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

7.6.2 TA/2-46

UNITED STATES GOVERNMENT

Memorandum

TO : DISTRIBUTION

DATE: 29 JAN 1968

FROM : MA/Apollo Program Director

SUBJECT: Minutes of the Apollo Site Selection Board Meeting of December 15, 1967

On December 15, 1967, the Apollo Site Selection Board met at the Manned Spacecraft Center, Houston, Texas. The meeting agenda is attached as Attachment A. Attendees are listed in Attachment B. Copies of the slides that were used were handed out in a bound volume* (copy attached for addressees not present). Copies of supplementary slides are attached.

As a result of changes in the membership of the Board, the results of the previous meeting were reviewed and the new Surveyor and Lunar Orbiter data that have been obtained were summarized.

The primary meeting objectives were as follows:

1. Report on the status of the site selection activities
2. Recommend the Set C sites for the first mission
3. Recommend the Set C sites for the second mission
4. Discuss the schedule for follow-on activities
5. Present the planned content and format of the site data books.

Landing Ellipse Topography

L. C. Wade presented the results of the detailed photointerpretation analysis of the best landing ellipses within the Set B sites. Landing ellipse II-6-1 had the best 'N' number, although the differences between all the sites were not great. It was noted by E. M. Shoemaker that the inside of many of the craters, which are considered reject areas in this analysis, may indeed be landable areas.

The photometric computer analysis, presented by J. L. Dragg and used to study static LM landings on sample areas of the ellipses, has become operational since the last meeting. Preliminary results of the cumulative percentage of landings that would occur on various slopes over the base of the LM were also presented and all sites appear to be acceptable.

The ellipse engineering properties were reviewed by J. W. Dietrich. Based on Surveyor data and the depressions caused by natural penetrometers (boulders), the soil strength at all Set B sites appears to be compatible with the LM landing gear design. The strength of the soil at the Surveyor V

*Apollo Site Selection Board Briefing, December 15, 1967, MSC

INDEXING DATA

DATE	OPR	#	T	PGM	SUBJECT	SIGNATOR	LOC
01-29-68	HQS		M	LEX	(Above)	PHILLIPS	075-27

touchdown point (II-P-6) appears to be slightly less than at the other Surveyor landing points and, according to H. Masursky, this is in agreement with the analysis of natural penetrometer measurements in this area.

Landing Approach Path Topography

J. W. Garcia discussed the extent to which the ellipse approach path photogrammetric profiles have been analyzed. Based on the available Lunar Orbiter data and the photogrammetric reductions, maximum datum slopes of 1° have been derived. Estimates of slope uncertainties average approximately $\pm 1°$.

Operational Considerations

D. C. Cheatham discussed the considerable progress that has been made since the last board meeting on the interaction of the approach path topography with the LM guidance system. Terrain elevation profiles have become available for some sites, a landing radar operating boundary model has been established and the closed loop guidance--landing radar--terrain simulation has been put into operation. Simulations have shown that the LM guidance system is able to fly the LM to all of the Set B sites, including II-P-11*, within satisfactory landing radar operating conditions and with satisfactory pilot visibility of the landing site after high gate.

Trajectory considerations were presented by Q. A. Holmes. Since only one Set B site, II-P-8, exists in the central region, there is no choice that can be made. With regard to sites in the eastern region, the controlling factor is the recycle time. Only two days are possible between II-P-6 and II-P-8, while a three day recycle time can be obtained between II-P-2 and II-P-8. General Phillips questioned whether a 44 hour recycle time could be achieved if a scrub occurred after cryogenic loading. Adm. Middleton of KSC stated that a 44 hour recycle could not be guaranteed or even assured with a high probability. KSC would like to continue trying to achieve 44 hours but would rather have 72 hours to recycle. With regard to the length of the launch window, support will be concentrated for a narrow window, however, planning will still allow for three hours.

*This site had previously been dropped from consideration, since a satisfactory approach path was thought to be unavailable. Letter from G. M. Low to J. H. Turnock, September 3, 1967; Subject: Selection of Lunar Landing Sites for First Lunar Landing Mission

Due to the free return trajectory constraint and the fact that the launch date is not yet known, two sites must be provided in the western region, roughly north and south of the equator. Only one Set B site, II-P-13, exists in the northwest. In the southwest, site III-P-11 was recommended on the basis of the three day recycle relative to II-P-8 and the fact that the sun angle at LM touchdown would be the same as for site II-P-8. The fact that Surveyor I had successfully landed in site III-P-12 did promote some discussion, however, it was noted that the spacecraft was some 38 km from the center of the candidate ellipse.

D. R. Anselmo presented the advantages of considering site I-P-1 (same as V-P-8) for the first mission. It would increase the recycle time to four days relative to II-P-8, thus giving greater assurance of a launch within a given month. Although the MSFN tracking time of the LM during descent would be reduced by 3 minutes (to 20 minutes) relative to II-P-2, the present requirement calls for only 5 minutes of tracking. Based on the screening of the photography of the site to date, it appears to be acceptable.

J. P. Loftus reviewed the sun elevations at LM touchdown for various launch windows and the recommended Set C sites, considering the present lighting constraints of 7° - 20°. As a result of Surveyor and Lunar Orbiter experience, the possibility of reducing the limits to 2° - 15° was also presented. Although additional lunar parking orbits may be required for some missions, lowering of the lighting constraint is presently under study and being given serious consideration. It was noted that the possibility of lowering the constraint was not relevant to the site selection process, and the recommendation should be given further study, so that any possible problems could be uncovered.

The schedule of products and documentation needed in support of the mission was presented by J. H. Sasser. Although a better job could be performed on a small number of sites, the workload required to carry along five sites could be handled. Mr. Sasser stated that a 200 man-year capability would become available at the DOD agencies after Lunar Orbiter III site work has been completed. The format and content of each site data book were also presented.

Recommendations

J. M. Eggleston gave a summary of the various talks and presented the recommended Set C sites for the first and second mission.

Recommended Set C, Mission I:
II-P-2, II-P-6, II-P-8, III-P-11, II-P-13

Recommended Set C, Mission II:
V-P-8, II-P-2, II-P-6, II-P-8, III-P-11, II-P-13

Assuming a first mission landing at one of the recommended Set C sites, the choices that would then be available for the second mission were also presented. The significance of a landed Surveyor within a site was again reviewed.

Future Activities

J. M. Eggleston and W. N. Hess discussed the work that should be started on the site selection process for missions after the second lunar landing. The following points were raised:

1. How long should we plan on using sites similar to those recommended for Missions I and II?

2. Study of highland sites in or near the Apollo zone should be started.

3. Study of changing the location of ellipses within the Apollo sites and the use of redesignation to land at a defined landing point within a site should be initiated. As an example, H. Masursky stated that a 5 km northerly shift of the ellipse II-8-3 would permit exploration of a marial wrinkle ridge. In site III-P-12, the ellipse could be biased to the north near the Flamsteed ring. H. Masursky also stated that since there are two kinds of mare in the Apollo zone, the second mission should be targeted for the western mare if the first mission lands in an eastern mare.

4. General Phillips agreed that more complicated tasks should be planned for the third mission, however, efforts should initially be concentrated on the selection of scientifically interesting features within the Set B group of Apollo sites.

Actions By The Board

1. The recommendation for the Set C sites for the first mission and the Set C sites for the second mission was approved subsequent to the meeting.

2. General Phillips emphasized that three launch opportunities should be provided for all months of the year and the possibility of a 44 hour recycle time should not be eliminated.

3. A meeting of the Board should be planned for February, 1968, to:

   a. Discuss the procedures for reducing the number of sites for the first mission to three (Set D).

   b. Discuss the sites that should be studied for missions beyond the first two, including the present Apollo type sites that have scientific features of interest as well as those sites that have not been previously considered.

Samuel C. Phillips
Major General, USAF
Apollo Program Director

Attachments
a/s

DISTRIBUTION:

Board Members

MA/Gen. S. C. Phillips
MA/Dr. J. H. Turnock
MO/Gen. J. D. Stevenson
ML/Mr. C. W. Mathews
SD/Mr. O. W. Nicks
MSC-PD/Mr. O. E. Maynard
MSC-TA/Dr. W. N. Hess
MSFC-R-RP/Dr. E. Stuhlinger
KSC-AP/Adm. R. O. Middleton

Information

AA/Dr. H. E. Newell
M/Dr. G. E. Mueller
M-D/Mr. E. M. Cortright
S/Dr. J. E. Naugle
R/Dr. M. C. Adams
T/Mr. E. C. Buckley
MSC-AA/Dr. R. R. Gilruth
MSFC-DIR/Dr. W. von Braun
KSC-CD/Dr. K. Debus
SL/Capt. L. R. Scherer
SL/Mr. B. Milwitzky
MSC-TH/Mr. J. M. Eggleston
LaRC-159/Mr. C. Nelson
MA/Mr. G. H. Hage
MA/Mr. W. C. Schneider
MA/Dr. L. Reiffel
MAO/Capt. J. K. Holcomb
MAS/Mr. R. L. Wagner
MAS/Mr. B. T. Howard
MAS/Mr. D. B. James
MLA/Mr. P. E. Culbertson

ATTACHMENT A

APOLLO SITE SELECTION BOARD

December 15, 1967

Manned Spacecraft Center

A G E N D A

Introduction	J. R. Sevier
LANDING ELLIPSE TOPOGRAPHY	
Photointerpreter Analysis	L. C. Wade
Photometric Computer Analysis	J. L. Dragg
Engineering Properties	Dr. J. Dietrich
LANDING APPROACH PATH TOPOGRAPHY	
Profiles from Photogrammetric Analysis	J. G. Garcia
OPERATIONAL CONSIDERATIONS	
Interaction of Approach Topography on Landing Performance	D. C. Cheatham
Trajectory Considerations	Dr. Q. Holmes
Launch Availability Factors	D. Anselmo, MAS
Special Lighting Considerations	J. P. Loftus
LUNCH	
Products, Schedules, and Documentation	J. H. Sasser
Recommendations for Set C	J. M. Eggleston
Discussion	
Adjourn	

ATTACHMENT B

Board Members Present:

Maj. Gen. S. C. Phillips, MA, Chairman
Dr. J. H. Turnock, MA, Secretary
Mr. O. E. Maynard, MSC
Dr. W. N. Hess, MSC
Dr. E. Stuhlinger, MSFC
Adm. R. O. Middleton, KSC

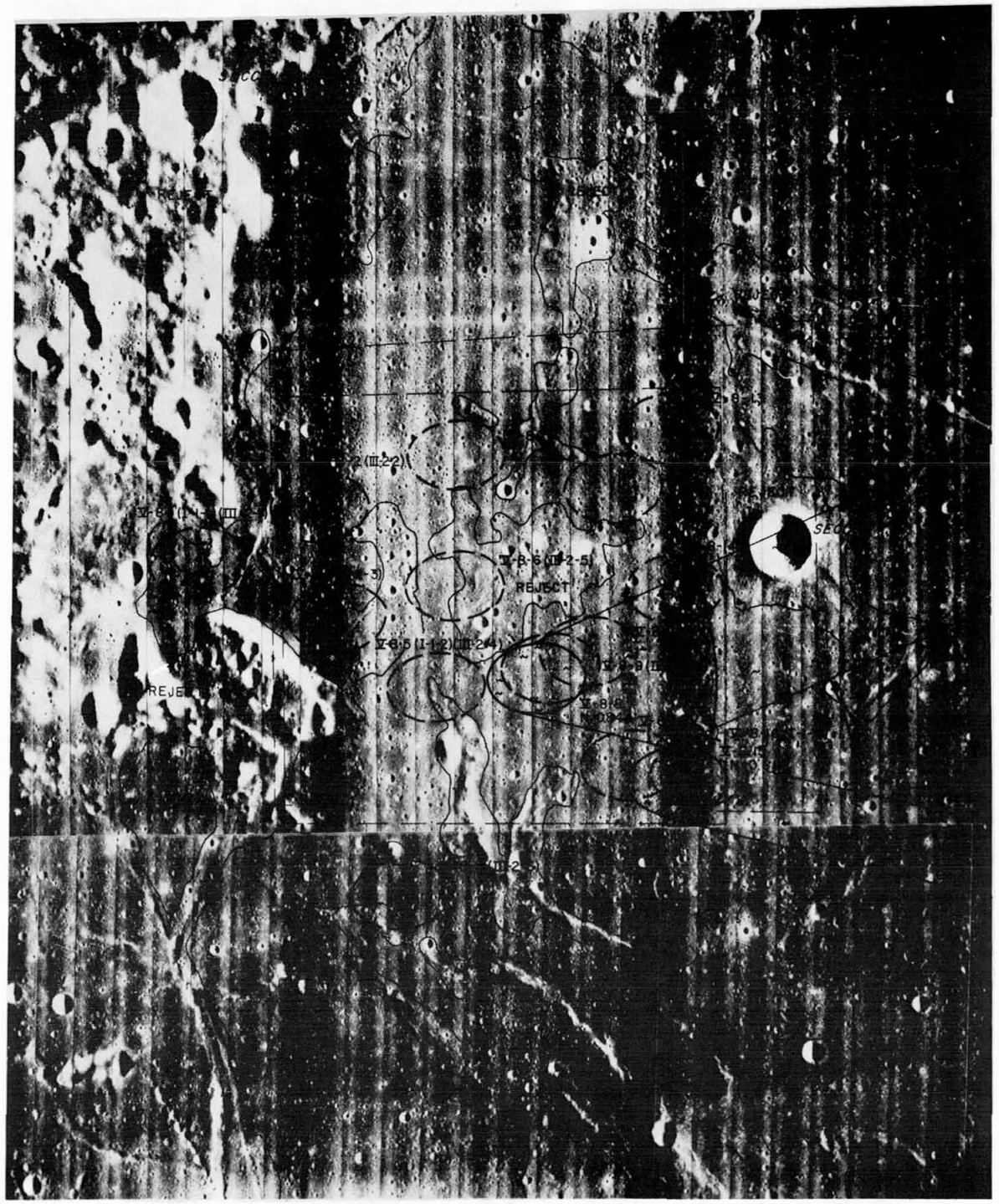
Board Members Absent:

Maj. Gen. J. D. Stevenson, MO
Mr. C. W. Mathews, ML
Mr. O. W. Nicks, SD

Other Attendees:

L. Reiffel, NASA Hq - MA
L. R. Scherer, NASA Hq - SL
W. H. Shirey, NASA Hq - SL
A. T. Strickland, NASA Hq - SL
J. M. West, MSC/AD
R. V. Gordon, MSC/AP3
J. P. Loftus, MSC/PD8
J. R. Sevier, MSC/PD12
R. J. Ward, MSC/PD12
V. D. Brand, MSC/CB
G. P. Carr, MSC/CB
S. A. Roosa, MSC/CB
H. H. Schmitt, MSC/CB
N. W. Naugle, MSC/ED13
D. C. Cheatham, MSC/EG2
H. H. Doiron, MSC/ES3
Q. A. Holmes, MSC/FM5
J. M. Eggleston, MSC/TH
J. W. Dietrich, MSC/TH2
J. E. Dornbach, MSC/TH3
J. L. Dragg, MSC/TH3
J. G. Garcia, MSC/TH3
J. H. Sasser, MSC/TH3
L. C. Wade, MSC/TH3
D. R. Anselmo, Bellcomm
B. T. Howard "
D. B. James "
F. N. Schmidt "
R. L. Wagner "
H. Masursky, USGS
E. M. Shoemaker, USGS
H. H. Haglund, JPL
J. B. Fariss, TRW Systems, Houston

PRESENTATION BY WADE



SITE V P-8

KILOMETERS
0 5 10
0 1 2 3 4 5
NAUTICAL MILES

AVERAGE SUN ELEV. = 21.3°

ANALYST : R BINIKI

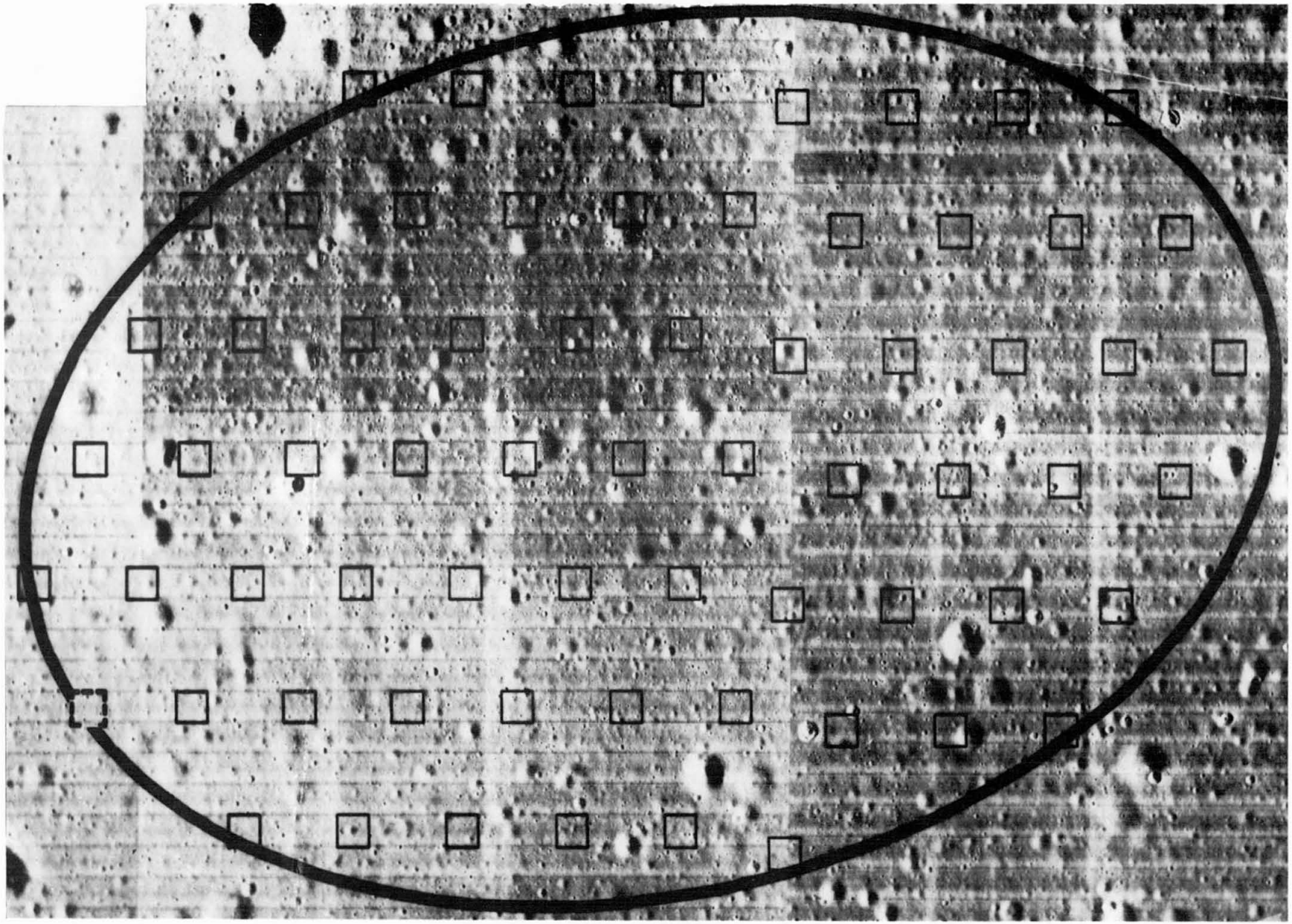
N

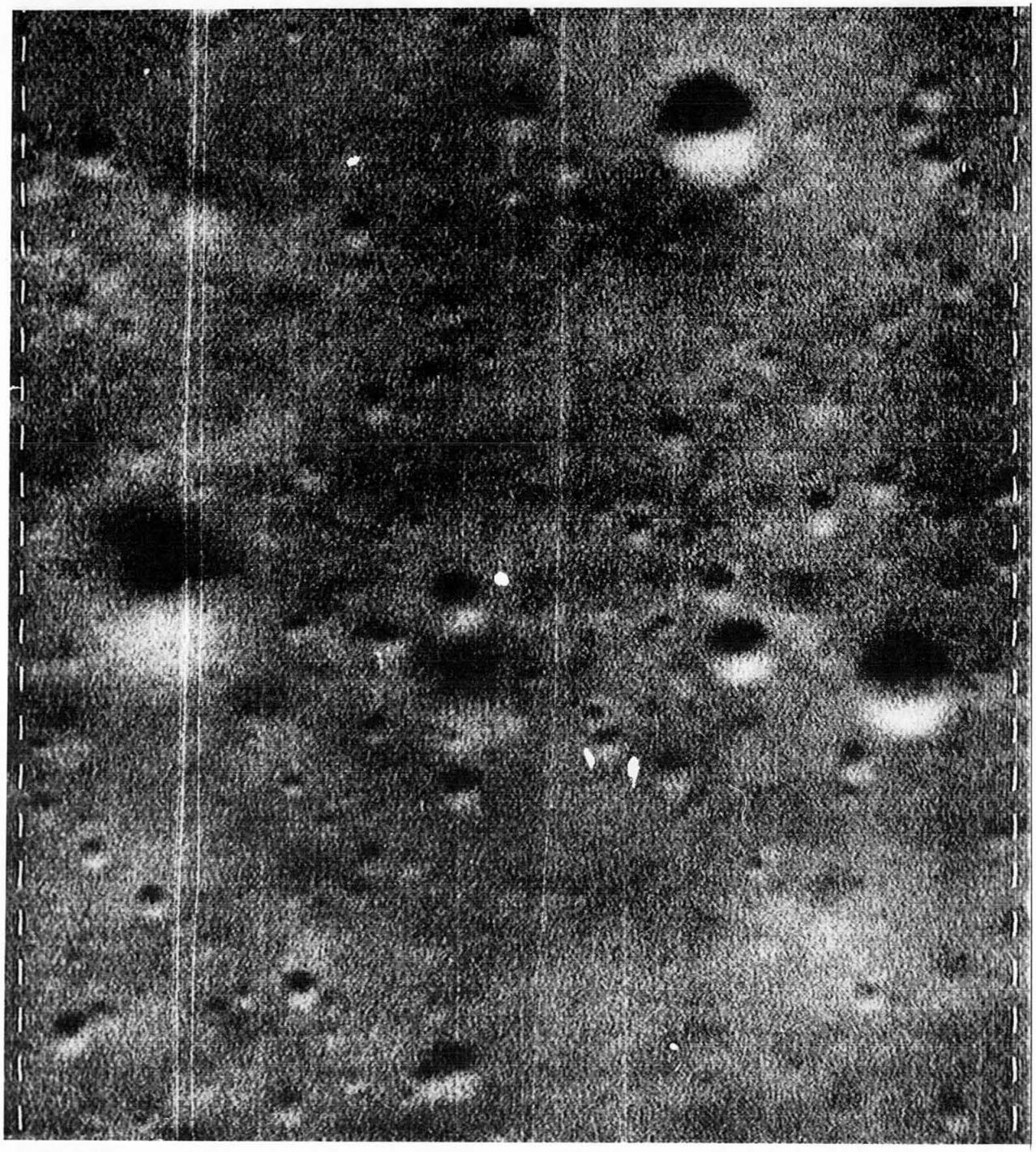
~ Feature that exceeds L.M. landing radar constraint

PRESENTATION BY DRAGG

NASA-S-67-8457

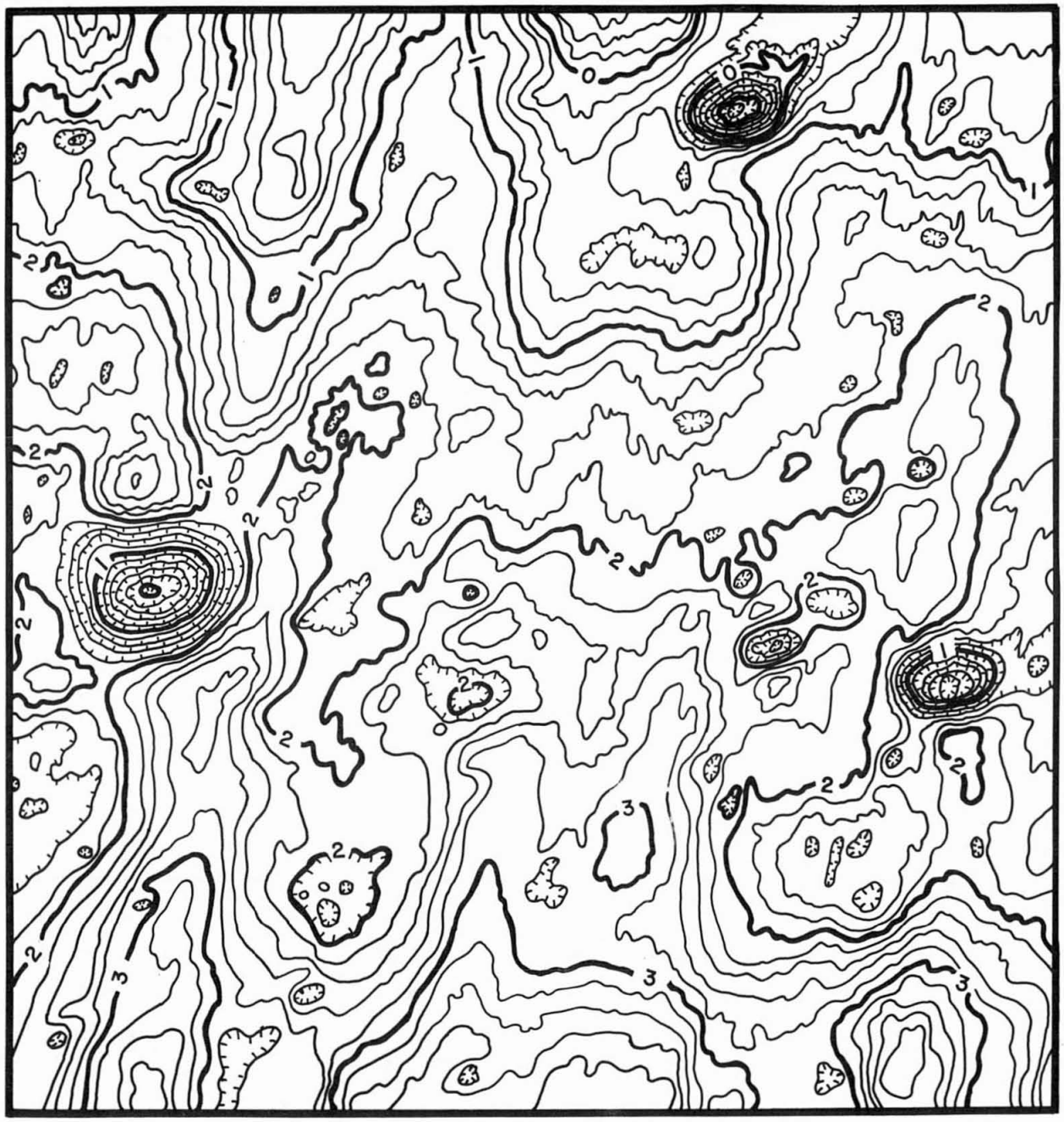
SITE II-13





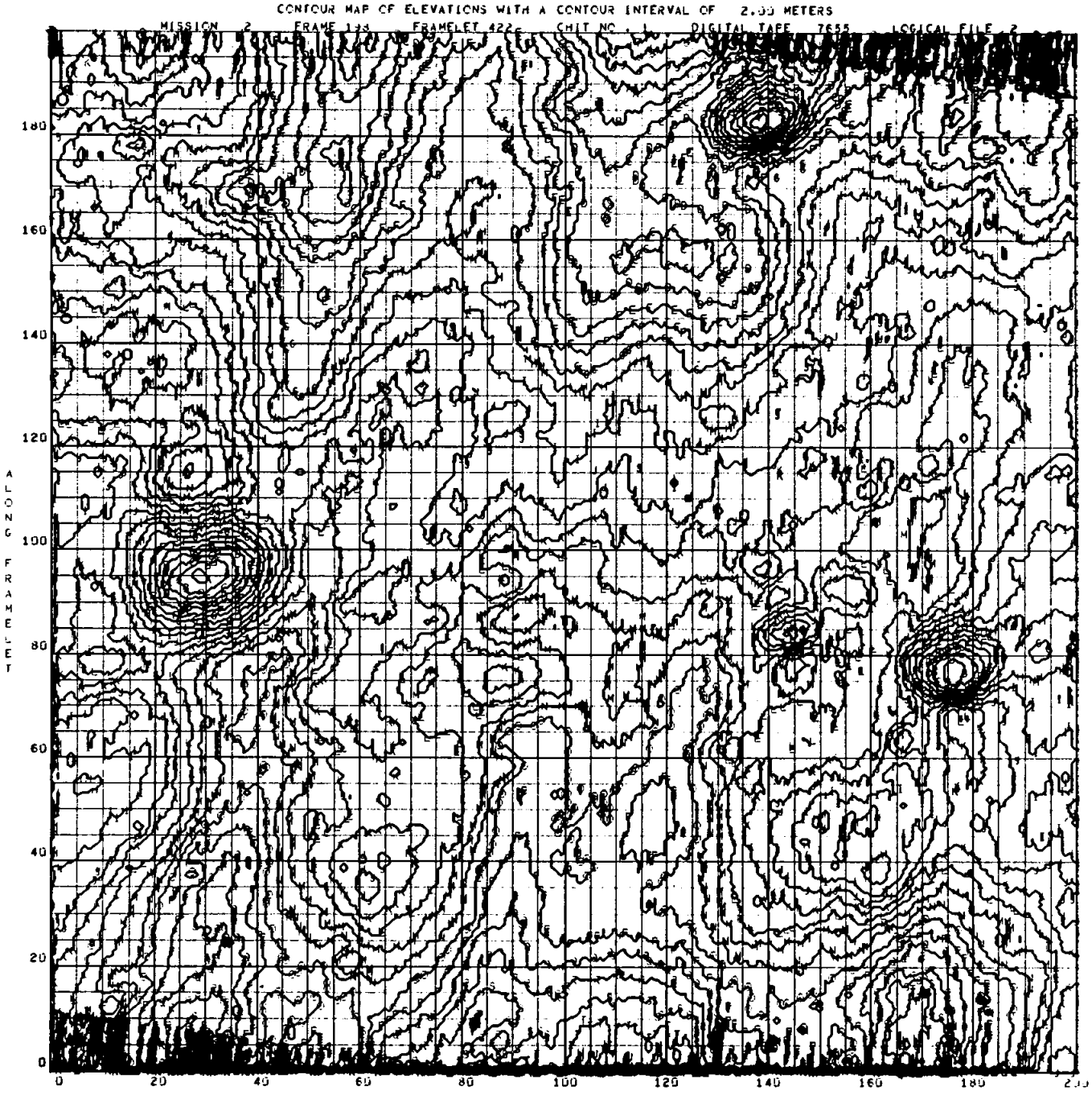
CHIT

LM SCALE



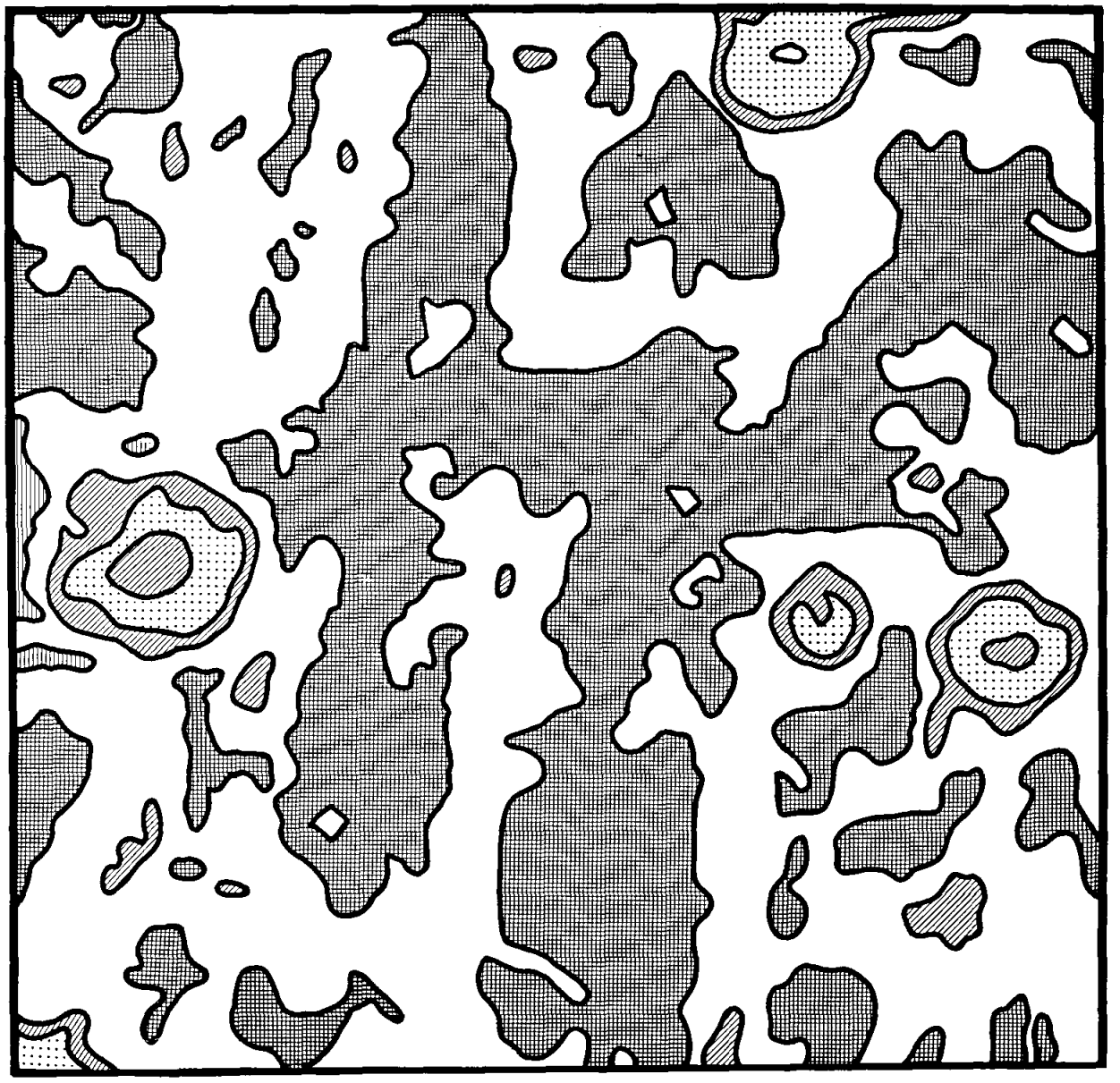
CHIT WITH
TOPO CONTOURS

LM SCALE



CONTOUR MAP
OF ELEVATIONS

LM SCALE



CHIT WITH SLOPE CONTOURS

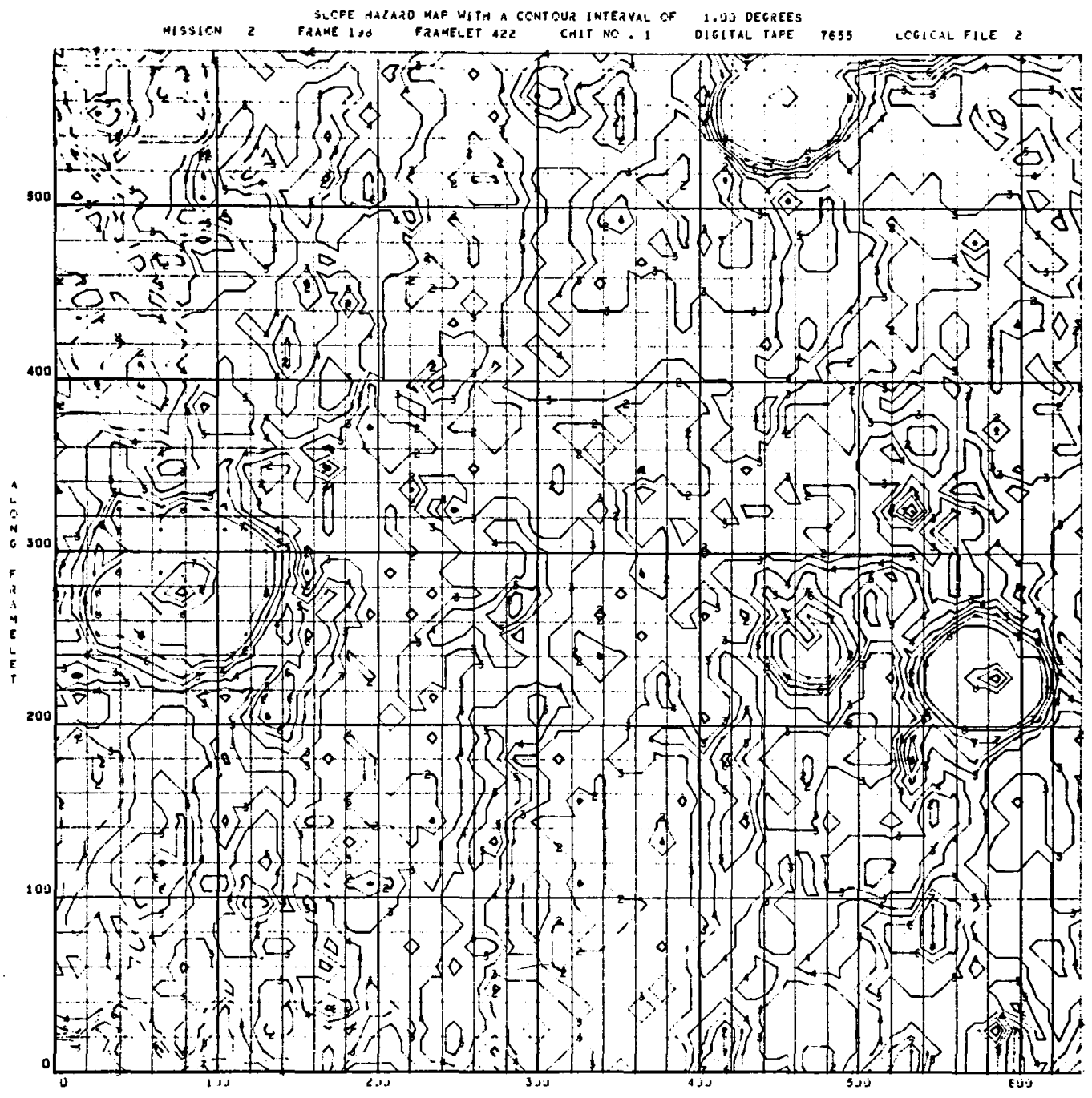
LM SCALE

7°-9°

5°-7°

3°-5°

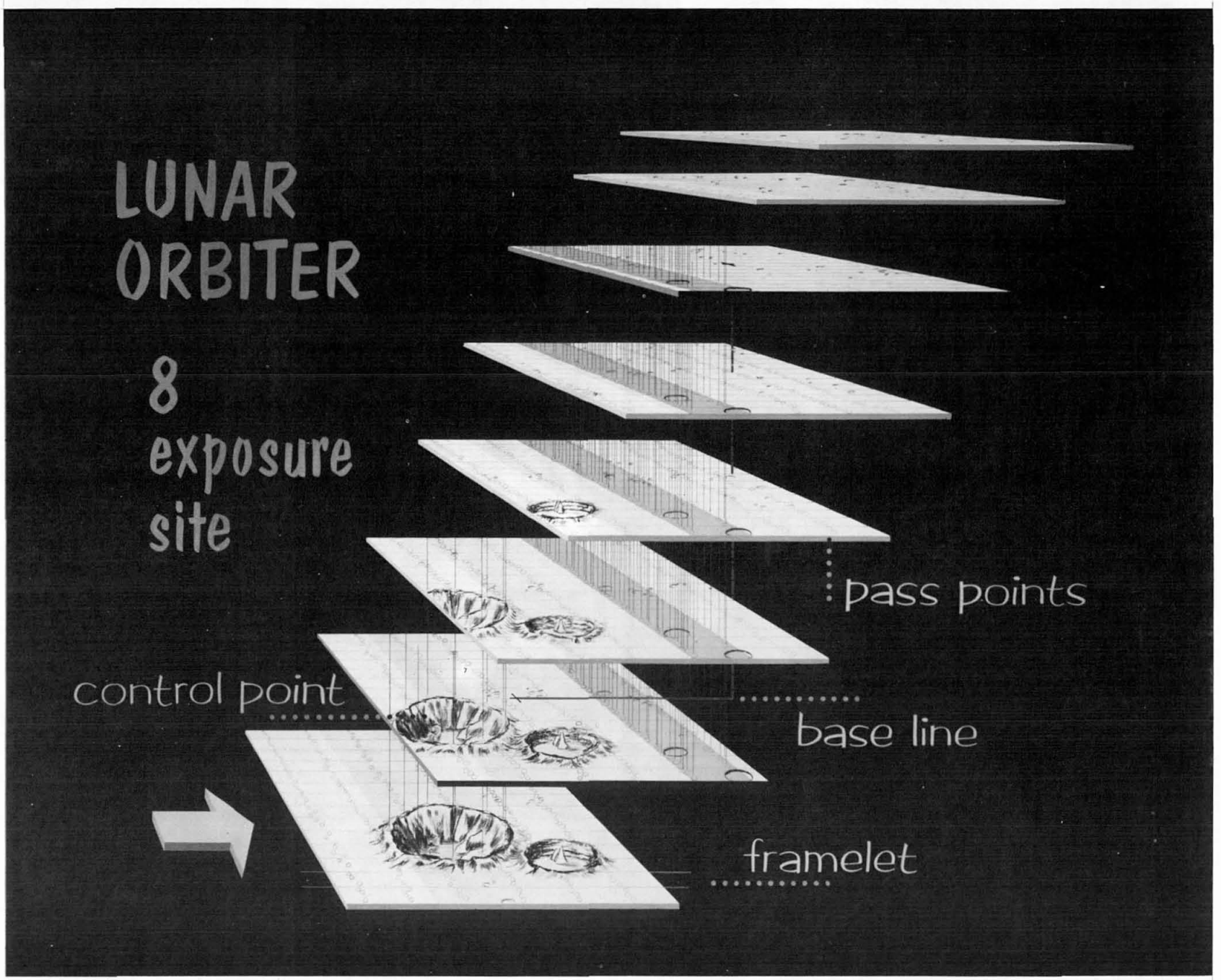
< 3°



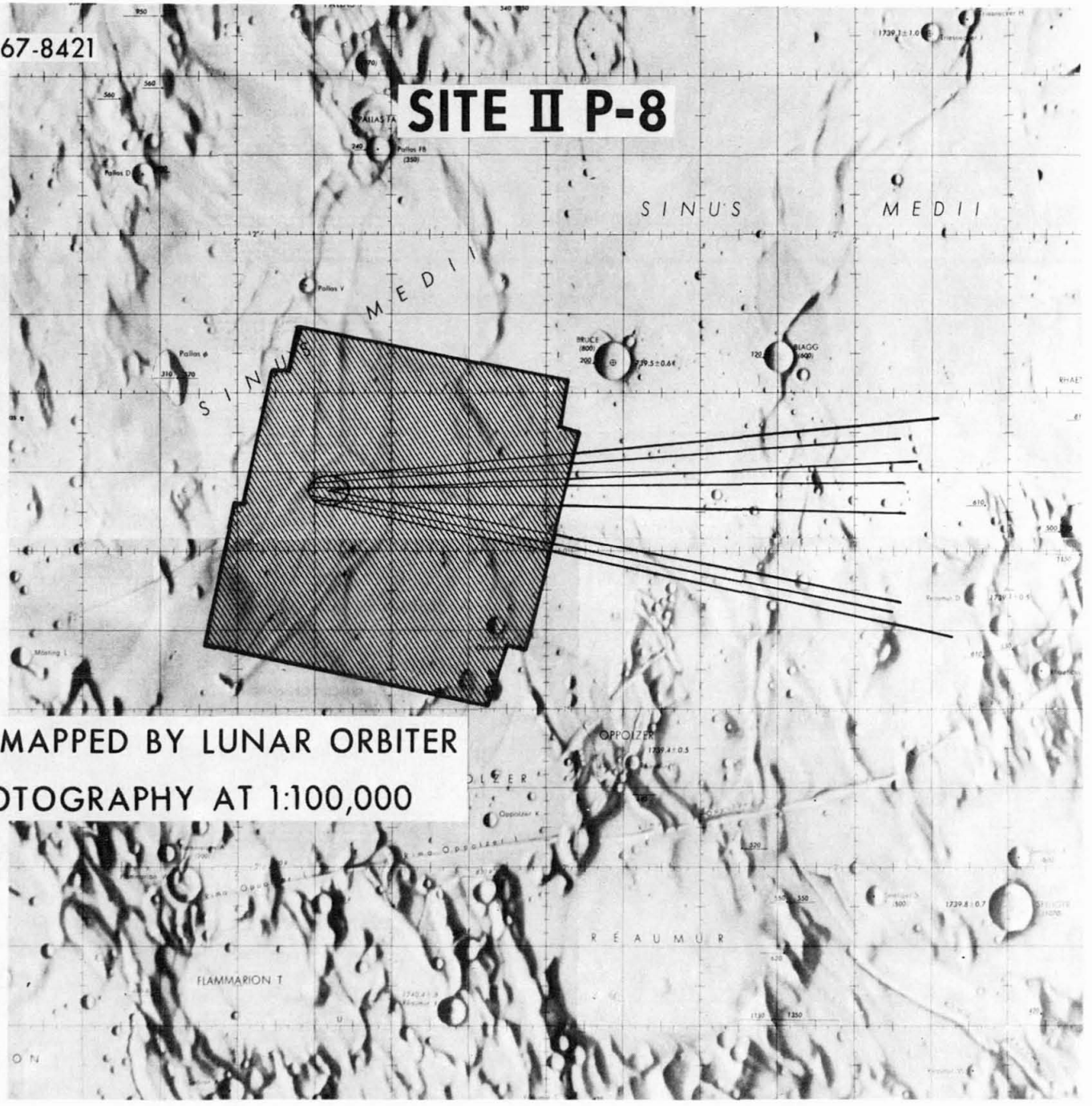
SLOPE HAZARD MAP

LM SCALE

PRESENTATION BY GARCIA

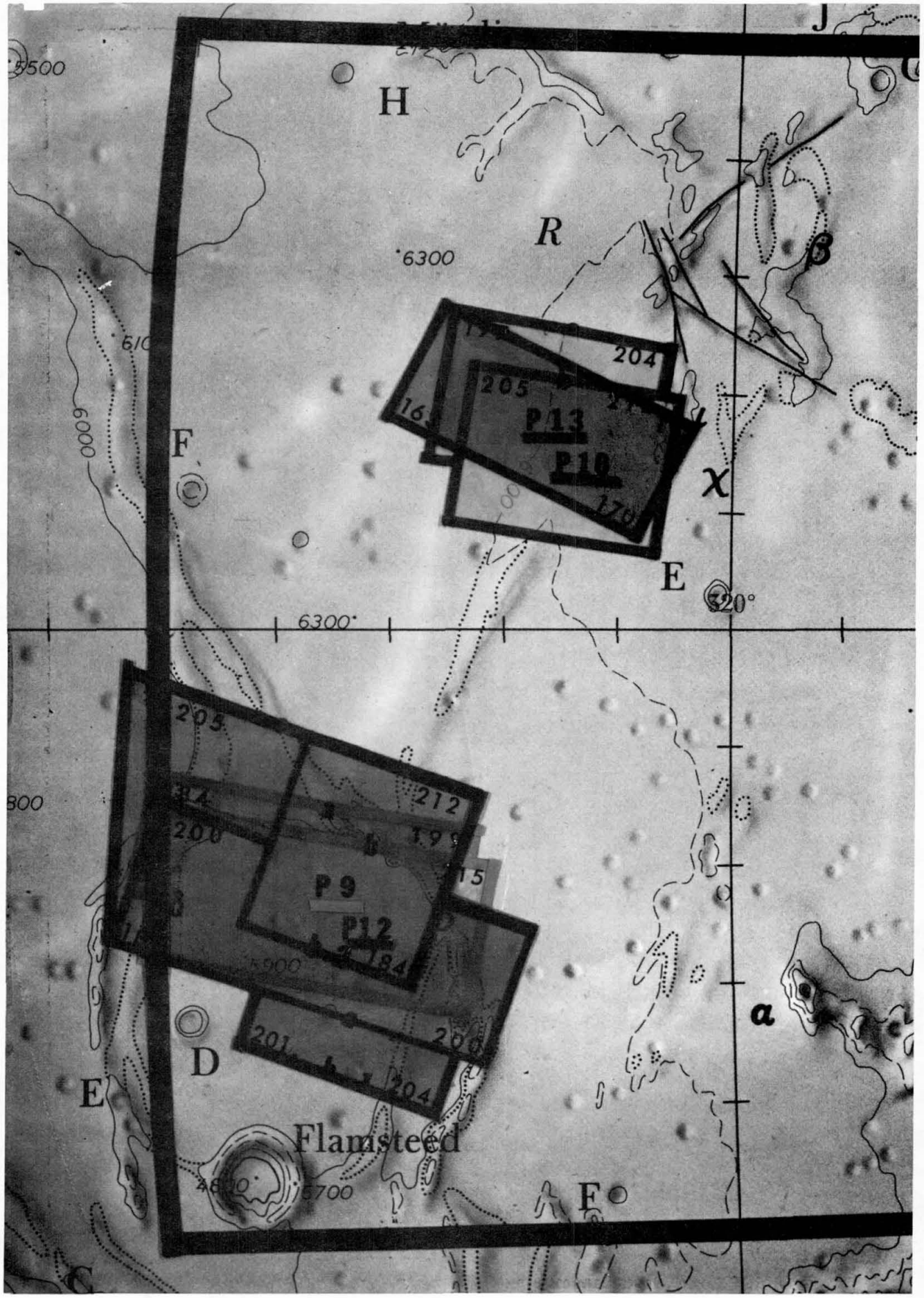

LUNAR
ORBITER
8
exposure
site
pass points
control point
base line
framelet

NASA-S-67-8421



AREA MAPPED BY LUNAR ORBITER

PHOTOGRAPHY AT 1:100,000


J
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a
β

PRESENTATION BY ANSELMO

LAUNCH AVAILABILITY FACTORS

- PROPELLANT REQUIREMENTS
- LUNAR LIGHTING
- RECYCLE
- MSFN TRACKING
- S-BAND COMMUNICATIONS

APOLLO OPPORTUNITIES — 1969

GREATER THAN 1000 LBS MARGIN

FROM ZERO TO 1000 LBS MARGIN

NEGATIVE MARGIN

LAUNCH DATE →

	−4	−3	−2	−1	0	1	2	3	4
JAN(A)	IP1	IIP2	IIP6		IIP8		IIIP9	IIIP11	
FEB(P)	IP1	IIP2	IIP6		IIP8		IIIP9	IIIP11	IIIP12
MAR(P)		IP1	IIP6		IIP8		IIIP9	IIIP11	IIIP12
APR(P)	IP1	IIP2	IIP6		IIP8		IIIP9	IIIP11	
MAY(P)		IP1	IIP6		IIP8		IIIP9	IIIP11	IIP13
JUN(P)	IP1	IIP2	IIP6		IIP8		IIIP9	IIP13	IIIP12
JUL(P)		IP1	IIP6		IIP8		IIIP9		IIP13
AUG(A)		IP1	IIP6		IIP8		IIIP9	IIIP11	IIP13
SEP(A)	IP1	IIP2	IIP6		IIP8		IIIP9	IIP13	
OCT(A)		IP1	IIP6		IIP8		IIIP9	IIIP11	IIP13
NOV(A)	IP1	IIP2	IIP6		IIP8		IIIP9	IIP13	
DEC(A)	IP1	IIP2	IIP6		IIP8		IIIP9	IIIP11	

RECYCLE

- A 44 HOUR RECYCLE CAPABILITY HAS BEEN SPECIFIED BY THE APOLLO PROGRAM THIS DOES NOT INCLUDE ALLOWANCE FOR SERIAL REPAIR OR BUILT IN HOLDS

- APOLLO 4 RECYCLE PLANS REQUIRED 73 HOURS FOR SCRUB AFTER CRYOGENIC LOADING

- APOLLO 4 RECYCLE PLAN DID NOT INCLUDE PROVISION FOR CREW, LM, ALSEP

- WITH A CONSTANT NUMBER OF LUNAR ORBITS:
  SITE IIP6 GIVES 2 DAY RECYCLE
  SITE IIP2 GIVES 3 DAY RECYCLE
  SITE IP1 PROVIDES 4 DAY RECYCLE
  7 MONTHS AND 3 DAY REMAINING MONTHS

TRACKING AND COMMUNICATIONS

- MSFN TRACKING REQUIRED TO BEGIN 5 MINUTES PRIOR TO START OF POWERED DESCENT. ALL THREE EASTERN SITES PROVIDE TWICE THE REQUIREMENT

- S-BAND COMMUNICATIONS ARE REQUIRED DURING ENTIRE POWERED DESCENT. LANDING RADAR DATA IS DESIRABLE AT THE EARLIEST POSSIBLE TIME. IP1 IS THE ONLY POSSIBLE PROBLEM IN THE EAST. IP1 WAS EXAMINED FOR EACH LAUNCH OPPORTUNITY IN 1969:

    - FOR 5 MONTHS NO LANDING RADAR CONFLICT EXISTS THROUGH ENTIRE POWERED DESCENT

    - FOR 11 MONTHS NO CONFLICT EXISTS FROM 30,000 FT

      IN JUNE A 2.6 DEG YAW IS REQUIRED FROM 30,000 FT TO 25,000 FT THEREAFTER NO YAW IS REQUIRED

S-BAND ATTITUDE REQUIREMENTS
1966 MISSIONS TO SITE IP1

MONTH	INJ. TYPE	YAW AT START	YAW AT 30,000 FT
JAN	A	4.8	0.0
FEB	P	14.4	0.0
MAR	P	14.5	0.0
APR	P	11.7	0.0
MAY	P	7.6	0.0
JUN	P	3.8	2.6
JUL	P	0.0	0.0
AUG	A	0.0	0.0
SEP	A	0.0	0.0
OCT	A	0.0	0.0
NOV	A	0.2	0.0
DEC	A	2.9	0.0

RECOMMENDATIONS

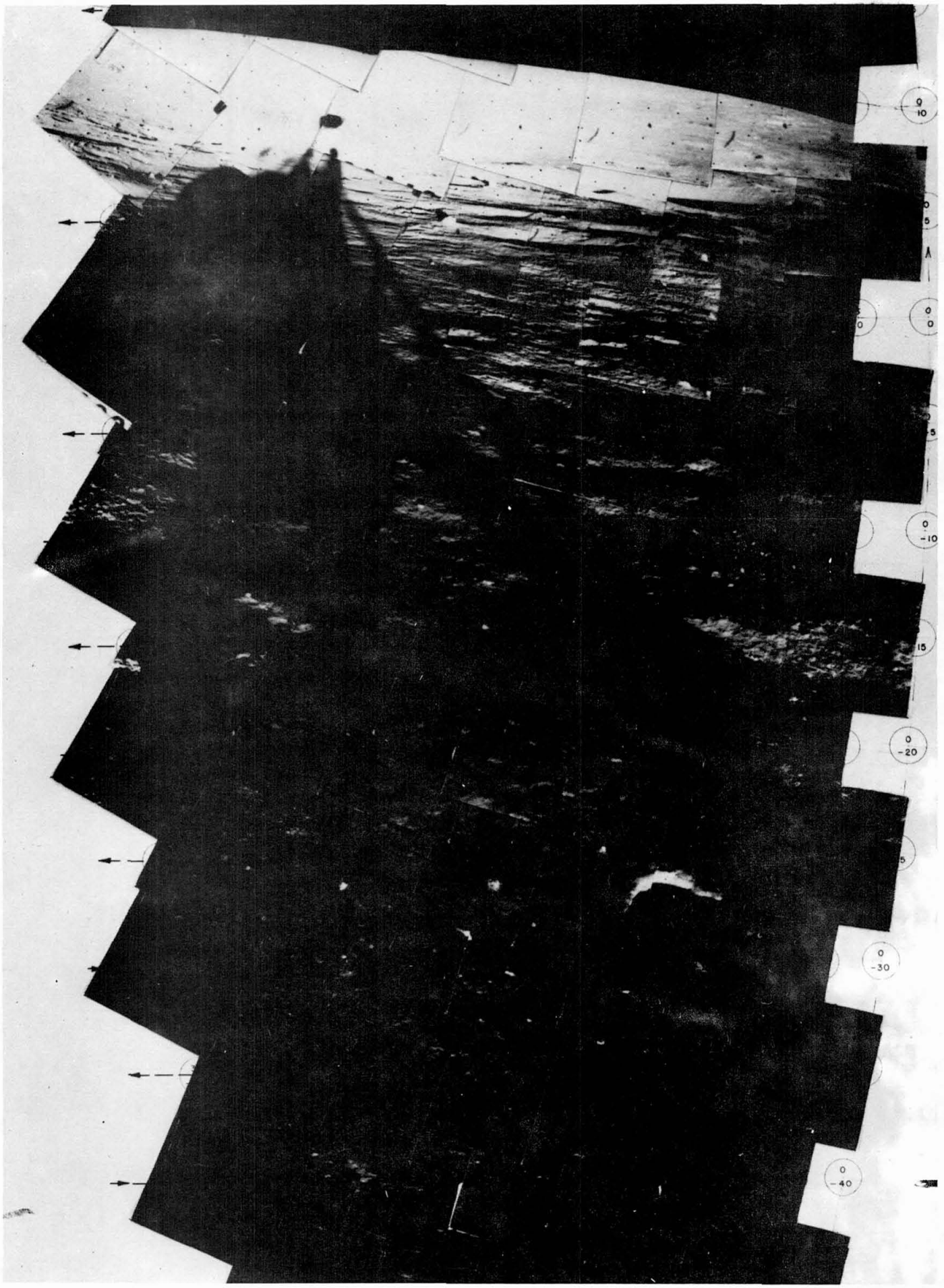
- TWO SITES SHOULD BE SELECTED IN THE EAST TO ACCOMMODATE UNCERTAINTIES IN ACHIEVABLE RECYCLE AND REPAIR CAPABILITY

- THESE SITES SHOULD BE SELECTED SUCH THAT:
  - IF THE PRESENT RECYCLE SPECIFICATION IS MET THE BEST SITE IS AVAILABLE
  - THE GREATEST RECYCLE MARGIN IS PROVIDED IN THE EVENT EXPERIENCE SHOWS THAT RECYCLE PLUS REPAIR HAVE A HIGH LIKELIHOOD OF EXCEEDING 44 HOURS

PRESENTATION BY LOFTUS

FACTORS DETERMINING SUN ELEVATION

- LAUNCH DATE
- LAUNCH AZIMUTH OR TIME IN LAUNCH WINDOW
- FIRST OR SECOND INJECTION OPPORTUNITY
- DETAILS OF TIMELINE IN LUNAR ORBIT


0
10
0
5
0
0
5
0
-10
15
0
-20
5
0
-30
0
-40

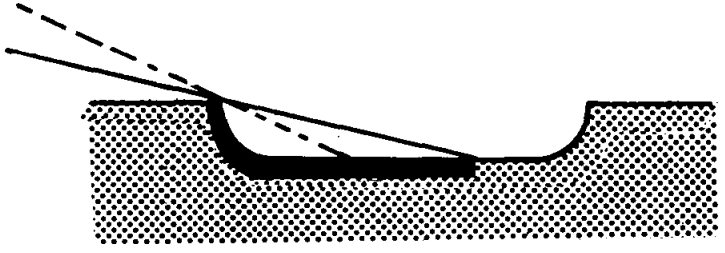
NASA-S-67-1610

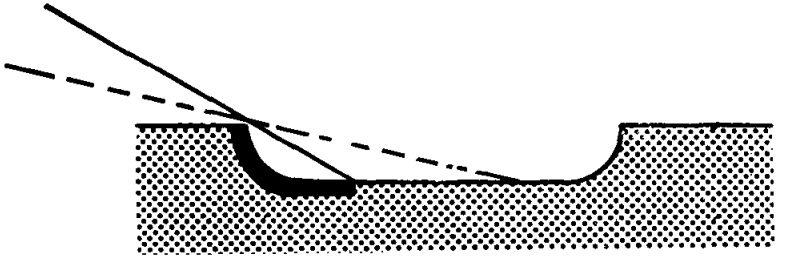
SHADOWS

CONTRAST EQUATION $C = \frac{L_T - L_B}{L_B}$

——— SUN LINE

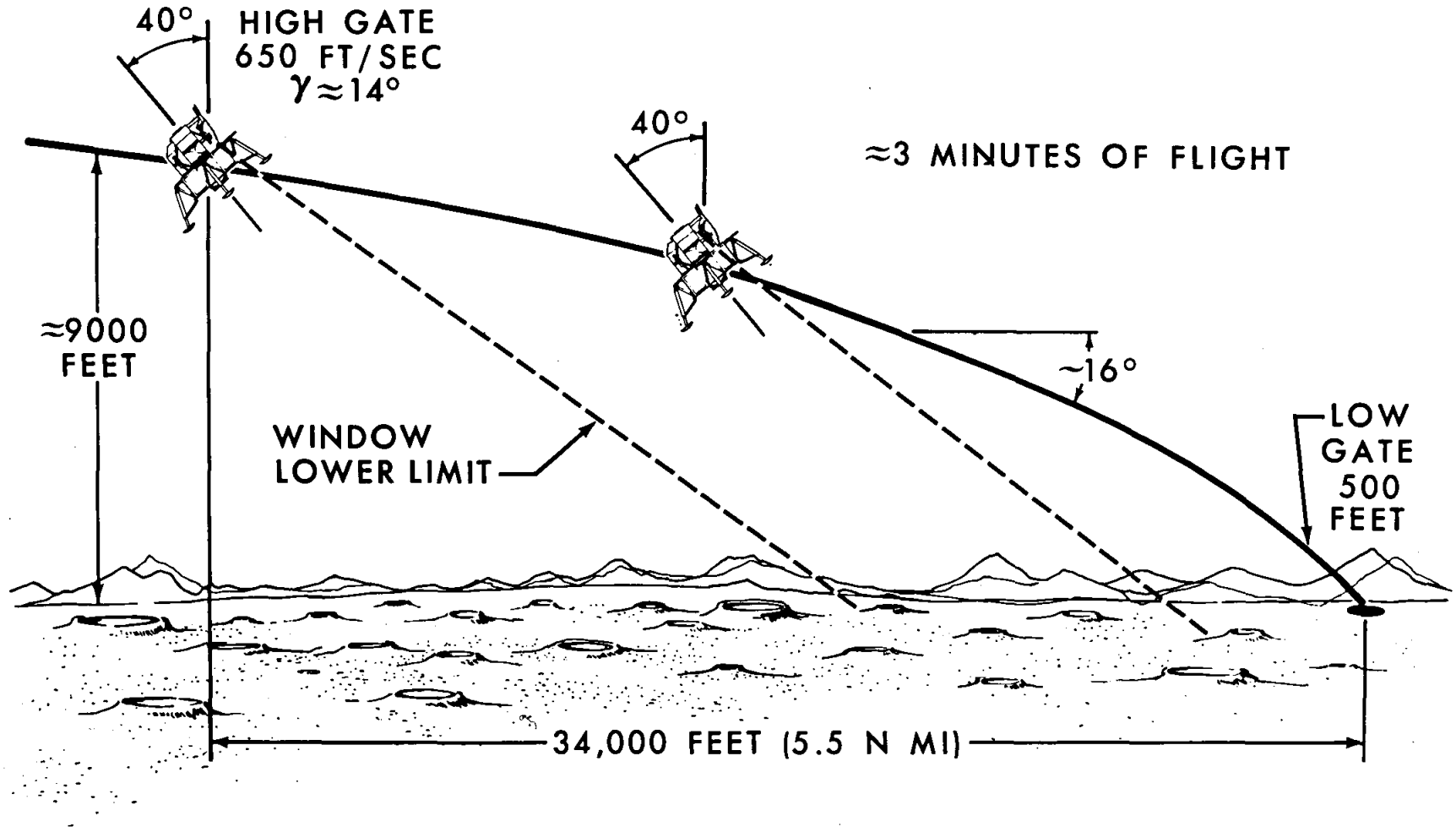
– – – – VIEWING LINE





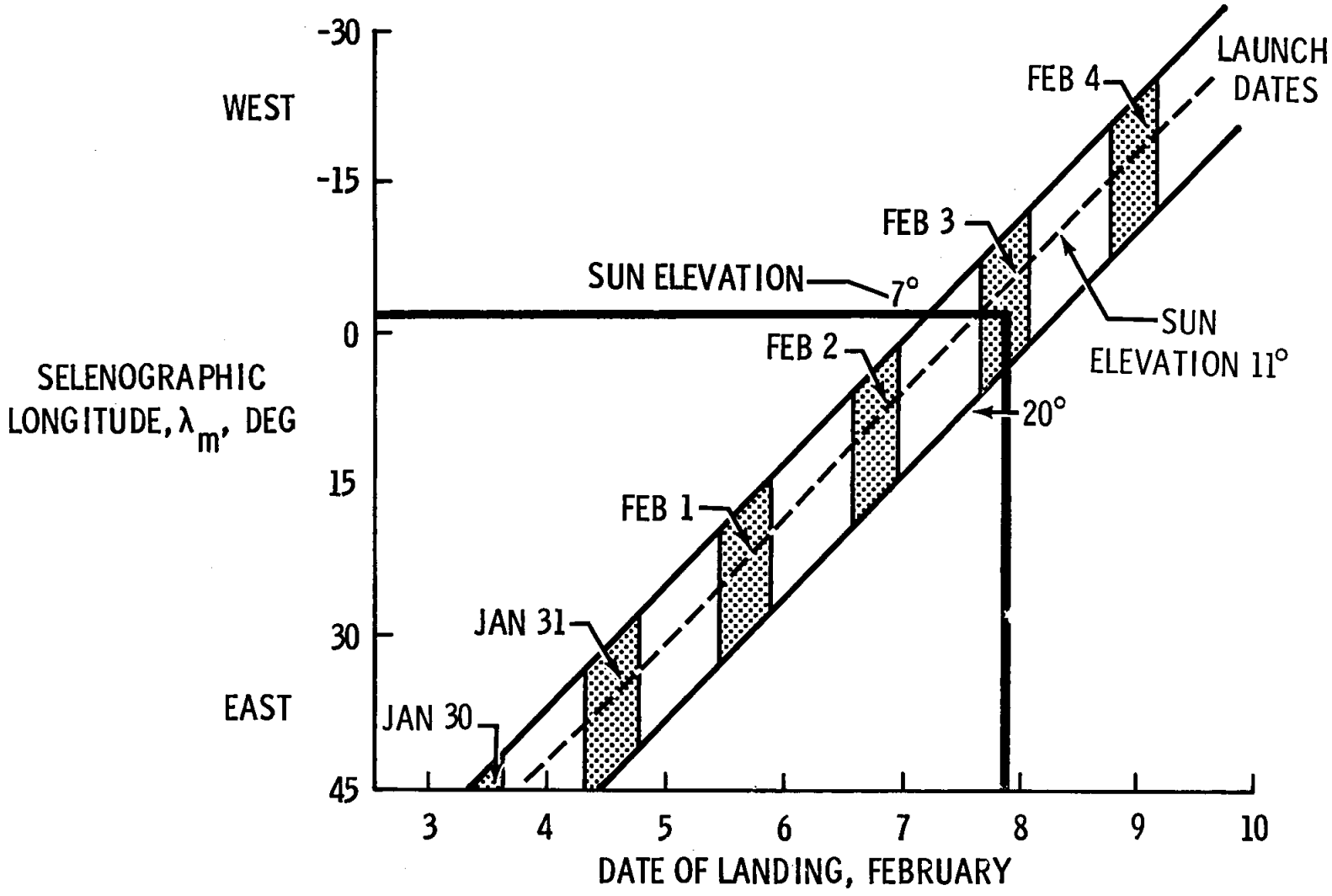
NASA-S-67-1095

LM FINAL APPROACH AND LANDING PROFILE



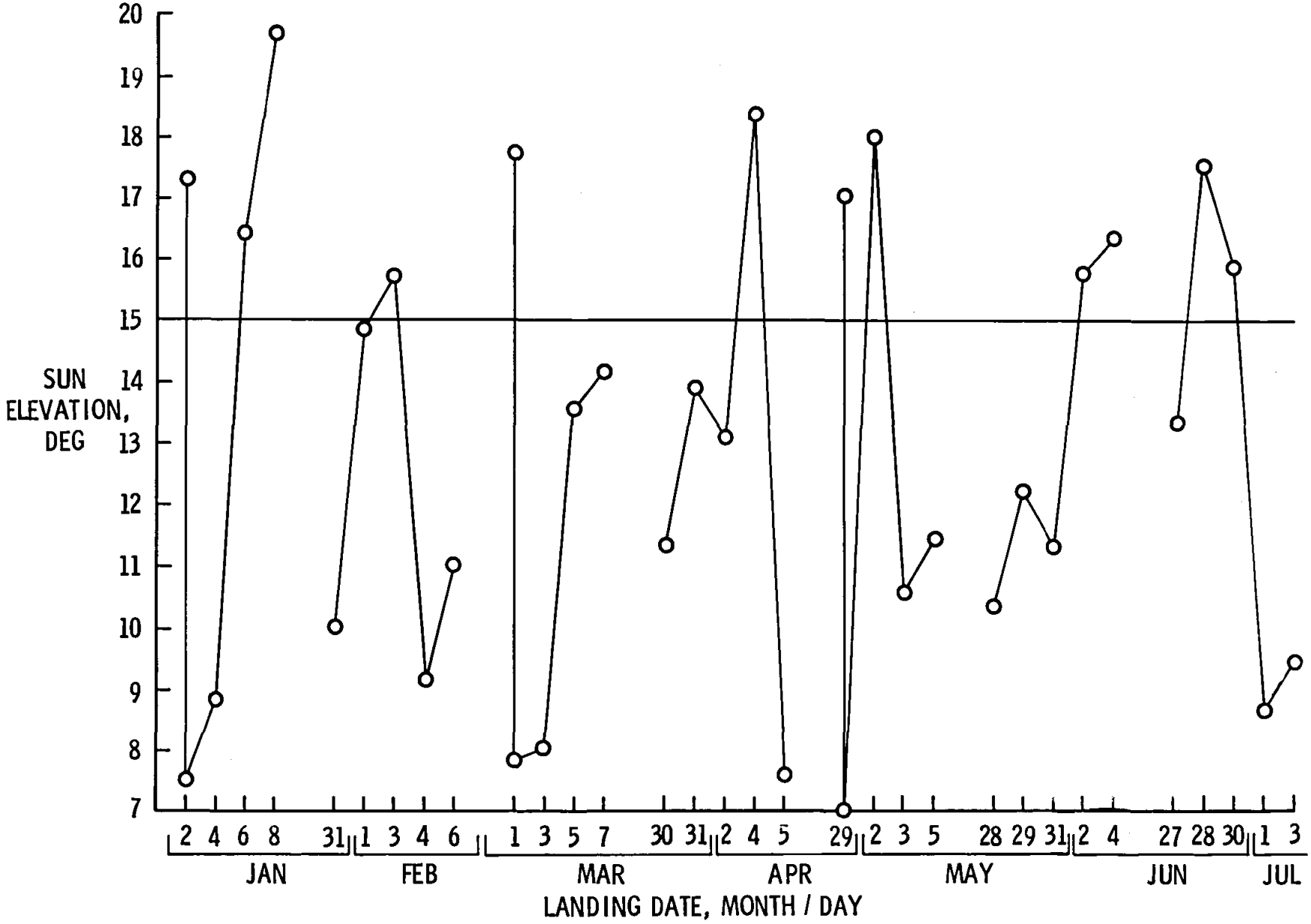
NASA-S-67-1902

VARIATION OF LIGHTING CONDITIONS



NASA-S-67-890

LIGHTING AT LM LANDING



NASA-S-67-8635

SOLAR ELEVATIONS AT LUNAR LANDING FOR VARIOUS LAUNCH WINDOWS