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PROJECT APOLLO

APOLLO 10 VISUAL TRACKING TEST RESULTS

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
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INTERNAL NOTE MSC-EG-69-27

PROJECT APOLLO

APOLLO 10 VISUAL TRACKING TEST RESULTS

PREPARED BY

Indulis Saulietis

APPROVED BY

Enoch M. Jones
Assistant Chief
Guidance Development Branch

Donald C. Cheatham
Assistant Chief for Engineering and Development

Robert G. Chilton
Deputy Chief, Guidance and Control Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

June 11, 1969

INTRODUCTION

Presented herein are the results of real-time tests involving visual spacecraft acquisition, tracking, and photography performed during the Apollo 10 mission using the facilities of the Bldg. 16 observatory. A description of the equipment used and preparations made prior to the mission is included. During the mission, the spacecraft was visually acquired during the first two days of translunar coast, during two consecutive terminator crossings (Revolutions 15 and 16), and on each of the two days of transearth coast. Based on data obtained at these times, recommendations are made with regard to using a visual telescope to point a laser beam at the spacecraft for crew use as a landmark. These recommendations do not favor on-site implementation and test of such a laser system.

FACILITIES AND EQUIPMENT PREPARATION

Appendix "A" to this document summarizes the results of attempts to track the Apollo 8 CSM during the translunar coast, lunar orbit, and transearth coast mission phases. These attempts were largely unsuccessful due to poor weather conditions and inadequate shielding of the observing equipment against scattered light. This equipment consisted of the following:

a. 16" Schmidt-Cassegrain telescope

b. Equatorial platform to point telescope

c. 4 x 5 camera mounted on 16" telescope

d. 6" Schmidt-Cassegrain guide telescope

A program was initiated following the Apollo 8 mission to improve the equipment to maximize the chances of performing optical tracking during the Apollo 10 mission. The following changes were made:

a. Scattered light baffles were installed on the 16" telescope. These baffles (Fig. 1) effectively prevent light from sources outside the actual field of view from reaching the image plane of the telescope. The baffles were designed in accordance with procedures given in Reference 1 and were tested by taking long exposure photographs of the night sky near the vicinity of the moon. An attenuation of scattered light by one order of magnitude was obtained.

b. Modifications to the equatorial platform control electronics were made to allow more accurate pointing of the telescope during long exposure photography. These modifications consisted of increasing the output of the right ascension drive power supply to eliminate a power drop-out condition noted earlier, and installing time-delay relays to minimize the chances of operator error while guiding the telescope during photographs.

c. A new 4" x 5" camera was designed, fabricated, and calibrated to replace the old camera. The camera previously in use was made up from various hardware already available in the interest of expediency, and did not supply sufficiently rigid film plane location during long exposures.

d. An 8" Cassegrain telescope was obtained to replace the 6" as a guide telescope because of the 6" scope's poor resolution and light grasp. An adjustable fixture was fabricated to allow the 8" scope's line of sight to be varied ±3° from the 16" line of sight.

In addition to the above hardware improvements, photographs were made on several types of film to determine the exposure times required to photograph objects of +15 magnitude (comparable to the predicted spacecraft apparent magnitude at lunar distance). Exposure times of 20 minutes were required to attain this magnitude on Royal-X film, for example.

The above programs and tests were completed about one week prior to the Apollo 10 launch date, and an operational test procedure for the sightings was developed and practiced. This procedure was designed to make maximum use of the relatively short duration of the tracking opportunities during the mission. The procedure was to first acquire the spacecraft visually, obtain confirmation of the sighting from several observers, measure the visual magnitude of the spacecraft with a photometer, and obtain photographs of the spacecraft (in that order of priority).

RESULTS OF APOLLO 10 VISUAL TRACKING TESTS

The following data summarizes the tests performed and data obtained on a day-to-day basis as the mission progressed. Most of the visual sighting data was recorded on tape, and Appendix "B" contains a debriefing of these voice tapes, in the form of Greenwich Mean Time (GMT) at each event. All times in this note are GMT unless otherwise stated. Tracking data for the lunar coast, lunar orbit, and transearth coast mission phases was supplied by ACR (Charles Allday) and was extrapolated from the latest and best state vectors as described:

a. Translunar coast to lunar orbit insertion: Data included translunar insertion burn and CSM-SIVB separation burn, but did not include mid-course corrections.

b. Lunar orbit data consisted of terminator crossing times and current selenographic latitude and longitude of the spacecraft. This data was obtained from the real time Mission Control Center (MCC) displays.

c. Transearth phase data included the transearth insertion burn, but no midcourse corrections.

Day 1 - Translunar Coast, May 19, 1969 - 01h through 04h GMT

Seeing conditions were clear, increasing haze to horizon. The range to the spacecraft was between 48,000 and 60,000 nautical miles, in this time interval. The platform was alined to the star ϵ Geminorum, then about 3° from the spacecraft predicted position. Observations commenced at 02h GMT and three flashing objects were seen by Indulis Saulietis, about 0.25° from the predicted spacecraft position. This observation was confirmed by Dennis Peterson (LEC), Clark Neily (FCSD), and John Ericson (FCSD). At one time, four separate objects were seen by C. Neily. No steady state brightness was observed in any of the objects. The brightest flashes were +8 to +10 magnitude and were of extremely short duration, thus precluding the use of the photometer to obtain quantitative data, since the photometer cannot measure dimmer than +6.5 magnitude. The objects were observed for approximately 20 minutes, and then a photograph of 20 minute duration was taken. None of the objects were recorded on this photograph due to their faintness, motion, and short flash duration.

The objects were again observed visually following the photograph, until the increasing haze limited visibility as the S/C neared the horizon at 04h. It was not possible to determine which object was the CSM-LM since no data was available for the relative positions of the SIVB booster and the four SLA panels, all of which were near the spacecraft at this time. The spacecraft was in the passive thermal control attitude for the duration of the sightings. Appendix "B" details the sightings and times.

Day 2 - Translunar Coast, May 20, 1969 - 01h through 03h GMT

Seeing conditions were clear, very much haze. Sun not visible 5° above horizon because of haze. The platform was alined on the star γ Geminorum, checked on κ Geminorum. Observations on spacecraft predicted position began at 02h. Dennis Peterson acquired a flashing source near the field of view center at 02h 18m 05s and observed it until 02h 26m 35s. Indulis Saulietis then observed and saw a flashing source of light at 02h 31m 05s. Continued observations until 02h 33m 05s, during which interval one flash of one sec duration was observed, followed by two or three very short flashes. This occurred at 02h 31m 55s. Dennis Peterson then observed and recorded several marks on flashes until 02h 47m 58s. There appeared to be more than one source of flashing light. Indulis Saulietis observed until 02h 51m 45s, at which time a series of flashes were visible. Dennis Peterson observed until 02h 57m 00s, reporting several more flashes. J. Riley then observed and reported some flashes. None of the observers reported any steady-state component to the light from the object. The magnitude of brightest flashes was estimated at +12. No photographs were taken due to the poor weather conditions and the extreme faintness of the sources. The nominal spacecraft range was 130,000 nautical miles and the spacecraft was in the PTC attitude.

Day 3 - Translunar Coast, May 21, 1969, 01h through 03h GMT

Seeing conditions were somewhat improved over Day 2, but not as good as Day 1. The platform was alined on κ Geminorum and the spacecraft position acquired at 02h 49m. I. Saulietis observed until 03h. No definite sightings were obtained, although a very faint flash or two were seen near the field center. One photograph was taken on 103a0 spectroscopic plate, 20 minute exposure duration. Results of the photograph were negative. Seeing conditions had degraded by 03h 20m so no further observations were attempted.

Day 4 - Lunar Orbit, May 22, 1969

Seeing conditions were clear, increasing haze to horizon. ACR supplied spacecraft earthside terminator crossing times for Revolutions 2 and 3. At the 69m orbital altitude, the spacecraft would be visible against a dark moon background for approximately 6 minutes 30 seconds after the terminator crossing time. The nominal ground track of the spacecraft was plotted on a large scale lunar map and the observers (D. Peterson and I. Saulietis) familiarized themselves with the spacecraft location and direction of motion with respect to identifiable lunar features through the 16" and 8" telescopes. No success in sighting the spacecraft was obtained.

Day 5 - Lunar Orbit, May 23, 1969

Seeing conditions were clear, much improved over Day 4. Spacecraft terminator crossing times for Revolutions 16 and 15 were obtained. The observing procedure was the same as for Day 4. During Revolution 15, I. Saulietis (using the 8") reported three flashes of light along the predicted vehicle ground track, D. Peterson (on the 16") also reported three flashes, the second one at the same time as the second flash seen by I. Saulietis. During Revolution 16, D. Peterson saw two or three flashes along the ground track with the 8" scope, J. Riley reported some flashes with the 16". The telescope was then set up for lunar photography and the lunar surface in the vicinity of the sightings was photographed.

Day 6 - Lunar Orbit, May 24, 1969

No observations were made this day.

Day 7 - Transearth Coast, May 25, 1969, 02h through 03h 30m

Seeing conditions were clear, cirrus forming to west. The platform was alined on ρ Leonis and the spacecraft position acquired at 02h. I. Saulietis observed and reported a twelfth magnitude flashing object in the field. Although no steady-state component of light was observed, the periods of visibility were much longer than previously, being one to two seconds in duration. D. Peterson confirmed the observation. Five persons from ACR were invited to confirm this sighting, and all five saw the spacecraft. These persons had no previous experience with optical observations. The spacecraft was easily seen as described until 03h 30m when high cirrus clouds formed, ending observations. The spacecraft range at this time was about 165,000 nautical miles.

Day 8 - Transearth Coast, May 26, 1969, 02 through 04h

Seeing conditions were clear, increasing haze to horizon. The platform was alined on ρ Leonis. The spacecraft position was acquired at 02h and observations of the spacecraft were attempted until 03h 50 m with negative results by I. Saulietis and D. Peterson. At this time I. Saulietis acquired a very faint (13th - 14th magnitude) flashing object and observed it for about five minutes. D. Peterson confirmed this observation. The location of the observed flashes was plotted using field stars as a reference. The plotted points lie on an approximately north-south line, agreeing with the predicted motion of the spacecraft at 04h. No satisfactory explanation of the extreme faintness of the spacecraft could be determined since the spacecraft was then 82,000 n.mi away as compared with the 165,000 n.mi on Day 7, and was much easier to see on Day 7.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be drawn from the data reported in Section II.

a. Because of basic differences in the inertial coordinate systems used to define the spacecraft position on the one hand and aline the platform on the other hand it was not possible to define the spacecraft in the field to better than 0.25°.

b. During the translunar coast phase, more than one object may be visible and unless the coordinate problem is solved, there is no way to visually distinguish the spacecraft from the SIVB or the SLA panels.

c. The flashing nature of the light returned from the spacecraft would make it extremely difficult to visually boresight a laser beacon on the spacecraft since the time interval between successive flashings is long enough for significant motion of the spacecraft in the field of view.

d. During the transearth coast phase, there is no identification problem, but since the vehicle now consists only of the Command and Service Modules, the visibility of the spacecraft is apparently highly sensitive to the attitude of the spacecraft with respect to the sun and to the telescope line of sight. This is because of the semispecular surface finish on the Service Module, which is the only portion of the vehicle which can reflect light back to the telescope (in the PTC attitude). If the spacecraft were oriented to allow the sextant to observe the earth, an unfavorable visibility attitude will most likely result.

e. Direct photography of the spacecraft appears to be impossible with our 16" telescope, due to the low total energy received from the spacecraft. The photographic threshold magnitude for the 16" is +15 for 20 minute exposures of stationary sources.

Recommendations for further activity in this area are as follows:

a. Development of spacecraft tracking techniques using an image orthicon camera - This technique would essentially supply the observer with real-time spacecraft location in the starfield, even for a flashing object appearance. The telescope to spacecraft boresight could then be updated knowing the direction and rate of spacecraft motion with respect to the starfield. Successive flashes would refine this boresight updating, perhaps allowing 10 arc second tracking accuracies to be realized. This branch is currently developing the necessary hardware for tests of this technique.

b. Rectification of coordinate system differences - On future missions it is hoped that the coordinates of the reference stars used to update the platform position prior to sightings can be supplied in the same reference frame as the spacecraft position, so that the spacecraft may be identified among other objects in the field of view. Smaller fields of view could also be used, allowing greater tracking accuracies.

c. The development and operational test of a prototype laser landmark should not be attempted until a satisfactory tracking technique is developed and tested.

d. Weather conditions for Apollo 10 spacecraft tracking were generally favorable throughout the mission, although by no means could these conditions be described as ideal. It is not expected that the weather will be any better for a July or August Apollo 11 test because of the high ambient humidity at this time of year. Better conditions could be obtained at a remote site or on-site during the winter months.

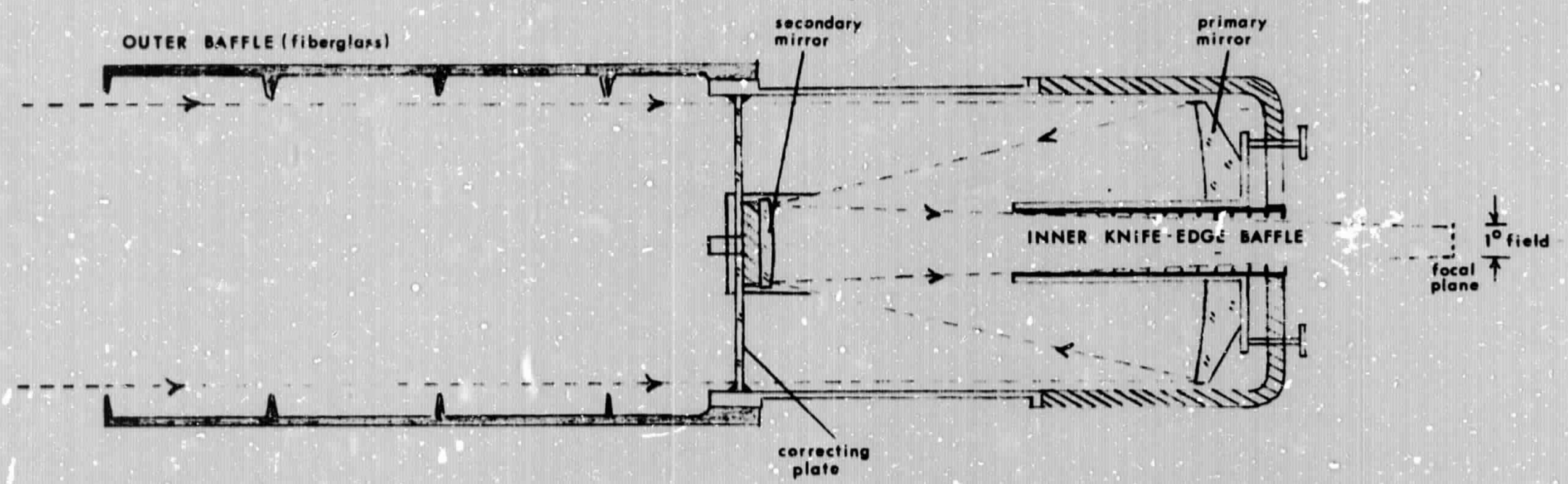


FIGURE 1 16" TELESCOPE LIGHT BAFFLES
(not to scale)

REFERENCES

1. Reference (1) articles in "Sky and Telescope"

   a. Masking Stray Light in a Large Reflector, Ivan King, "Sky and Telescope", August 1963 - P 104-105

   b. Eliminating Stray Light in Casegrain Telescopes, R. R. Wiley, "Sky and Telescope", April 1963 - P 232-235

APPENDIX "A"

RESULTS OF VISUAL TRACKING PERFORMED DURING APOLLO 8

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : EG/Deputy Chief, Guidance and Control Division

DATE: February 10, 1969

In reply refer to:
EG26-69-17

FROM : EG26/Chief, Guidance Development Branch

SUBJECT: Visual tracking of the Apollo 8 CSM

Local weather conditions permitted only two attempts to visually acquire and track the Apollo 8 CSM during the translunar coast and lunar orbit phases of the mission. The first opportunity occurred at 60h 23m GET when the CSM was 188,483 n.mi from the observing site. The 16" telescope located in the Bldg. 16 observatory was used for the sighting attemp. Telescope pointing information was supplied by the RTCAF group, based on an extrapolation of the CSM state vector about 10 hours after TLI. Several observers attempted to acquire the spacecraft, with no conclusive results. Glare from the nearby moon was a major factor affecting the observations. Six photographs of the starfield around the CSM's predicted position were obtained, at 15 minute time intervals. Two of the photographs reveal a very faint image which changes position over a 15 minute time interval. Measurements of the image's direction and extent of apparent motion with respect to the stars indicate close agreement with the predicted rate and direction of the S/C's motion during the time interval between the two photos. The images are so faint, however, that it cannot be said with any certainty that the tracking attempt was successful.

The second sighting opportunity occurred on the following night, when the CSM was in lunar orbit. A single terminator crossing of the S/C was observed beginning at 86h 12m GET when the S/C crossed the moon's terminator going nightward. S/C sunset occurred at 86h 18m, yielding a 6 minute time interval during which the S/C was sunlit against a dark moon background. Because of the short duration of the event, only one observer could attempt a sighting. The observer reported visual acquisition of the S/C as it crossed the terminator immediately south-southwest of the crater Arago. No confirmation of this was possible because this terminator crossing was the only one observable that night. However, later comparison with lunar ground track data indicates that the S/C was indeed at the location where it was observed. The attached LEC memorandum documents the two sightings discussed.

In addition, several major observatories participated in visual and photographic sightings of the S/C. Mr. Harold Liemohn of the Boeing Scientific Laboratory coordinated this unofficial exercise, and his report of the success of the exercise is enclosed.

In view of the partial success of this test, it is felt that further sighting attempts should be made during subsequent lunar flights, as the data obtained is of great value in confirming predictions of S/C visibility and for the feasibility of visual boresighting of possible laser landmark systems. Improvements in the equipment and techniques used for the test are in progress.

The test personnel would like to thank Mr. Charles Allday's RTCAF group for their efforts in our behalf in supplying the pointing data essential to this test.

Paul E. Ebersole

Enclosures 3

cc:
EA/M. Faget
EA2/R. Gardiner
CA/D. Slayton
FA/C. Kraft
FM3/C. Allday

EG26:ISaulietis:bb 2/10/69

INTERDEPARTMENTAL COMMUNICATION

TO I. Saulietis DEPT./ORGN. EG26 BLDG./ZONE 16 PLANT/FAC. MSC DATE 30 Jan 1969

FROM D. A. Peterson DEPT./ORGN. 671-32 BLDG./ZONE 16A PLANT/FAC. MSC EXT. 2916

SUBJECT: VISUAL TRACKING OF APOLLO 8 SPACECRAFT

12/23/68 - Translunar Trajectory

The equitorial platform was aligned on a star near the spacecraft with pointing data supplied from the Building 30 real time computer group. The platform was adjusted to the trajectory coordinates and visual acquisition was attempted. No conclusive sightings were obtained. Pictures of the subject sky area were taken.

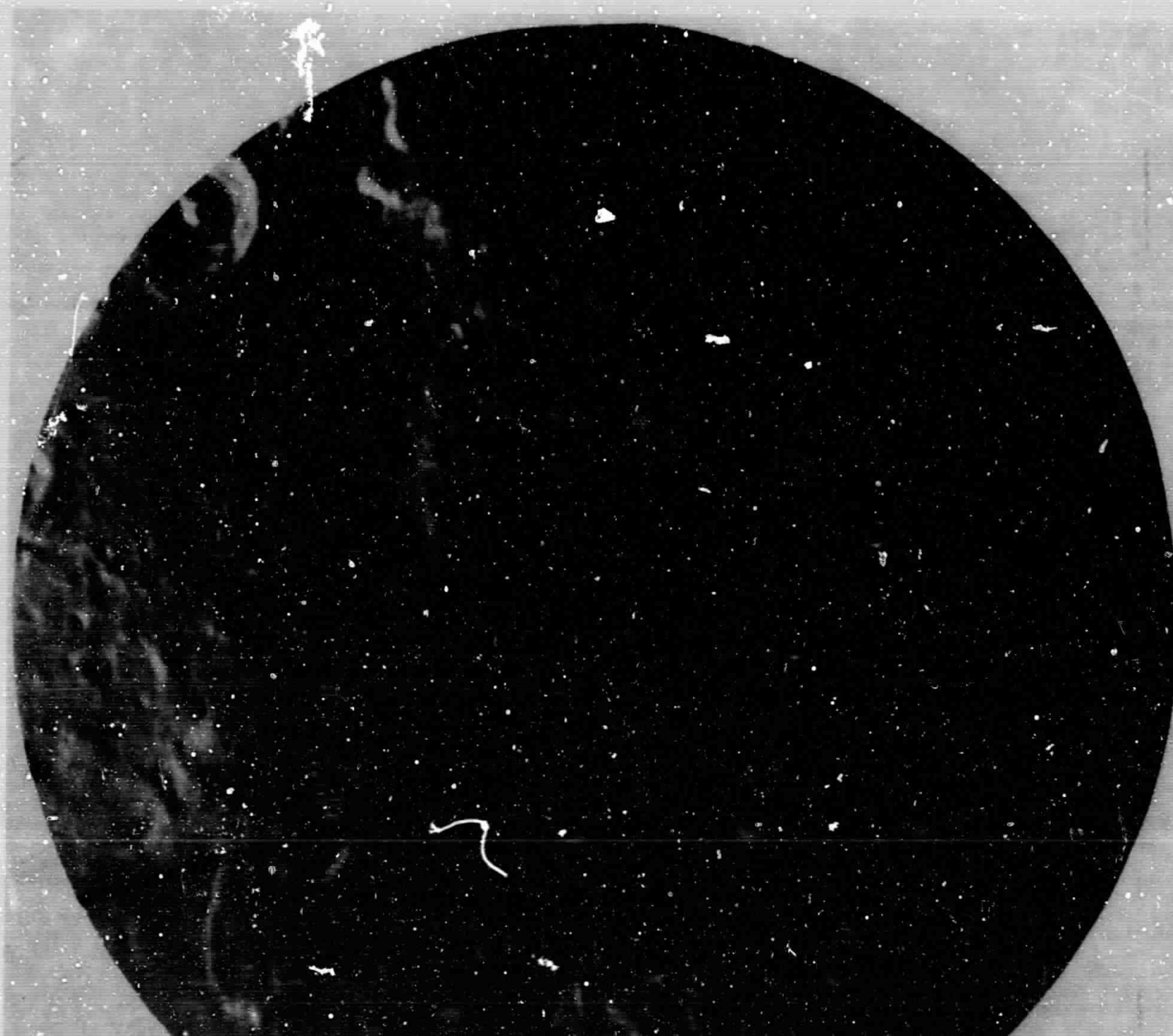
12/24/68 - Circumlunar Trajectory

The selenographic ground track of the spacecraft was obtained from the real time computer group. The telescope was pointed at the acquisition and terminator crossing points at the proper times. "Seeing" conditions were exceptionally good during this test. During the first opportunity, pictures were taken with polaroid film. Between this time and the next acquisition two pictures were taken of the area of the sky, where the spacecraft was to be during translunar flight. These are for comparison with the photographs of the previous evening. During the second opportunity visual tracking was attempted using 250x magnification. The spacecraft was visually seen just past the terminator southeast of the crater Arago (see the attached picture). An attempt was made on the third opportunity to confirm this sighting by using a different observer, but the moon had descended too low into the atmosphere and seeing conditions had deteriorated. Bad weather prevented any further attempts on subsequent nights.

DA Peterson

D. A. Peterson

DAP/RAS/reh



TELESCOPE FOV

$3^h 4^m$ 25 Dec 68 GMT

BOEING SCIEN... RESEARCH LABORATORIES
P.O. BOX 3981
...TLE, WASHINGTON 98124

IN REPLY REFER TO
1-8230-9-41

PRELIMINARY RESULTS OF APOLLO 8 OPTICAL TRACKING EXPERIMENT

Several observatories succeeded in sighting and photographing the Apollo 8 spacecraft during its lunar mission on 21-27 December 1968. This preliminary report contains a brief account of the sightings, tentative interpretations, and some conclusions about the program. A more complete review including some photographs will be published in the March issue of Sky and Telescope.

Sightings. During the trans-lunar trajectory the command-service module (CSM), the four quadrant panels for the service lunar module adapter (SLA) and the S-4B booster rocket created a spectacular array of flashing objects. No one sighted the CSM during its lunar orbits but the weather was generally bad. On the return trans-Earth trajectory the brightness of the CSM again varied significantly. Tabulations of participating observatories and their results are enclosed.

On the first night, 21 December, most observatories noted at least two 12th magnitude objects which flashed to 8 - 10th magnitude occasionally. Both trailed and tracked photos were made so that brightness and position data will be available as a function of time. Pic-du-Midi sighted the Apollo briefly through a thin cloud layer at 1710 UT and a strange white cloud appeared on the trajectory at 1730 UT. Catalina tracked at the sidereal rate and obtained trailed images of 3 objects on 25 plates of 4X emulsion. Flash durations of less than one second were noted visually, but photographs show bright periods lasting several seconds. Corralitos obtained photographs of their image orthicon presentation but did not detect flashing due to long integration time. U. S. Naval Observatory detected four flashing objects surrounding a central dim object but were unable to photograph more than 3 at one time. Table Mountain, Lowell and Mount Wilson also reported sightings and made photographs.

On Sunday and Monday, 22 and 23 December, only two sources were reported. Their brightness diminished proportional to the square of the distance so that near the Moon their magnitude was approximately 14 to 15. Such sources would be very difficult to detect close to the lunar crescent. The two objects were separated by several minutes of arc on the 21st and 20-30 minutes on the 22nd. This is in apparent agreement with the CSM approaching the dark limb and the S-4B approaching the bright limb.

The trans-Earth trajectory was marked by a wide range of brightness on 26 December. At Lick Observatory 150 minutes of television tape were filmed with a video camera on the 120-inch telescope. They report magnitudes varying from 10 to less than 17, the threshold of their instrument. Fullerton, California reported a highly variable source averaging about 11th magnitude and fading occasionally below their threshold of 13th magnitude. They saw some flashes about 530 UT which may have been as bright as 5th magnitude but no photographs were obtained. Although most observatories were ready to operate that night, the weather was generally bad throughout the Southwest.

Unconfirmed Interpretation. On 21 December the observatories undoubtedly detected some SLA panels as well as the CSM and S-4B. The S-4B was kept in inertial hold so that its brightness should have been fairly dim and steady. The CSM attitude changed slowly so that its diffuse component changed slowly and any bright flashes would be widely spaced. The four SLA panels were blown off in opposite directions and tumbled wildly which may account for most of the bright flashing sources. The bright cloud at 1730 UT may be due to a short burn as the CSM evaded the S-4B.

On 26 December several tests were made of the orientation thrusters which may account for some bright flashes. Also, if a water dump took place, the ensuing cloud of ice crystals would account for the very bright flash which was reported. The solar position and spacecraft orientation was more favorable during this phase of the mission so that the reflection was generally brighter than on the 21st.

A time-line of flashes will be prepared to compare with spacecraft attitude, correction thrusts, and water dumps to ascertain any correlations which will permit better tracking on future missions.

Conclusions. The feasibility of optical tracking for Apollo missions to the Moon was confirmed by the observatory sightings. Unfortunately the vagaries of weather remain a deterrent to its routine utility. The brightness estimates which were reported are in reasonable agreement with some crude theoretical estimates which preceded the flight. It is unlikely that the Apollo can be monitored optically in lunar orbit since the lunar crescent is too bright for discrimination. On the other hand, if the bright flashes can be attributed to special attitudes, thrusts, or water dumps, it may be possible to track optically for brief periods near the lunar disk.

The actual trajectory for this mission was very close to the nominal trajectory predicted in advance. Discrepancies of only a few minutes of arc were noted on 21 and 26 December, but the shift remained well within the field of most telescopes. The accurate position data plus the rapidly varying source make identification and tracking relatively easy with moderate-sized instruments. The spacecraft position can be verified immediately with an accuracy of ± 10 arc seconds in a good starfield and an accuracy of ± 0.1 arc seconds is achievable with photographic plate measurements.

Future interest in optical tracking will depend on how effectively the data from Apollo 8 tracking can be utilized by NASA. Their interest was generated by the desire to determine the feasibility of visual boresighting on the spacecraft. Evidently this is possible during trans-lunar and trans-Earth trajectories. During lunar orbit it is unlikely unless special arrangements can be made to enhance the source brightness. Hopefully this or some other technical application of optical tracking will bear fruit.

The next Apollo mission is the Earth orbit of Apollo 9 beginning 28 February to check out the lunar excursion module (LEM) and other systems. I have no plans to arrange optical tracking of this mission. The next lunar mission is Apollo 10 which is scheduled to be launched on 17 May. Since the LEM will travel independently in lunar orbit and rendezvous with the CSM, the rocket thrusts, water dumps, and large plane surfaces on the LEM may provide some fairly bright sources. Thus I hope optical tracking can be arranged for this mission particularly during the lunar orbits.

If optical tracking is attempted on future Apollo missions, I would recommend a modification in the data dissemination. I believe the nominal trajectory should be made available to observatories well in advance of the launch. I would further propose that temporal and positional changes in the orbital parameters be transmitted at predetermined intervals over the amateur radio network. This will enable a much wider participation in the tracking program which would take advantage of local breaks in the weather. If the trajectory digresses considerably from the nominal one, new trajectory data could be prepared for selected locations by a backup computer.

There was considerable interest on the part of professional and amateur groups alike to participate in this first manned lunar mission. I believe the public interest in manned space flights would be enhanced by continued opportunities to track Apollo missions.

I would like to take this opportunity to extend my appreciation to all who participated in this program. I was proud to take part in such an interesting team effort. I hope we can do it again soon.

Yours truly,

Harold Liemohn

Harold B. Liemohn
Staff Member
Geo-Astrophysics Laboratory

APOLLO 8 OPTICAL TRACKING RECORD

	21	22	23	24	25	26
Catalina	S	S				W
Corralitos	S	S	S	W	W	W
Kitt Peak				W		
Lick	W	W	W	W	W	S
Lowell	S	S	S			W
McDonald		S				
Pic-du-Midi	S	W	W	W	W	W
Table Mountain	S	S	S			W
U. S. Naval	S	S	S			W
Mount Wilson	S	S	S	W	S	W
Fullerton						S

S - Sighting, visual/photographic

W - Weather, light cirrus/blizzard

APPENDIX B

INTERDEPARTMENTAL COMMUNICATION

TO I. Saulietis DEPT./ORGN. EG BLDG./ZONE /16A PLANT/FAC. MSC DATE 11 June 1969

FROM R. A. Smith DEPT./ORGN. 671-32 BLDG./ZONE /16A PLANT/FAC. MSC EXT. 2916

SUBJECT: REPORT OF S/C SIGHTINGS DURING FLIGHT OF APOLLO 10 USING 16" TELESCOPE AND 8" TELESCOPE

During flight in Cis Lunar space the 16" telescope was used with a 35mm eyepiece. This arrangement yielded a magnification of 160x or a Field of View (FOV) of 27 arc minutes. The 8" telescope was used with a 12.5mm eyepiece which gave a magnification of 240x and a FOV of 6 arc minutes. During circum-lunar flight the 16" telescope was used with a 25mm eyepiece which yielded a magnification of 220x and a FOV of 9 arc minutes. The 8" telescope was used as above.

Listed below is a tabulation of all successful spacecraft sightings and the times at which they were made. All times in this list are Greenwich Mean Time.

May 19, 1969
Translunar Flight

C. Neily spotted three flashing objects

02:21:04	Objects 1
02:21:29	Objects 1
02:22:16	Objects 2
02:22:21	Objects 2
02:22:39	Objects 2
02:22:56	Objects 2
02:23:12	Objects 2
02:24:24	Objects 1
02:24:29	Objects 3

D. Peterson

02:27:24	Confirms 3 flashing objects
02:30:34	Objects flashing less

J. Riley

02:23:54	Negative

I. Saulietis

02:34:49	Flash from Objects

D. Peterson

02:41:04	Flash from one object

The range to the S/C was 48,000 nautical miles. Spacecraft position in the sky was in the vicinity of 6 hours, 40 minutes right ascension and +28° 36' declination. Magnitudes of the flashes from the S/C were estimated to be between +8 and +10.

May 20, 1969 01-03h GMT
Spacecraft (S/C) position was acquired at 02:12:35

D. Peterson

02:18:05	Flash at center of field
02:19:45	Flash at center of field

I. Saulietis

02:31:05	Saw flash toward left edge
02:31:55	Saw flash of 2 sec duration plus 2 or 3 short ones

D. Peterson

02:36:15	Saw source of variable brightness
02:37:13	Saw flash
02:38:33	Saw flash
02:38:40	Saw flash
02:41:27	Saw flash
02:46:03	Saw flash
02:47:34	Saw flash
02:47:48	Saw flash
02:47:58	Saw flash

I. Saulietis

02:51:45	Saw flashes: appeared to be more than one object

D. Peterson

02:53:25	Saw flash
02:53:56	Saw flash
02:54:05	Saw flash
02:54:24	Saw flash 3 or 4 objects are present
02:55:20	Saw flash

The position of the tracking platform had to be moved every 10 minutes during the above two nights. All targets appeared to be about +10 or +11 magnitude. Spacecraft position was approximately 7 hours (h) 55 minutes (m) right ascension (_) and +25° 46' declination ( ) during the sightings of May 20, 1969.

May 21, 1969
No sightings were attempted due to overcast sky

May 22, 1969
The S/C was in circum-lunar orbit during this pass. All sightings were made between the time the S/C had crossed the lunar terminator and the time it went behind the edge of the moon from the sun (i.e. sunset for the S/C). Both the 8" and the 16" telescopes were used.

There were no positive sightings on this night. The moon was within 30 degrees of the horizon and the local atmosphere was hazy.

May 23, 1969
The S/C was still in circum-lunar orbit. "Seeing" conditions were good for the Houston area, about 6 on a scale of 10.

S/C revolution 15-16 01 h GMT

I. Saulietis (I. S.) was observing with the 8" telescope. D. Peterson (D.P.) was using the 16" telescope.

01:39:56 S/C terminator crossing
LAT: 00° 29' 25.1"
LONG: 09° 46' 34.4"

NOTE: All LAT and LONG data is taken from a computer printout of lunar ground track information obtained from ACR.

01:40:25 (I.S.) reported a flash inside a crater on terminator
S/C Pos. LAT: n+00° 27' 00"
LONG: n+07° 44' 53"

01:43:00 (I.S.) reported a flash 1/3 of the FOV from the center to the edge. (D.P.) confirmed this flash, and indicated that it was very short.
S/C Pos. LAT: n+00° 15' 28"
LONG: n+01° 38' 05"

01:45:56 (I.S.) reported a flash just above the center of the FOV
S/C Pos. LAT: +00° 02' 04"
LONG: -09° 02' 36"

01:46:11 (D.P.) reported a flash at center of FOV
S/C Pos. LAT: +00° 05' 05"
LONG: -09° 48' 17"

S/C revolution 16-17 03 hrs GMT

03:38:30 S/C Terminator Crossing

D. Peterson (D.P.) was observing with the 8" telescope and J. Riley (J.R.) was using the 16".

03:42:05 (D.P.) reported a flash approximately 3 times the diameter of Godin crater toward the center of the FOV from the terminator.
S/C Pos. LAT: +00° 15' 26"
LONG: -02° 41' 03"

03:43:29 (D.P.) reported a flash
S/C Pos. LAT: +00° 10' 02"
LONG: -09° 59' 29"

03:43:32	(D.P.) reported a flash	
	S/C Pos.	LAT: $+00^{\circ}$ 09' 51"
		LONG: -10° 08' 37"
03:43:57	(D. P.) reported a flash	
	S/C Pos.	LAT: $+00^{\circ}$ 08' 14"
		LONG: -08° 22' 02"
03:44:30	(D.P.) reported a flash	
	S/C Pos.	LAT: $+00^{\circ}$ 06' 05"
		LONG: -10° 02' 32"
03:44:37	(D.P.) reported a flash	
	S/C Pos.	LAT: 00° 05' 37"
		LONG: -10° 23' 51"
03:46:00	Observations end	

May 24, 1969
No sightings were attempted

May 25, 1969 02-04 h GMT
The S/C was in Trans-Earth flight at this time. "Seeing" was very good (about 6 or 7). Platform alignment was on ρ Leonis; and, range to the S/C was approximately 165,000 nautical miles.

A 35mm eyepiece was used with the 16" telescope.

D. Peterson Obs.

02:41:43 Reported a flash
02:41:46 Reported a flash
02:41:50 Reported a flash
02:41:53 Reported a flash

The flashes were reported as equal to about +14 magnitude (mv).

02:43:45 Reported steady illuminance of about 1 sec.
02:45:47 Reported a flash next to a +13 or +14 magnitude star

I. Saulietis Obs.

02:46:41 Reported that star mentioned above is changing in brightness
02:47:25 Reported star gone
02:48:56 (D.P.) confirmed sighting
02:49:03 (I.S.) reported a flash
02:49:16 Reported many flashes

D. Peterson Obs.

02:49:25 Reported definite flashes
02:49:28 Reported a flash
02:49:42 Reported a flash also target moved

I. Saulietis Obs.

02:50:14	Reported a flash
02:50:20	Reported a flash
02:50:45	Reported a flash
02:50:15	Reported a flash
02:52:34	Reported a flash
02:53:40	Reported a flash

D. Peterson Obs.

02:54:20	Reported a flash
02:54:28	Reported a flash
02:54:57	Reported a flash
02:59:23	2 second steady state flash

I. Saulietis Obs.

03:00:06	Reported a flash and that target had moved since his last sighting

Five observers from ACR tried to see the S/C. All five reported they could see it flashing and two of them stated that it appeared to move with respect to the stars.

The S/C moved between the positions : 10h 21.9m, +11° 47' and α10h 21.4m, +11° 43' during the observations for this night.

May 26, 1969 01-04h GMT
"Seeing" conditions were relatively poor (about 3 or 4). There was a lot of haze or smog and stars were twinkling at the zenith.

D. Peterson Obs.

01:57:34	Reported a flash
02:45:00	Reported a flash
02:47:25	Reported a flash
02:48:18	Reported a flash

I. Saulietis, Obs.

03:30:45	Reported a flash
04:09:31	Reported a flash

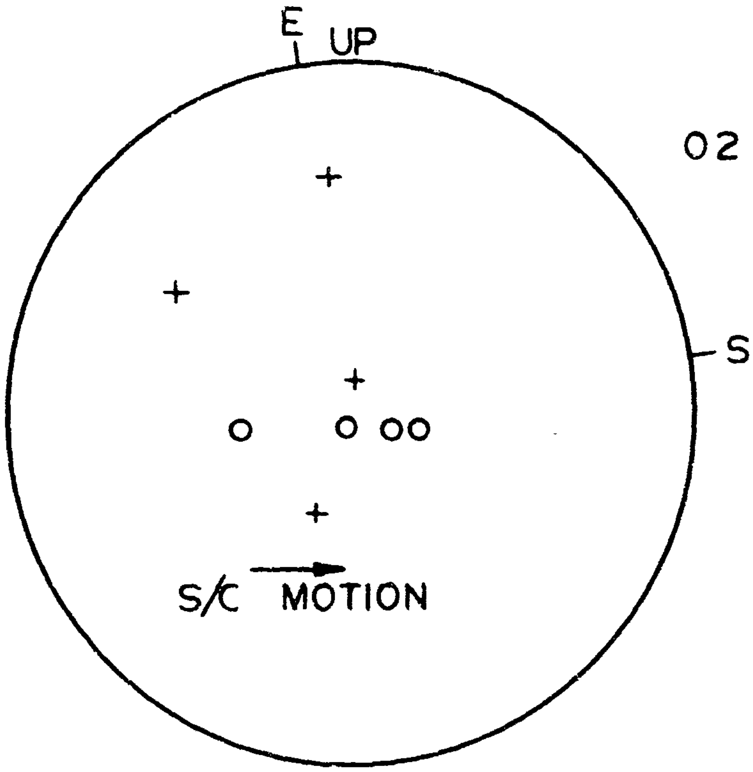
D. Peterson, Obs.

04:11:11	Reported a flash
04:14:38	Reported a flash
04:15:50	Reported a flash

Because of poor visibility the positions of the target flashes were plotted on a star background during this night's observations. These plots are shown in Figures 1 and 2.

R. A. Smith

RAS/reh



TIME 02:29

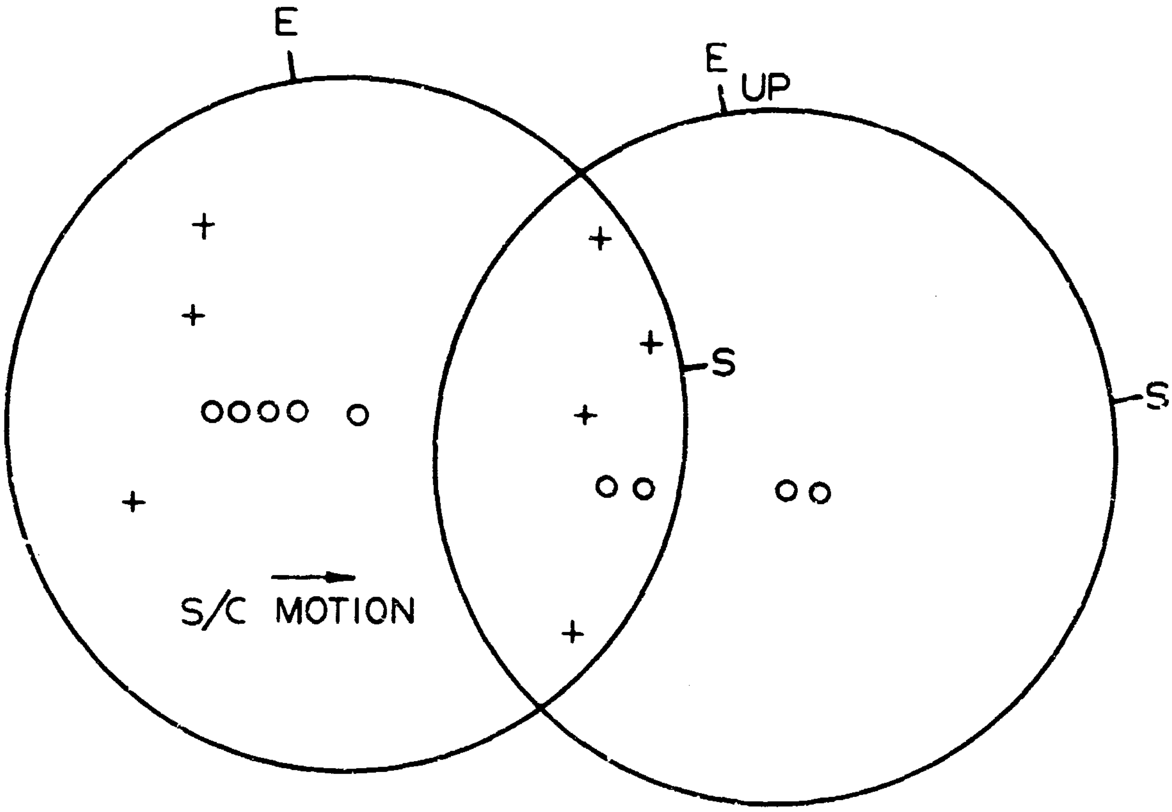
FOV 27 ARC MIN.

α 10h 45.5 m

δ 08°00′

1 SAULIETIS

FIG. 1



TIME 02:39	TIME 02:49
FOV 27 ARC MIN.	FOV 27 ARC MIN.
α 10h 45.5 m	α 10h 45.1 m
δ +08° 00′	δ 08° 05′
OBS D. PETERSON	OBS I. SAULIETIS AND D. PETERSON

FIG. 2