 payload.

The impact of experience gained in building and flight testing what amounts to a mock-up or pre-prototype of the Apollo 17 UVS will be of considerable significance, particularly since the scheduled flight data of May 25, 1971 (Aerobee 17:11UA, Wallops Island, Va.), precedes the critical design review. The performance and engineering information acquired from the flight will be presented in a special report for that review. An analysis of the expected optical performance of the Apollo 17 UVS, including optical aberrations and exit slit mirrors, will be prepared and submitted as a special report. This analysis will include comparison with the in-flight optical performance of the preprototype spectrometer. The study will be conducted by Mr. Fastie and completed by April 1, 1972.

VII. Scientific Analysis and Data Programming.

The plan for programming and analyzing the Apollo 17 UVS data is the subject of a separate report (DRD #DM-024T due July 9, 1971). The discussion herein will deal with that aspect of the data problem that is impacted by the Technical Studies program. Since the flight data will reflect in part the results of the studies and since the scientific analysis of the data will affect the post-flight technical studies, it is imperative that there is close coordination between the scientific studies, the instrument data system, the UVS flight data format, the supporting flight data, and the data programming plan.

The required coordination will be effected through the efforts of Professor Paul D. Feldman of this laboratory, an experienced research physicist who has specialized in analysis of our rocket research data, and in computer programming of telemetry data for such analyses. Professor Feldman will be responsible for all aspects of the data problem and will work closely with the principal investigator, the other experimenters and the instrument data development team at APL to accomplish our objective. This work will be a continuing effort until completion of the flight data analysis.

Analysis of the flight data will be the responsibility of the PI and of the coexperimenters and will be accomplished as soon as possible after receipt of flight tapes.

VIII. Funding

The program outlined above will be possible within the financing provided in the current contract for Task I. Any addition or modifications which may develop will probably not affect the total cost.