LUNAR INTERNATIONAL OBSERVERS NETWORK

OPERATION DURING THE APOLLO 10 MISSION

27 June 1969

Prepared by
Lockheed Electronics Company
for
Lunar and Earth Sciences Division
Under NASA Contract NAS 9-5191
LEC Document 645D.21.028

Prepared by Louis E. Schneider
Louis E. Schneider

Barbara M. Middlehurst
Barbara M. Middlehurst

Approved by Norman C. Allen 6-25-69
Section Supervisor

Approved by W. R. Walker
Department Manager

NASA Manned Spacecraft Center
Houston, Texas

NASA CR 108175

TABLE OF CONTENTS

PREFACE

This report has been prepared by Lockheed Electronics Company for the Lunar and Earth Sciences Division by Louis E. Schneider and Barbara Middlehurst under Action Documentation 3024-AD-03-02 of NASA Contract NAS 9-5191.

INTRODUCTION

In 1540, observers at Worms noted an unusual bright spot on the dark side of the moon. This is the first known record of a Transient Lunar Event. Since that time, more than six hundred events have been reported by reputable observers. The nature of the event varies. Bright spots are the most common, but blinks, obscurations and colors of red, blue and violet have been reported.

The first attempt to correlate lunar phenomena with tidal forces was by J. Green in 1964.[1] During the following years, J. Burley and B. Middlehurst made a broader study that also included tidal correlations. Both investigations indicated a causal relation to tidal stress. In 1967, W. Chapman expanded upon the tidal study developed by Green, by including the libration factor. Although this study was limited to the Aristarchus area, a good correlation was indicated.

Many other interesting papers on the subject of Transient Lunar Phenomena have been published. It is not within the scope of this brief report to mention them. The few papers noted will furnish sufficient introductory material for an extensive review of the subject.

Increased interest in lunar events developed, rather naturally, with the Space Program. Organizations were formed to insure consistent observation of selected areas of the moon. Informative reports are available on the ALPO Program, Argus-Astronet and Operation Moon Blink. Many members of these organizations are now contributing valuable support to the LION Program.

---

1. References are cited at the end of this report.

The Apollo 8 mission furnished the first opportunity for direct observation of the lunar surface. Thus, there existed the possibility that earth based observations could be confirmed by astronaut observations and photography.

At the request of Miss Barbara Middlehurst, Mr. Robert Citron arranged communications between the Smithsonian Center for Short-Lived Phenomena and 125 observing stations in 21 countries. Reports received at the Center were transmitted to Mr. William Chapman at the MSC in Houston. Details of this operation are covered by Mr. Citron's report of January 5, 1969.

The LION Program to observe Transient Lunar Phenomena is an extension of this volunteer program for observation of the moon during Apollo 8. This program is funded by the NASA, MSC, Houston, Texas.

The Lunar International Observer Network (LION)

Objectives

The nature of transient lunar phenomena is controversial. The objectives of this program are, therefore:

> To determine whether ground observations of lunar events can be confirmed by crew members of Apollo spacecraft during lunar orbit, and to obtain further evidence that may help determine the cause of lunar events.

Program Organization and Management

Operation LION is funded by the NASA, MSC, Houston, Texas. Responsibility for management of the program rests with the Geophysics Branch.

Lockheed Electronics Company, Support Contract NAS 9-5191, is the prime contractor for operation LION with the responsibility for maintaining contact with the observer network. All letters to observers and reports on LION mission support are developed by personnel in the Lunar and Earth Sciences Department. To assist with the organization of LION and furnish expert advice on lunar phenomena, Lockheed engaged the services of Miss Barbara Middlehurst. Through the courtesy of Encyclopedia Britannica, Miss Middlehurst is retained by the Lunar and Earth Sciences Department as the Consulting Astronomer.

To establish and maintain a highly efficient communications network, the Geophysics Branch contracted for the services of the Smithsonian Institution Center for Short-Lived Phenomena. Mr. Robert Citron,

Director of the Center, supervises communications procedures, developes codes, cable formats and furnishes invaluable support to the program.

Direct control of operation LION rests with a committee consisting of representatives from the NASA, Geophysics Branch; LEC, Lunar and Earth Sciences Department, Geophysics Section; Mr. Robert Citron and Miss Barbara Middlehurst.

The organization of the LION Committee is as follows:

Mr. J. O. Annexstad, Chief, Geophysics Branch, Chairman
Mr. John Evans, Geophysics Branch, Coordinator
Mr. William Chapman, Geophysics Branch, Chief Scientist
Mr. Robert Citron, Director, Smithsonian Center, Communications Coordinator
Mr. Norman Allen, LEC, Supervisor, Geophysics Section
Mr. Louis E. Schneider, LEC, Geophysicist
Miss Barbara Middlehurst, LEC, Consulting Astronomer

Communications

All communications to and from the lunar observer network flow through the Smithsonian Center at Cambridge, Massachusetts. Two private line telephones link Smithsonian and the Science Support Room in Houston. Contact with the spacecraft is through the Director of the Science Support Room to Mission Control.

Under the direction of Mr. Robert Citron, a detailed "Observing Program and Communications Procedures" was developed by Smithsonian and mailed to all observers. This excellent paper is updated for each Apollo mission and serves as a guide for observers.

A comprehensive report of the Smithsonian communications support during Apollo 10 has been sent to all members of the LION network. A supplementary report containing statistics of the observation program and detailed observer reports, will follow immediately.

The time delay between the initiation of an observer report and the reception of that report in the Science Support Room varied from one minute to thirty-nine (39) hours. The average time delay for all reports received in Houston was five and one-half hours.

Most reports from overseas were sent by telex or cable. The shortest transmission time was due to the excellent radio communications of Astronet.

All observers are encouraged to use the fastest means of communication during future Apollo missions.

Observer Network

During the Apollo 10 mission, 46 observing stations in 15 states formed the observer network in the United States. Overseas, there were 130 observing stations in 31 countries, supporting the LION Program. This is indeed an outstanding example of international cooperation and of cooperation between professional and amateur astronomers. The locations of observer stations in the world-wide network are presented on maps identified as Figures 1 and 2.

Since each station is generally staffed by two or more observers, the actual number of individual observers is estimated to be about three hundred.

Equipment utilized by observers varied from a one hundred inch aperture reflector with sophisticated auxilliary equipment, to 2 1/2 inch refractor instruments. All instruments had one very essential attachment - an enthusiastic and dedicated observer.

Many interesting letters and personal communications have been received from LION members in distant countries. Russian astronomers, in particular Dr. Kozyrev at Leningrad and Dr. Teifel at Alma Ata, have sent congratulations to the Astronauts and letters containing most welcome comments. Other interesting letters have come from:

Lewiss Bartha and Péter Hédervári, Hungary; Raul Dário Kuplich and Jose Manuel Luis da Silva, Brazil; Toshihiko Osawa, Japan; J. M. Oliver, Spain; Ivan L. Thompsen, New Zealand; DELAYE Yves, France; Rafael CAPDEVILLE Celis, Chile; Michael Lindhorst and Dr. H. Haffner, West Germany; J. Classen, East Germany.

These personal communications are most welcome and are very much appreciated.

Recent additions to the observer network include several Moonwatch teams in Brazil, Thailand, the Phillipines and Guam. These strengthened weak areas in global coverage. Their support is most welcome.

In Hungary a group of thirty observers, represented by Dr. Péter Hédervári, have offered their services. Another group of thirty in southern France, represented by Monsieur DELAYE Yves, will be observing during future missions.

It is most encouraging that world-wide interest and enthusiastic support continue to increase.

Procedure

The general procedure for LION operations provides for observer communication to Smithsonian and from there to a LION representative in the Science Support Room. At the LION desk, reports are recorded on a prepared form, precisely as received. A detailed "Operations Log" is kept for the period during which the International Network is observing the moon. Normally, this will be during lunar orbit.

When lunar events are reported, a committee consisting of Miss Middlehurst and Messrs. Chapman and Schneider, determines what action is to be taken. Should the decision be to request confirmation by the Apollo crew, a request is submitted to the Director of the Science Support Room who will generally forward it without delay to Mission Control.

There are times when the Apollo crew is too occupied to accept additional activities, so the request must again be screened by Mission Control. Voice communication from Mission Control to the spacecraft and comments by the crew are heard in the Science Support Room. This information is recorded in the log book and completes a communication chain that may have started in Leningrad or New Zealand.

Report Statistics

During the Apollo 10 mission, 54 reports were received by the Smithsonian Center. Thirty of these were positive; twenty-four were negative. Of this total, nineteen positive reports and seven negative reports were telephoned to the LION desk in the Science Support Room. The remainder were received after termination of the LION alert at the MSC.

Positive reports are tabulated by lunar area in Table 1.

TABLE 1

Event Reports by Lunar Areas

Lunar Feature	Number of Separate Reports	
1. Aristarchus	17	
2. Harpalus	2	(New)
3. Harpalus & Bauger	2	(New)
4. Ross D	2	
5. Manzinus	1	(New)
6. Atlas	1	
7. Bula	1	(New)
8. Rabi Levi	1	(New)
9. Pasidonius	1	
10. Maskelyne	1	(New)
11. Censorinus	1	
	30	

It is interesting to note that more than half of the events reported are for the crater Aristarchus and vicinity. Six of the remaining thirteen features reported active are new additions to the list of lunar transient event sites.

Activity at Aristarchus was described by various observers as scintillations, pulsations, blinks or intermittent increases (or variations) in brightness, or color.

The crater Aristarchus, at latitude 23N and longitude 47W, could have been seen from the spacecraft only during the approach to the moon and briefly on the horizon during the first high orbit. On May 21 at 2212 GMT, the Apollo crew observed Aristarchus and reported "no sign of activity". Ground observers also reported no activity at Aristarchus during this period of Apollo 10 observation.

The crater Harpalus, North of Aristarchus, on the border of Mare Frigoris, was reported very bright on two successive nights by observers at the Brazilian National Observatory. Changes in Atlas, Biela, Bouguer, Manzinus, Maskelyne and Ross D, (all increases in brightness), were observed on one occasion each.

The Maskelyne brightenings were reported by the Montreal group. The report was received after the mission had ended but has particular interest for two reasons. Crater Maskelyne is situated between landing Sites 1 and 2 and was the only report area that could have been directly visible to the Apollo 10 crew while they were in lunar orbit. Secondly, what appeared at first to be photographic records of Maskelyne activity, made on the following night, were received from Farley Dickinson University Planetarium, Trenton, New Jersey.

A careful examination of contact prints by B. Middlehurst revealed no unusual phenomena. The bright spot appearing on two prints near Maskelyne was determined to be a photographic defect. On several plates of the same series of photographs the crater Menelaus appears very bright. A proper examination of the original material, to determine whether these are photographs of a transient event, has not yet been possible.

Reports from Observers

Many LICK observers do not read English. To provide a simple system for reporting events and reduce the cost of cables, a code was developed by Mr. Citron and transmitted to the network. The code and sample messages are included in the Smithsonian Report, "Communications Support for Transient Lunar Phenomena During the Apollo 10 Mission". In practice this code worked well, and the messages received were clear and concise. Nearly all observers used the code; many confirmed their cables or telephone messages with longer descriptions sent by mail. In only two cases were initial reports ambiguous. One report contained a trivial error that was easily corrected. A second report, from Hawaii, indicated daylight times for the observing period and was considered to be in error.

Only one observer communicated directly with the Science Support Room in Houston.

Considering the number of observers reporting, this is an excellent record. Such diligence and cooperation is to be commended.

While the data reported during Apollo 10 are not sufficient for statistical evaluation, they are a valuable addition to information obtained

during Apollo 8. With additional reports from Apollo 11 observations, it may be possible to make statistical studies, tidal correlations and possibly seismogram correlations, that will contribute to the understanding of lunar phenomena.

It is disappointing that most of the observatories equipped photographically, photoelectrically or to take spectra (eg., Allegheny, Toledo, Ohio, in U.S.; Kiev, Pulkovo, Alma Ata, in the U.S.S.R.; the Japanese observatories; New Zealand, etc.) were clouded out. At the present time, no report has come in from Helwan, Egypt; Meudon, France; Britain or from Corralitos Observatory, New Mexico.

Tidal Effects

The pattern of lunar events appears to correlate with tidal forces on the moon, which are strongest at perigee and apogee. The launch dates for Apollo 8 and 10 coincided favorably with periods of tidal activity.

The locations of Harpalus and Bouguer (53N, 40E), Biela (52S, 52W), Manzinus (67S, 30W) and Rabi Levi (35S, 25W) are near the libration zone of maximum tidal amplitude. Mr. Chapman has computed tides for the period during which events were reported at these sites. His report states: "For the two new event sites in the second lunar quadrant and the three event sites in the fourth quadrant, tidal amplitudes substantially above average peak-to-peak values were exhibited for the time of the Apollo 10 mission."

Validity of Reports

In most cases at least two observers worked together giving independent confirmation of an event. The meaning of independent confirmation was

defined in communications from Tucson to observers in 1967. It was agreed that, if details beyond a rough indication of where to look for an event are discussed before two reports are formulated, there will be only two versions of the same report, not independent confirmation. In all but two reports, at least two (often nine) observers, operating with two to nine telescopes, independently confirmed the event sighted. It is reasonably sure that all reports were made in good faith and with the proper scientific objectivity.

Observing Conditions

During Apollo 10, bad weather was reported from many parts of the world. Clouds stopped observing completely in Kiev, Tokyo, most of New Zealand, Alma Ata, parts of Brazil, many parts of Europe and elsewhere. Observing time was reduced throughout most of the U.S.A.. Apollo weather photographs taken during this period show heavy cloud cover over much of the Earth.

Summary

The Apollo 10 mission put to the test all plans and procedures developed for the LION Program. Considering the broad geographic coverage of the observer network and the many countries involved, communications were remarkably rapid. All observers, and those involved in message transmission, are to be congratulated.

Detailed reports of the activities of the Smithsonian communications center have been prepared by Mr. Robert Citron. Each LION member will receive copies.

The LION desk in the Science Support Room was occupied, on a twenty-four hour schedule, by a member of the Geophysics Branch or Lockheed Electronics Company. Miss Middlehurst and Messrs. Chapman and Schneider

were on call twenty-four hours a day. This schedule began at Launch Time, May 18, and continued until May 25 at 0100 GMT. Everyone who participated in this operation is to be congratulated for a job well done.

The number of positive reports was more than had been conservatively estimated, and their quality was uniformly good. During the May 20-24 period, nineteen reports of transient events were recorded in Houston. These are listed in Table 2. Several negative reports were received but are not included. Locations of reported events are indicated on Figure 3.

As during the Apollo 8 mission, cloudy conditions hampered observations, and no acceptable permanent records of changes or anomalous appearances of lunar features were obtained. One set of photography was obtained at Farley Dickenson Observatory but the bright spots recorded were photographic flaws. A possible brightening elsewhere on the photographs is still under review.

On May 21 at 2050 GMT, a request for Astronaut confirmation of events reported around Aristarchus was originated at the LION desk. Thanks to the cooperation and interest of people in charge of the Science Support Toom, Mission Control and in particular, Mr. J. W. Schmitt, who was in voice contact with Apollo 10, the request was forwarded without delay. At 2212 GMT, the Apollo 10 crew reported "no sign of activity in Aristarchus".

A second request for observation of Aristarchus was forwarded to Mission Control on May 23 at 0450 GMT. At that time, the Apollo 10 crew was enjoying a well deserved sleep period and the request was not transmitted.

TABLE 2
Reports of Transient Events

No.	Received Date	Received GMT	Feature	Event	Observed Date	Observed GMT	Observer	Location	Elapsed Time Hours	Elapsed Time Min.
1	20	1150	Arist	Pulsation	20	0417 0427	Cross	New Mexico	7	23
2	21	0247	Arist	Bright Inter.	20	1955 2030	Oliver	Spain	6	17
3	21	0400	Arist	Blink	21	0340	Calkins	California		20
4	21	0540	Arist	Bright	21	0343 0348	Kelsey	California	1	52
5	21	1306	Harpalus	Bright	19	2120 2200	Mourao	Brazil	39	6
6	21	1308	Harp. & Bouger	Bright	20	2110 2230	Mourao	Brazil	14	38
7	22	0435	Manzinus	Red Inter.	22	0304 0310	Jean	Canada	1	25
8	22	0813	Arist	Pulsation	22	0429 0440	Reike Harris	Arizona	3	33
9	22	0813	Arist	Bright	22	0500	Reike	Arizona	3	13
10	22	0813	Arist	Bright	22	0506	Harris	Arizona	3	7
11	23	0310	Atlas	Rim Bright	22	2120	Wald	Switzerland	5	50
12	23	0312	Arist	Blink	22	2030	Wald	Switzerland	6	42
13	23	0404	Arist	Pulsation	23	0358	Reike Leasure	Tucson Phoenix		6
14	23	0428	Biela	Red (Moonblink)	23	0232 0300	Engle	Texas	1	28
15	23	0526	Arist	Bright	23	0525	Harris Sheridan	Arizona		1

TABLE 2
Reports of Transient Events

No.	Received		Feature	Event	Observed		Observer	Location	Elapsed Time	
	Date	GMT			Date	GMT			Hours	Min.
16	23	0650	Arist	Bright	23	0354	Reike	Arizona	2	56
17	24	0720	Arist	Pulsation	24	0240	Reike	Arizona	4	40
18	24	0145	Arist	Bright	22	2320	Mourao	Brazil	26	25
19	24	0735	Ross D	Bright	24	0506	Harris	Arizona	2	29

Conclusions

The LION Program for Apollo 10 was generally successful. This was due in a large measure to excellent cooperation between observers in thirty-one countries overseas, the U.S. network, Smithsonian Center, all the people involved in the program at MSC in Houston and the Apollo 10 crew. Experience gained during this operation will contribute to an even more efficient program for Apollo 11.

In all probability, the number of observers for the Apollo 11 mission will be considerably larger than the present network. Two large groups, one in France and one in Hungary, have offered their cooperation, and several individual observers will probably be added to the program.

Two conclusions can be arrived at from time laps data noted in Table 2. The first is that radio is the most rapid means of transmitting information. All short intervals between "Observed Time" and "Received Time" (Elapsed Time) are due to the Astronet system of radio communication.

The second very apparent factor is that with the present communications system, it is practically impossible to deliver a message to an Apollo crew within the time period of event activity.

When possible, radio networks or telephones should be utilized to speed up message transmissions to the Smithsonian Center.

Acknowledgments

The cooperation and support of the world-wide LION network is most sincerely appreciated.

REFERENCES

1. Chapman, W. B., Tidal Influences at the Lunar Crater Aristarchus, Journal of Geophysical Research, Vol. 72, No. 24, 1967.

2. Citron, Robert, Report on Center Communications Support for Transient Lunar Phenomena During the Apollo 8 Mission, Smithsonian Institution Center for Short-Lived Phenomena, Cambridge, Massachusetts, 1969.

3. Green, J., Tidal and Gravity Effects Intensifying Lunar Defluidization and Volcanism, Ann, N. Y. Acad. Sci., 123 (Part 2), 403-469, 1965.

4. Bornhurst, L. and Calkins, W., ARGUS-ASTRONET Report, Report No. 123168, 1968.

5. Burley, J. and Middlehurst, B., Apparent Lunar Activity: Historical Review, Proc. Natl. Acad. Sci., 55 (5), 1007-1011, 1966.

6. Cameron, W. S. and Gilheany, J. J., Operation Moon Blink and Report of Observations of Lunar Transient Phenomena, NASA, Goddard Space Flight Center, Greenbelt, Md., 1966.

7. Middlehurst, B., An Analysis of Lunar Events, Reviews of Geophysics, Vol. 5, No. 2, 1967.

8. Ricker, C. L. and Kelsey, H. W., Lunar Transient Phenomena: The ALPO Program, Interim Report, The Strolling Astronomer, Vol. 21, Nos. 1-2, 1968.

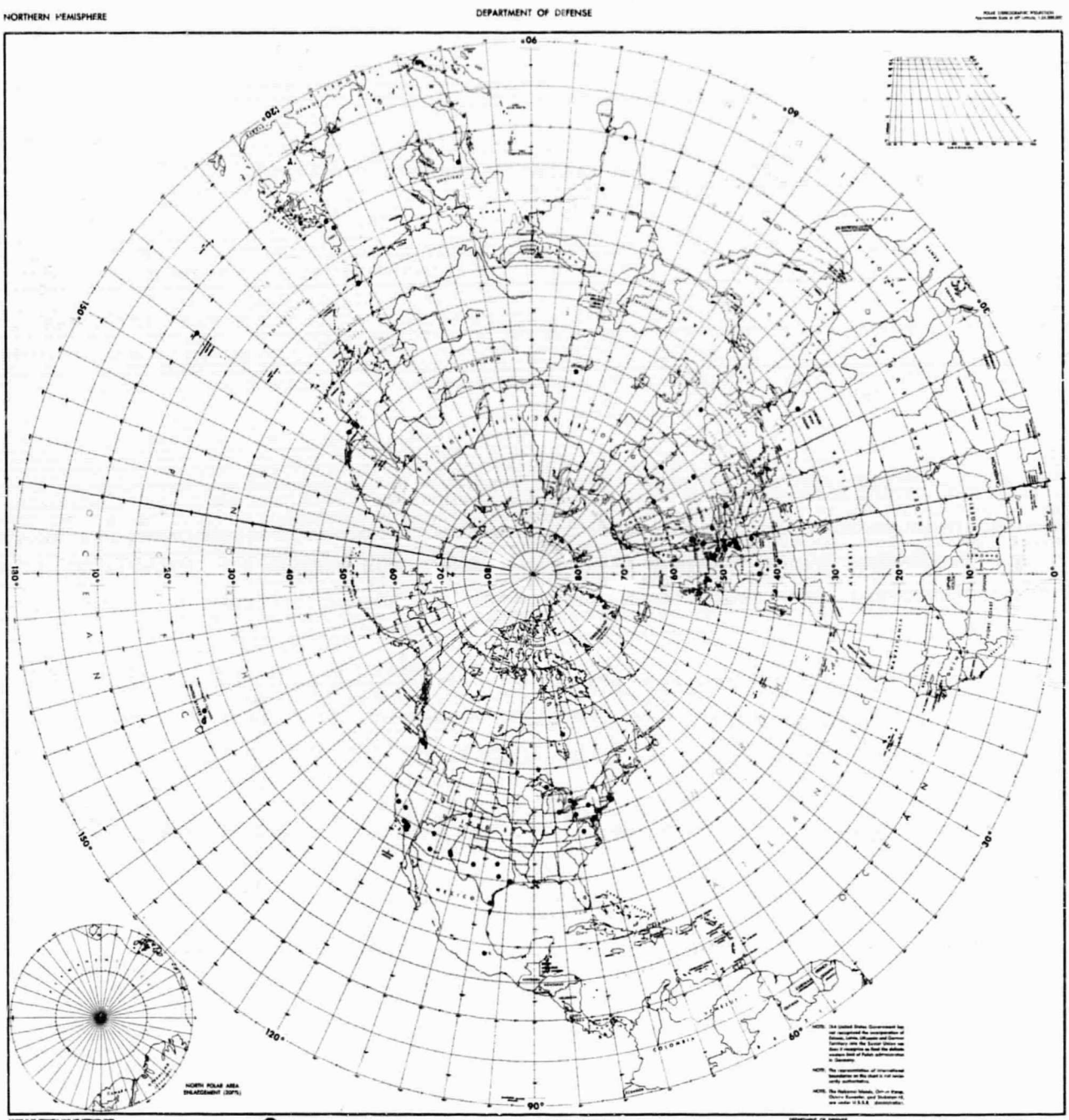

FIGURE 1 – NORTHERN HEMISPHERE OBSERVER NETWORK

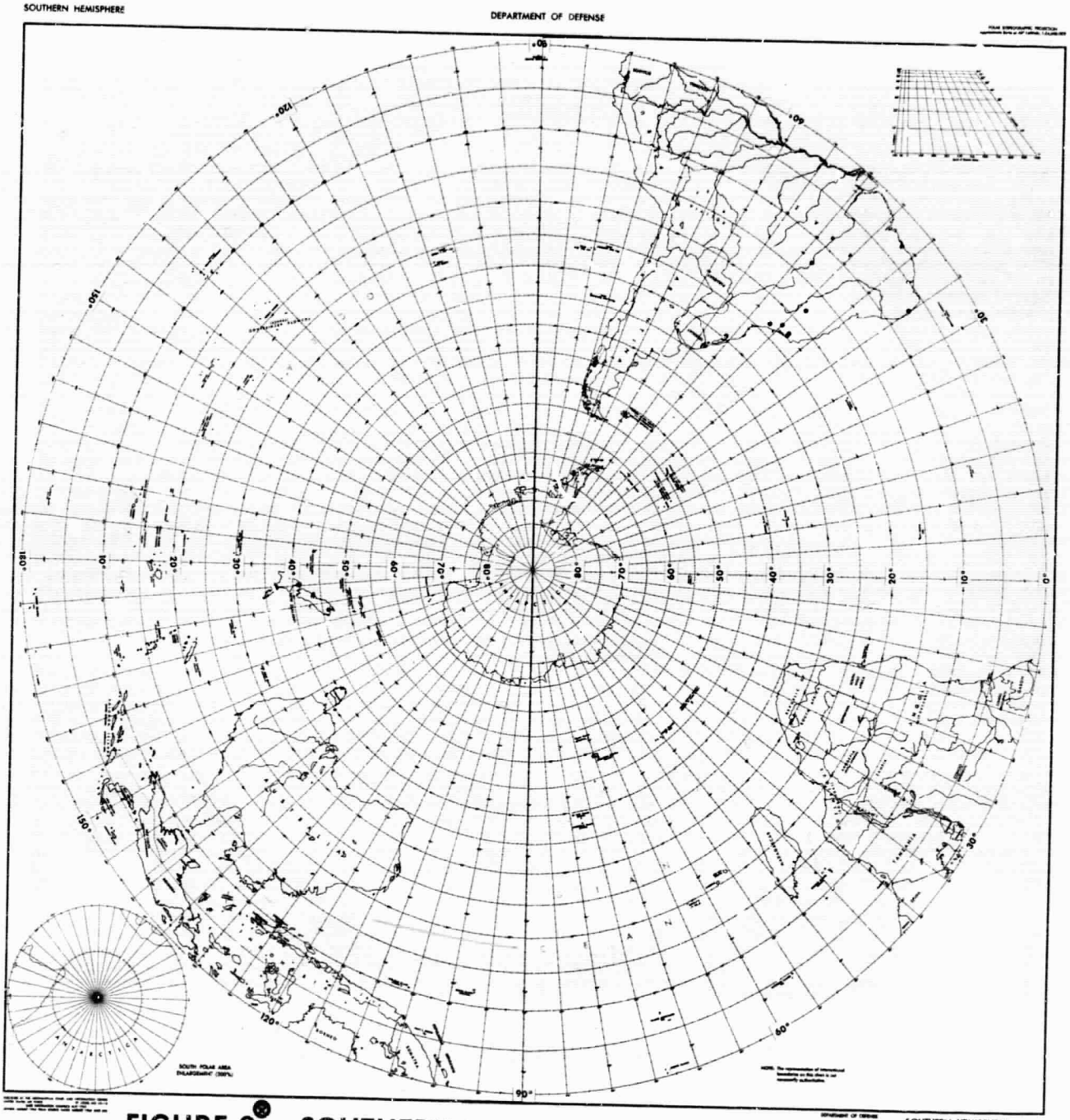

FIGURE 2 – SOUTHERN HEMISPHERE OBSERVER NETWORK

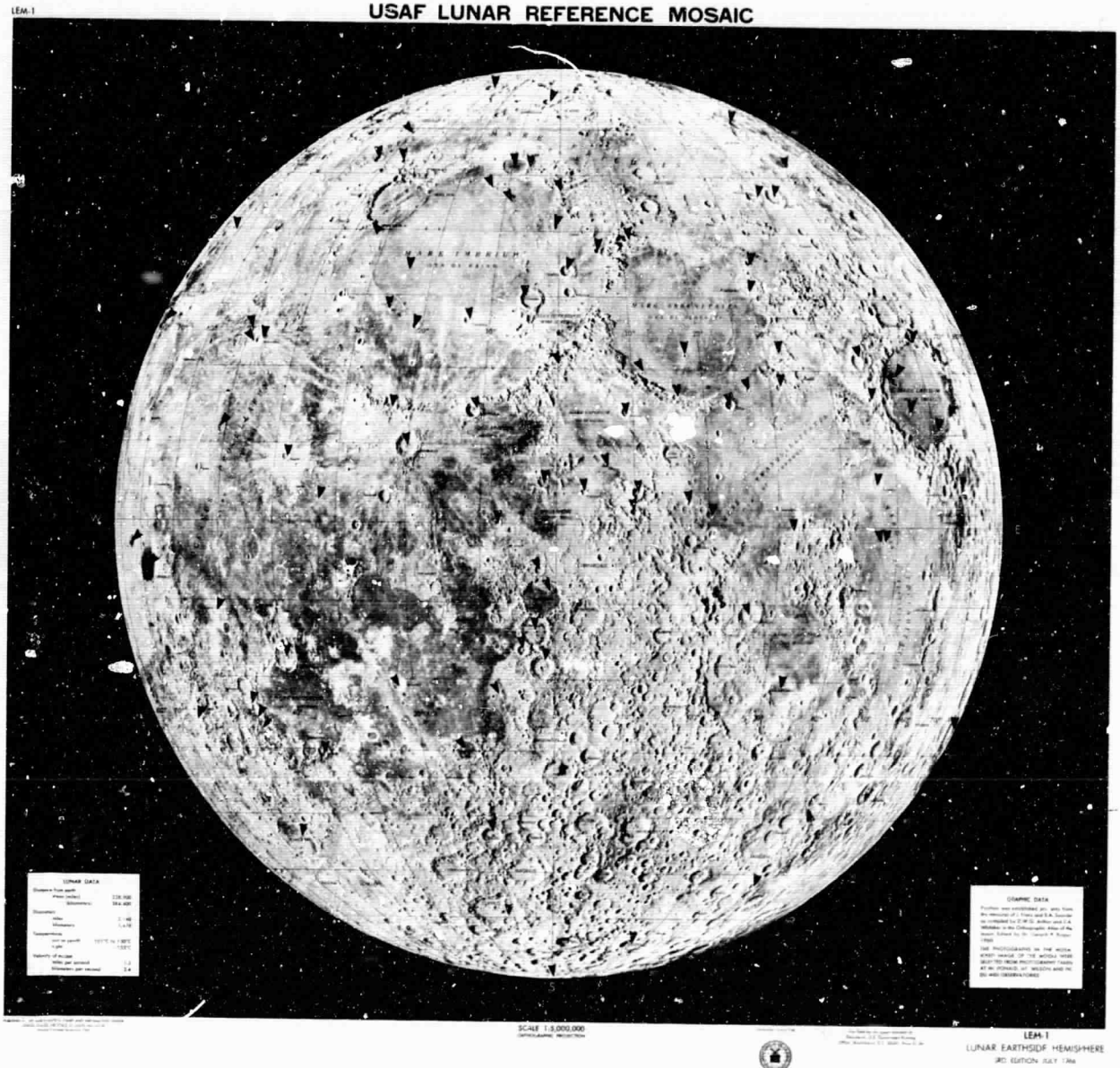

FIGURE 3 – TRANSIENT EVENT SITES