Quarterly Progress Report 4

Radar Studies of the Moon

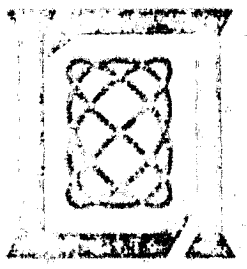
15 April 1969

Prepared for the U.S. National Aeronautics and Space Administration under Contract NAS 9-7830 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts



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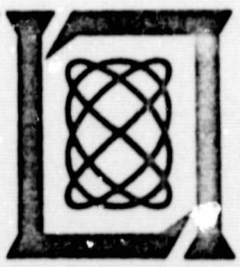

FOREWORD

This report is the fourth in the series under Contract NAS 9-7830. The measurements for the high-resolution lunar maps are 70 percent complete, and the production of the subarea maps is under way. The investigation of ephemeris anomalies and the interpretation of the data have begun.

We have been informally advised that NASA will extend the completion date for this work through the end of calendar 1969 as a result of their request that we add to this task an intensive program of topographic radar measurements on Mars, centered around the 31 May – 1 June apposition. A change in scope and funding to the existing contract to cover this work is in progress. The Mars observations have been placed on the Haystack schedule beginning in early May.

RADAR STUDIES OF THE MOON

I. SUMMARY

Of the 227* ZAC areas on the near hemisphere, 157 (70 percent) had been successfully measured, with apparently good data resulting, by 1 April. An additional 13 areas (out of 36) in ZAC Ring 10.0 have also been measured as the moon's libration has permitted. Computer post-processing is still lagging, in part because of program difficulties. To date, however, 43 ZAC areas have been processed completely, 38 of them in both the polarized and depolarized returns.

Ephemeris discrepancies are still observed and are being investigated with the help of our improved resolution in both delay and doppler.

II. PLANNING OF THE OBSERVATIONS

The Planetary Radar Box was on the antenna through 7 February and again from 10 March through the end of this reporting period. We were able to make use of a relatively large fraction of the available time for our lunar mapping observations, thanks to a powerful set of long-range and short-range planning programs that could be computer-generated well in advance of our scheduled PR Box time. Figure 1 is a sample page from a short-range planning run showing for each half-hour the available range resolution (in units of 10 micro-seconds) for each of those ZAC areas that also satisfy our other criteria for an acceptable map. These criteria are:

(a) Range and doppler resolution strips to be within 15 degrees of a right angle to each other,

(b) No ambiguous points to be within the antenna beam,

(c) For ZAC Ring 10.0, at least half the area to be observable on the sub-earth hemisphere.

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* Stated, erroneously, as 224 in QPR No. 3, 15 January 1969.

LUNAR MAPPING PLANNING RUN FOR 7/16/1969

ZAC	1200 0	1200 30	1300 0	1300 30	1400 0	1400 30	1500 0	1500 30	1600 0	1600 30	1700 0	1700 30	1800 0	1800 30	1900 0	1900 30	2000 0	2000 30	2100 0	2100 30	2200 0	2200 30	2300 0	2300 30	NEW0 0	NEW0 30	100 0
4.20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4.21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4.22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4.23	133	133	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4.24	133	133	133	133	133	133	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.01	..	157	157	157	158	158	158	158	159	159	159	159	159	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.02	..	..	..	156	156	156	156	157	157	157	158	158	158	158	159	159	159	160	160	..	..	..	..	..	..	..	..
5.03	..	..	..	..	..	..	..	..	155	155	155	156	156	156	157	157	158	158	158	158	159	159	..	..	..	..	..
5.04	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	155	155	155	156	156	156	157	157	157	..	..	..
5.05	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	155	154	154	154	155	155	..
5.06	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	157	157	157	156
5.07	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	158	159
5.08	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	160
5.09	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.14	145	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.15	141	141	141	141	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.16	..	138	138	138	138	138	139	139	139	139	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.17	..	..	..	135	135	135	135	135	136	136	136	137	137	137	138	138	138	..	..	..	..	..	..	..	..	..	..
5.18	..	..	..	..	..	..	..	..	132	133	133	133	133	134	134	134	135	135	135	136	136	..	..	..	..	..	..
5.19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	131	131	132	132	132	132	133	133	133	..	..	..
5.20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	130	130	130	130	130	130	..
5.21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	133	133	132	132
5.22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	136	136
5.23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.28	158	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.29	159	159	159	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5.30	158	158	158	159	159	159	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.01	..	179	179	179	179	180	180	180	180	181	181	181	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.02	..	..	..	177	177	177	178	178	178	179	179	179	180	180	180	181	181	181	..	..	..	..	..	..	..	..	..
6.03	..	..	..	..	..	..	..	..	175	176	176	177	177	177	178	178	179	179	179	180	180	180	..	..	..	..	..
6.04	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	175	176	176	176	177	177	177	178	178	..	..	..
6.05	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	175	175	174	175	175	175	..
6.06	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	178	177	177	177
6.07	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	180	180
6.08	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	182
6.09	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.14	170	170	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.15	167	167	167	167	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.16	..	163	163	163	163	164	164	164	165	165	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6.17	..	..	..	160	160	160	160	161	161	161	162	162	162	163	163	164	164	..	..	..	..	..	..	..	..	..	..
6.18	..	..	..	..	..	..	..	..	157	158	158	158	159	159	159	160	160	160	161	161	162	..	..	..	..	..	..
6.19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	156	156	157	157	157	158	158	158	158	..	..	..

Fig. 1. Short-range lunar planning run (16 July 1969).

In addition to this detailed planning sheet, there is a long-range form (Fig. 2) that shows the available ZAC areas for an entire month on a daily basis from which we can decide on our requests for observing time on the antenna. Finally, after a day's operation has been blocked out, a detailed plan (Fig. 3) is computed a day or two in advance that presents all pertinent settings for the radar sequencer, the antenna pointing coordinates, and check values for antenna and doppler tracking for each 5 minutes of the observing period. With this plan, we are able to recover from a bad start in time for the next 5-minute mark and can reduce to a minimum any time lost because of operator errors. Actually, there have been fewer operator errors from the start than are to be expected in such a complex operation.

III. PROGRESS OF THE OBSERVATIONS

During this quarter, 143 additional ZAC areas were measured, bringing to 157* the total in Rings 1.0 through 9.0 and adding 13 of the 36 areas in Ring 10.0 (on the far-side hemisphere). Figure 4 is a diagram of the areas that have been observed so far. The heavy outlines in Fig. 4 indicate the 42 near-side ZAC's which have been carried through to finished photographs, 38 of them to a pair of photographs in both polarizations. We obtained excellent resolution from the first through the 8th rings and a good but noisy return from the 9th ring. For the 10th ring, although features can be discerned, the back-scattered signal is so weak that most of the map is covered by noise "snow." A few more 10th-ring areas will be attempted, but only where the results are expected to be unusually interesting (e.g., Mare Smythii).

We have begun to examine some of the maps but will not report on any interpretation of our results at this time.

It should perhaps be reported that several weeks were spent in February on revisions of the mapping program (Phase 3 of the data reduction), mainly to set up all four conformal map projections and equalize the scale factors between them, and also to permit us to edit bad spots from the data tapes.

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*The ZAC 5.22 data measured during the last quarter were found to be defective and had to be discarded.

LUNAR LONG-RANGE PLAN

-3-11834

JULY 1969

ZAC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
4.20	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	.	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
4.21	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	.	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
4.22	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
4.23	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	XXX	XXX	..	..	XXX	XXX	XXX	..
4.24	XXX	..	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..
5.01	..	..	..	..	..	.	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.02	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.03	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.04	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.05	..	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.06	..	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	.	..	..	..	..	..	..
5.07	XXX	XXX	XXX	..	..	.	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX
5.08	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.09	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.10	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.11	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	.	..	..	XXX	XXX	XXX	XXX
5.12	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.13	XXX	XXX	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	XXX	..	..	XXX	XXX	..	..
5.14	XXX	..	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	..	XXX	XXX	..	XXX	..	..	..
5.15	XXX	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	..	..	..
5.16	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	..	XXX	XXX	XXX	..	..	..	..	..
5.17	..	..	..	..	..	.	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.18	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.19	..	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.20	..	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.21	..	..	..	..	..	.	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
5.22	..	..	XXX	..	..	.	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	XXX	XXX
5.23	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	XXX	..	..	..	..	XXX	XXX	XXX
5.24	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.25	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.26	XXX	XXX	XXX	XXX	..	.	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.27	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
5.28	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	XXX	XXX	..	..	XXX	XXX	XXX	XXX
5.29	XXX	XXX	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	XXX	XXX	..	..	XXX	..	..	..
5.30	XXX	..	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	XXX	XXX	XXX	..	..	XXX	..	..	..
6.01	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.02	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.03	..	..	..	..	.	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.04	..	..	..	..	..	.	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.05	..	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.06	..	..	..	..	..	.	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.07	..	XXX	XXX	..	.	.	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	..	..	..	..	XXX	..	XXX	..	..	..	..	XXX	XXX	XXX
6.08	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	..	..	..	..	..	..	..	..	.	..	..	XXX	XXX	XXX	XXX
6.09	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
6.10	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	..	..	..	..	..	..	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX
6.11	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	.	..	..	XXX	XXX	XXX	XXX
6.12	XXX	XXX	XXX	XXX	..	.	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	.	..	..	XXX	XXX	XXX	XXX
6.13	XXX	XXX	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	..	..	..	..	..	..	..	..	..	XXX	XXX	..	XXX	XXX	..	..
6.14	XXX	..	..	..	.	.	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	.	..	..	..	..	..	..	..	XXX	XXX	..	XXX	..	..	..
6.15	XXX	..	..	..	..	..	XXX	XXX	XXX	XXX	XXX	..	.	XXX	XXX	XXX	..	..	..	..	..	..	..	XXX	XXX	XXX	..	..	..	..	..
6.16	..	..	..	..	.	..	..	XXX	XXX	XXX	XXX	..	.	XXX	XXX	XXX	XXX	..	..	..	..	..	..	XXX	XXX	XXX	..	..	..	..	..
6.17	..	..	..	..	..	..	..	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.18	..	..	..	..	..	.	..	XXX	XXX	XXX	XXX	.	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..
6.19	..	..	..	..	..	.	..	..	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	XXX	XXX	XXX	XXX	XXX	..	..	..	..	..	..

Fig. 2. Lunar long-range plan (July 1969).

GMT DATE 7 16 1969

OFFSET FOR SELEN LATITUDE(DEG) -24.559 SELEN LONGITUDE(DEG) -38.973 ZAC 5.20

DIRECTION COSINES XI-0.572061 AND ETA-0.415627

RUN TIME FILLS 2 REELS, DUAL POLN

DATE	GMT HR MIN	AZIM	ELEV	LOC DOP ANG	DOPPLER (CPS)	E DELAY (MS)	IPP	RUN (MIN)	LATE BURST	CTR.OFFSET (MS)	BURST-TO-CORNER DELAYS (MICROSECONDS)			
7 16	22 0	255.084	40.158	13.840	-11678.929	2650.658	36.724	14	7770	2.733	-655	-650	655	649
7 16	22 5	256.079	39.273	13.279	-11902.261	2651.109	37.248	14	7770	2.732	-655	-650	655	649
7 16	22 10	257.056	38.386	12.704	-12119.681	2651.569	37.787	14	7769	2.732	-655	-651	655	650
7 16	22 15	258.016	37.494	12.114	-12331.089	2652.037	38.341	14	7768	2.731	-654	-650	655	651
7 16	22 20	258.961	36.600	11.509	-12536.392	2652.513	38.912	15	7768	2.731	-654	-651	654	650
7 16	22 25	259.890	35.704	10.888	-12735.497	2652.997	39.500	15	7768	2.731	-654	-651	654	650
7 16	22 30	260.805	34.805	10.249	-12928.315	2653.488	40.106	15	7768	2.730	-654	-651	654	650
7 16	22 35	261.707	33.904	9.593	-13114.761	2653.987	40.731	15	7766	2.730	-653	-650	654	652
7 16	22 40	262.596	33.001	8.918	-13294.750	2654.493	41.375	15	7766	2.730	-653	-651	654	652
7 16	22 45	263.474	32.097	8.223	-13468.203	2655.005	42.040	16	7767	2.729	-653	-652	653	651
7 16	22 50	264.341	31.191	7.507	-13635.044	2655.524	42.726	16	7767	2.729	-653	-652	653	651
7 16	22 55	265.198	30.285	6.769	-13795.199	2656.049	43.435	16	7765	2.729	-652	-651	653	652
7 16	23 0	266.045	29.377	6.009	-13948.604	2656.581	44.168	17	7765	2.729	-652	-651	653	652
7 16	23 5	266.884	28.468	-5.224	-14095.235	2657.117	44.926	17	7765	2.729	-652	-651	653	653
7 16	23 10	267.714	27.559	4.414	-14234.978	2657.659	45.710	17	7766	2.728	-652	-652	652	653
7 16	23 15	268.537	26.650	3.577	-14367.772	2658.206	46.521	17	7765	2.728	-651	-652	653	653
7 16	23 20	269.353	25.741	2.712	-14493.558	2658.758	47.362	18	7765	2.728	-651	-652	652	653
7 16	23 25	270.163	24.831	1.817	-14612.283	2659.315	48.233	18	7765	2.728	-651	-652	652	653
7 16	23 30	270.966	23.922	.891	-14723.896	2659.877	49.137	18	7766	2.728	-652	-653	651	653
7 16	23 35	271.764	23.014	-0.067	-14828.348	2660.442	50.074	19	7766	2.728	-652	-653	651	653
7 16	23 40	272.558	22.105	-1.060	-14925.597	2661.012	51.048	19	7766	2.728	-651	-653	651	653
7 16	23 45	273.347	21.198	-2.090	-15015.600	2661.584	52.060	20	7765	2.728	-650	-653	651	654
7 16	23 50	274.132	20.292	-3.157	-15098.321	2662.161	53.113	20	7765	2.728	-650	-653	651	654
7 16	23 55	274.914	19.386	-4.264	-15173.725	2662.740	54.209	20	7766	2.728	-651	-654	650	654
7 17	0 0	275.692	18.482	-5.413	-15241.783	2663.322	56.528	21	7766	2.728	-651	-654	650	654
7 17	0 5	276.468	17.579	-6.607	-15302.477	2663.906	57.770	22	7766	2.728	-651	-654	650	654
7 17	0 10	277.242	16.678	-7.846	-15355.770	2664.492	57.782	22	7766	2.729	-651	-654	650	654
7 17	0 15	278.014	15.779	-9.133	-15401.642	2665.081	59.080	22	7766	2.729	-650	-654	649	654
7 17	0 20	278.785	14.881	-10.470	-15440.076	2665.670	60.436	23	7766	2.729	-649	-654	650	655
7 17	0 25	279.555	13.985	-11.860	-15471.058	2666.261	61.855	23	7767	2.729	-650	-655	649	655
7 17	0 30	280.324	13.092	-13.304	-15494.578	2666.854	63.342	24	7767	2.730	-650	-655	649	655
7 17	0 35	281.093	12.201	-14.805	-15510.628	2667.447	64.901	25	7767	2.730	-650	-655	649	655
7 17	0 40	281.862	11.312	-16.364	-15519.205	2668.040	66.539	25	7768	2.730	-650	-655	649	655
7 17	0 45	282.632	10.426	-17.983	-15520.307	2668.634	68.260	26	7768	2.730	-650	-655	649	655
7 17	0 50	283.402	9.543	-19.664	-15513.939	2669.228	70.072	27	7767	2.731	-649	-655	650	656
7 17	0 55	284.174	8.663	-21.407	-15500.106	2669.821	71.982	27	7769	2.731	-650	-656	649	656
7 17	1 0	284.947	7.785	-23.215	-15478.813	2670.413	71.998	27	7769	2.732	-650	-656	648	656
7 17	1 5	285.722	6.911	-25.088	-15450.038	2671.004	74.014	28	7769	2.732	-650	-656	648	656
7 17	1 10	286.499	6.041	-27.025	-15413.837	2671.594	76.146	29	7770	2.732	-650	-656	648	656

Fig. 3. Detailed plan for lunar observations (ZAC 5.20, 16 July 1969).

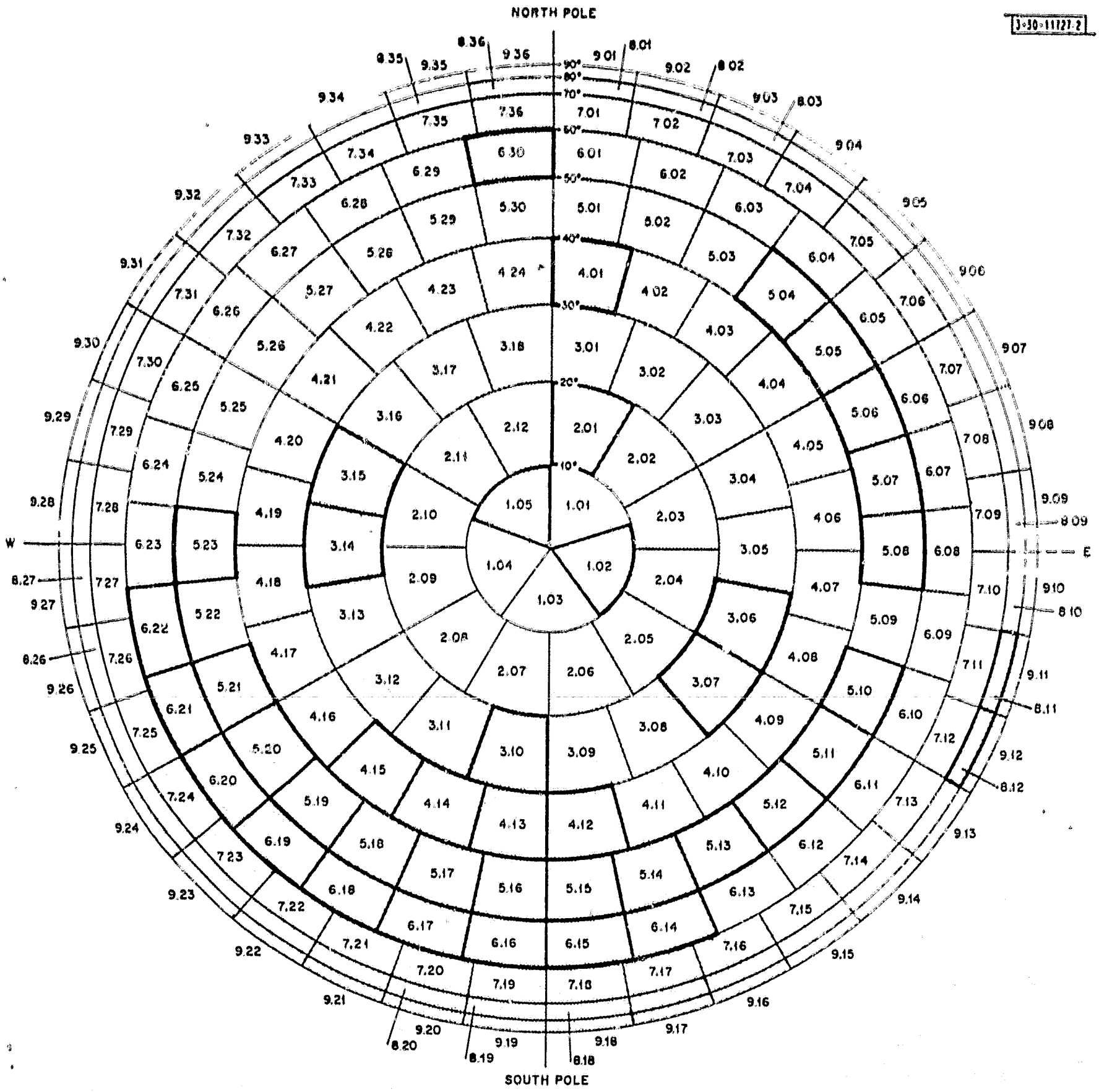

Fig. 4. Lunar ZAC area (shaded areas have been observed as of 12 April 1969).

IV. EPHEMERIS DISCREPANCIES

On 25 March, we were scheduled for 15 consecutive hours of observations, during which time we took calibration measurements on the leading edge of the moon (center of the visible disk) at 2-hour intervals. The results of these measurements were corrected for instrumental effects and then compared with the Eckert (JPL integrated) lunar ephemeris for both doppler and range. Discrepancies were found in both quantities. The analysis is not yet complete and several more days' data have yet to be reduced, but it appears that both quantities are time-varying and also, surprisingly, that the time-derivative of the range error does not equal the doppler error. The possibility still exists that an instrumental effect is causing the discrepancies, but no type of error has been determined that would produce these results.

V. PLANS FOR NEXT QUARTER

The observations for the map should be completed early in the next quarter except for any need to replace bad data. However, it does not appear that the post-processing can be finished before September at the earliest, in part because of the pressure of other radar observations on the computer for real-time processing and in part because of the computer time that has been needed for debugging programs.

The ephemeris discrepancies will be investigated in more detail in the hope of providing precise data to assist in the revision of existing lunar ephemerides.

In addition, work will be started on the interpretation of the results in terms of physical characteristics of the lunar surface on a detailed, rather than a statistical, basis.