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955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B69 10020

SUBJECT: EVA Communications from Surveyor III Site on Apollo 12 - Case 320

DATE: October 8, 1969

FROM: I. I. Rosenblum

nasw-417

ABSTRACT

The candidate site for LM landing on Apollo 12 is at a point 1000 feet east and 500 feet north of the Surveyor III spacecraft. The communications line-of-sight between the LM and Surveyor locations is obstructed by the rim of the crater in which Surveyor is positioned.

In this memorandum three aspects of Apollo 12 EVA communications are examined:

1. The VHF signal margin for the planned LM landing site is estimated.
2. The region, north of the Surveyor III spacecraft, in which line-of-sight conditions would obtain is approximated.
3. A broad region is defined in which, at the same radial distance as the planned site, diffraction losses are about 6 db lower.

It is concluded that communications from the currently planned landing site would be adequate, although margins from other touchdown points in the immediate area would be greater.

The study uses as its basis, the attenuation calculations at 300 MHz for diffraction loss over a rounded obstacle (crater rim). Elevation information is based primarily on 10 meter and 2 meter contour interval topographic data.

(NASA-CR-107371) EVA COMMUNICATIONS FROM SURVEYOR 3 SITE ON APOLLO 12 (Bellcomm, Inc.) 13 p

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MEMORANDUM FOR FILE

1.0 INTRODUCTION

The planned LM landing site for Apollo 12 is at a point 1000 feet east and 500 feet north of the Surveyor III location.(1) Line-of-sight conditions do not exist because of obstruction by the rim of the crater in which Surveyor III rests. In some quarters this loss of line-of-sight has been equated to loss of communications (which, as will be seen, is not necessarily a good equation) and has stimulated a search for solutions to the "problem."

This study seeks to quantitatively identify the communications "problem" for the planned operations and to define alternate areas for LM landing which would improve EVA communications without hardware impact.

2.0 CANDIDATE SITE COMMUNICATIONS TO SURVEYOR III

The Apollo 12 landing site is at a distance of approximately 342 meters from Surveyor III on a heading of about 63° east of north (see Figure 1). Based on these given locations, the geometry of the situation was developed by reference to topographical data(2,3) and the communications loss was estimated by calculating the diffraction loss for a rounded obstacle based on the methods given in References 4 and 5. Figure 2 illustrates the geometry associated with rounded obstacle loss calculations and provides characteristic curves for total attenuation values, A (v, p), in db. In this figure, "v" is a dimensionless parameter strongly influenced by the ray path geometry and "p" is a dimensionless index of curvature for the crest radius. In the rounded obstacle model, the attenuation is thus a function not only of the diffraction angle and separation distances, but also of the curvature of the obstacle edge. Loss values obtained using rounded obstacle representation are usually larger and are more accurate than comparable values using knife-edge diffraction,(5) such as was employed in a previous study of screening by crater rims at Apollo 11-site 2.(6)

Results indicated that the diffraction loss from LM to EVA at the Surveyor location over the rounded crater rim is approximately 16.6 db. This loss is with reference to the free space field. In determining this loss, the heights of the EVA and LM antennas were assumed to be 2 meters and 7.6 meters, respectively, above terrain, and the radius of curvature of the line-of-sight obstacle was approximated by fitting the rim crest elevation point, A in Figure 1, and another point, B, (one contour interval lower) along the signal path, to a circular arc. A frequency of 300 MHz was used in the calculations as an approximation to the LM voice frequencies of 296.8 MHz and 259.7 MHz. The distance from Surveyor III to the rim crest was determined from scale measurements using Figure 1, taken from Reference 2. The elevation of the rim crest relative to the EVA antenna was also taken from Figure 1. The distance between Surveyor III and LM was scaled from Reference 3 which is partially shown in Figure 3 and the elevation of LM relative to EVA was estimated by interpolating between the contour intervals in that figure.

For the case being considered, a good idea of the available circuit margin can be obtained by considering the three dominant factors, i.e., allowable path loss, free space attenuation and diffraction loss, and ignoring secondary effects (reflections, antenna gains, polarization, etc.). The allowable path loss is taken as 119 db from the EVCS specification. The free space attenuation is given in db by:

$$L(db) = 32.5 + 20 \log d_o \text{ (km)} + 20 \log f \text{ (MHz)} \quad (1)$$

and for the .342 km separation distance and 300 MHz frequency

$$L = 72.6 \text{ db.}$$

The circuit margin is 119 -(72.6 + 16.6) = 29.8 db. On the basis of this prediction, no communications difficulty for the planned LM landing site is expected at the Surveyor III location.

3.0 IMPROVED EVA COMMUNICATIONS TO SURVEYOR III AT ALTERNATE LM LANDING POINTS

The planned LM landing site for Apollo 12 is understood to have been chosen largely on the basis of smoothness. Discussions with parties familiar with the guidance aspects of the mission indicated that a capability for redesignating the target point during the terminal descent exists and that the area most likely to contain the redesignated landing site (should this occur) is downrange and to the left because of visibility restrictions through the LM windows.

Inspection of the topography surrounding the planned LM landing site suggested to the writer that the chosen site may not be optimum from the communications standpoint and that alternate sites in the immediate area, perhaps in the redesignation region, might be better. It was anticipated that improvement in communications might arise from:

a) increased height of LM landing point elevation

b) closer proximity to Surveyor

c) lower elevation angle to crater rim (and, therefore, lower diffraction angle) associated with look angles (headings) to the north, northwest and west

d) smaller radius of curvature of crater rim.

Investigations were carried out at several headings in the areas northeast and northwest of Surveyor, including the following:

90° East

63° East

50° East

30° East

10° East

0° East

4° West

20° West

30° West

50° West

63° West

90° West

It was found that the line-of-sight distance from Surveyor III varied considerably with heading angle, increasing from a value of approximately 140 meters at 90°E and 63°E to approximately 270 meters in the region between 0° and 63°W. The parameter most responsible for this is the elevation angle from the EVA to the (level) crater rim which decreases markedly from a value of approximately 7 degrees elevation at a 63°E heading to about 3 degrees elevation at a 63°W heading. This reduction more than offsets the unfavorable gradual terrain dropoff as the LM landing site is moved from East to West. The approximate line-of-sight distance is shown in Figure 3 by the dashed line. LM touchdown anywhere within this area would be within line-of-sight of an EVA at Surveyor III. In this region the predicted signal margin is in the order of 40 to 50 db.

Of particular interest is the comparable performance of communications to be expected from alternate landing sites located the same radial distance from Surveyor III as the planned site (342 meters).

Because of the combined effects of lower diffraction angle and smaller radius of curvature of the crater rim, LM landing sites selected to the north and northwest of Surveyor, offer tangible advantages (communications-wise) over the planned site (at approximately the same or greater radial distance from Surveyor III). Table 1 provides a list of calculated diffraction loss values (for rounded obstacle) for sites at several selected headings and shows approximately a 6 db signal margin advantage over that at the planned site. The heading directions and LM landing points associated with the Table 1 signal paths are illustrated in Figures 3 and 4.

4.0 CONCLUSIONS

On the basis of the investigation it is concluded that:

a) the current candidate LM landing site is satisfactory, but

b) other sites in the immediate area would provide considerably better communications and

c) a redesignation requirement arising during the mission in real time should evoke first consideration of the region northwest of Surveyor III, because of the predicted communications advantage.

I. I. Rosenblum

2034-IIR-drc

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Attachment
Table 1
Figures 1 thru 4

REFERENCES

1. Sennewald, P. F., "Limitations on EVA to Surveyor III Spacecraft Due to Apollo 12 EVA Communications Constraints," Memorandum for File, August 19, 1969.

2. "Surveyor III Mission Report - Part II - Scientific Results," JPL Surveyor Project Technical Report 32-1177, June 1, 1967.

3. "Surveyor III Site 1:2000 1st Edition January, 1968," Mercator Projection Map, Contour Interval - 10 Meters, Army Map Service, Corps of Engineers, U. S. Army.

4. Barsis, A. P., Longley, A. G., Norton, K. A., and Rice, P. L., "Transmission Loss Predictions for Tropospheric Communication Circuits," N.B.S. Technical Note No. 101, U. S. Department of Commerce, N.B.S. Volume 1 Rev. January 1, 1967, Volume II May 7, 1965.

5. Dougherty, H. T. and Maloney, L. I., "Application of Diffractions by Convex Surfaces to Irregular Terrain Situations," Radio Science Journal of Research N.B.S./ USNC-URSI, Volume 68D, No. 2, February, 1964.

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TABLE 1

ROUNDED OBSTACLE DIFFRACTION LOSS FROM SURVEYOR III AT SELECTED HEADINGS TO LM

Path	Heading to LM	Dist. to Rim	Rim Radius of Curv.	LM Ant. Elev. Above Rim	Dist. to LM	Rounded Obstacle Loss
	(Degrees)	(Meters)	(km)	(Meters)	(Meters)	(db)
*A	63 E	76	.081	21.6	342	16.6
B	4 W	120	.049	13.1	342	11.3
C	10 W	131	.072	13.1	342	10.2
D	20 W	144	.056	10.6	332	9.7
E	30 W	150	.049	10.6	390	11.0
F	40 W	154	.049	8.6	342	10.6
G	50 W	173	.049	6.6	342	10.6
H	63 W	170	.049	5.6	362	12.3

*Planned

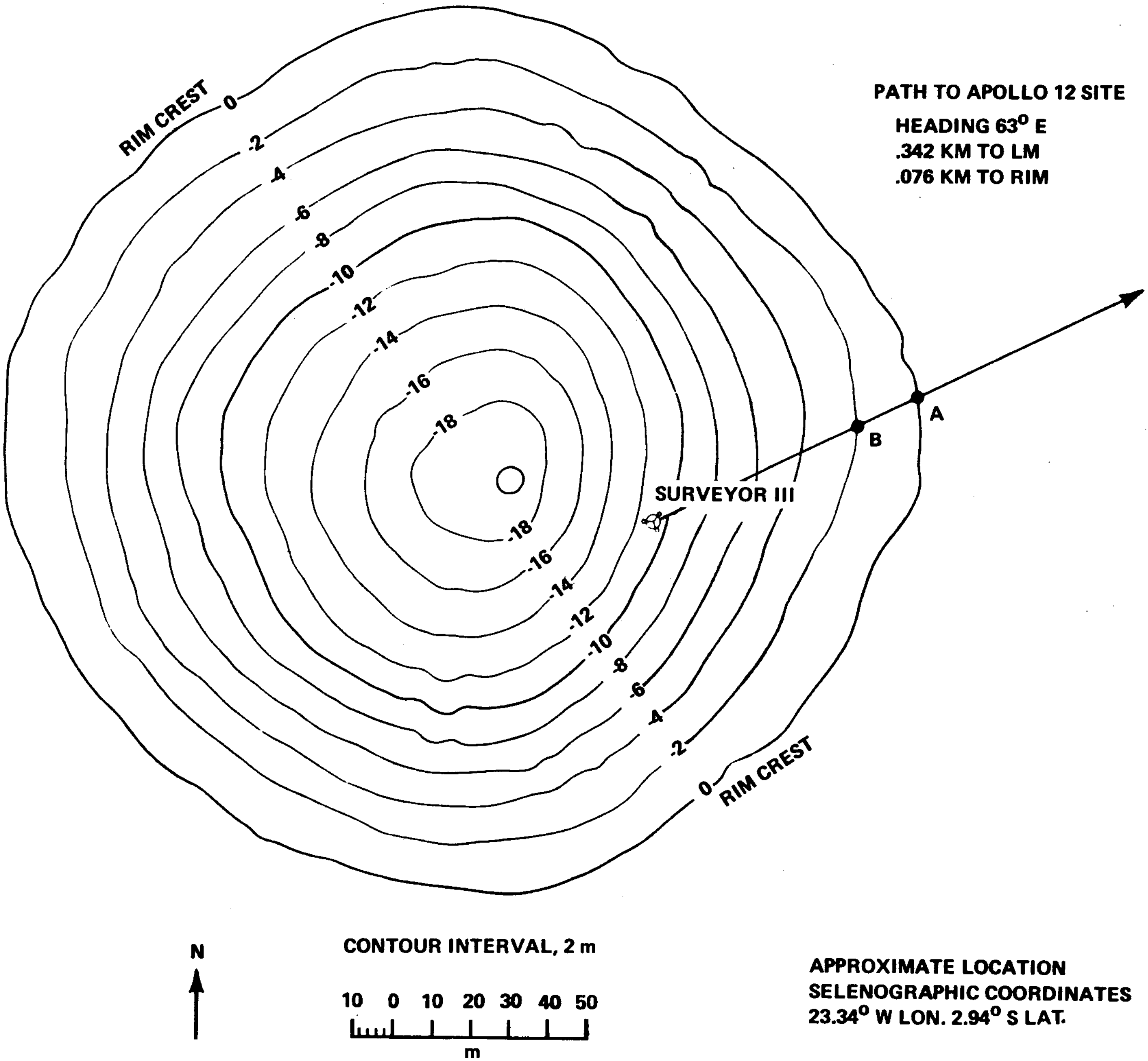

FIGURE 1 - CONTOUR MAP OF SURVEYOR III LANDING SITE PREPARED FROM PHOTOCLINOMETRIC PROFILES DERIVED FROM LUNAR ORBITER III PHOTOGRAPH H154, FRAMELET 27 (PHOTOCLINOMETRY BY H. E. HOLT AND S. G. PRIEBE) (FROM REFERENCE 2)

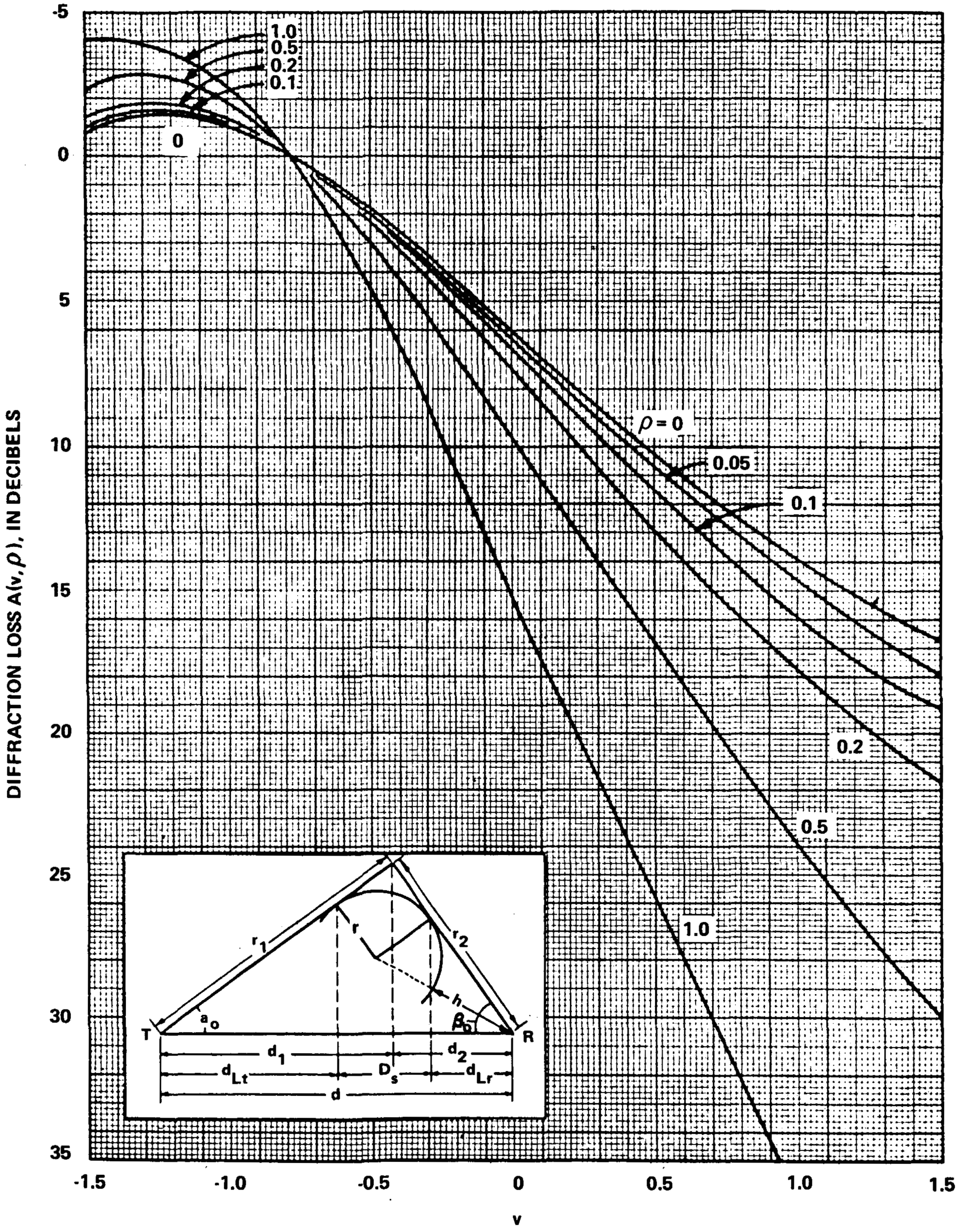

FIGURE 2 - DIFFRACTION LOSS, A(v, ρ), FOR A ROUNDED OBSTACLE

SURVEYOR III SITE

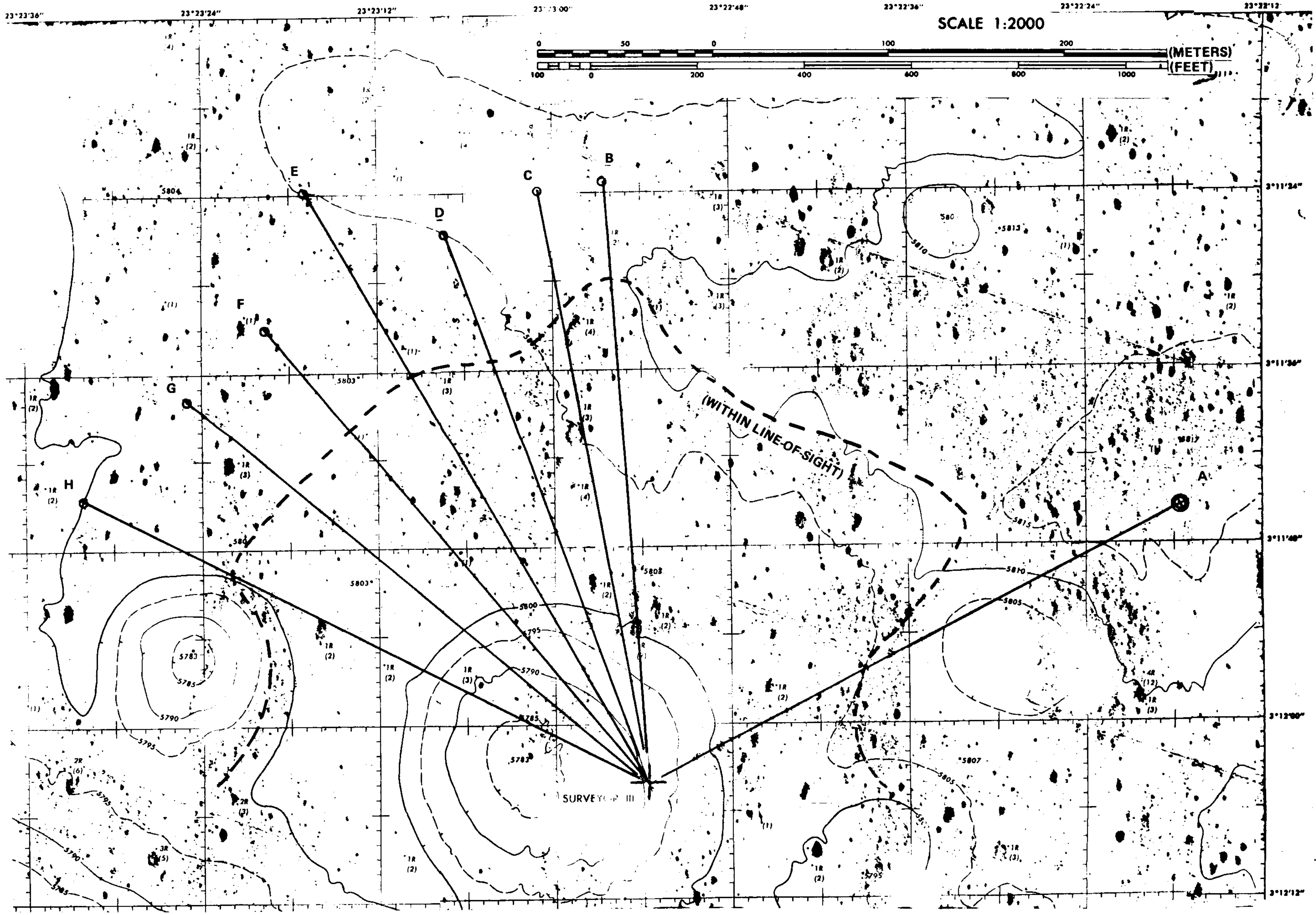

FIGURE 3 - COMMUNICATION PATHS (TABLE 1) AND LINE-OF-SIGHT DISTANCE FROM SURVEYOR III SITE (BASE MAP FROM REFERENCE 3)

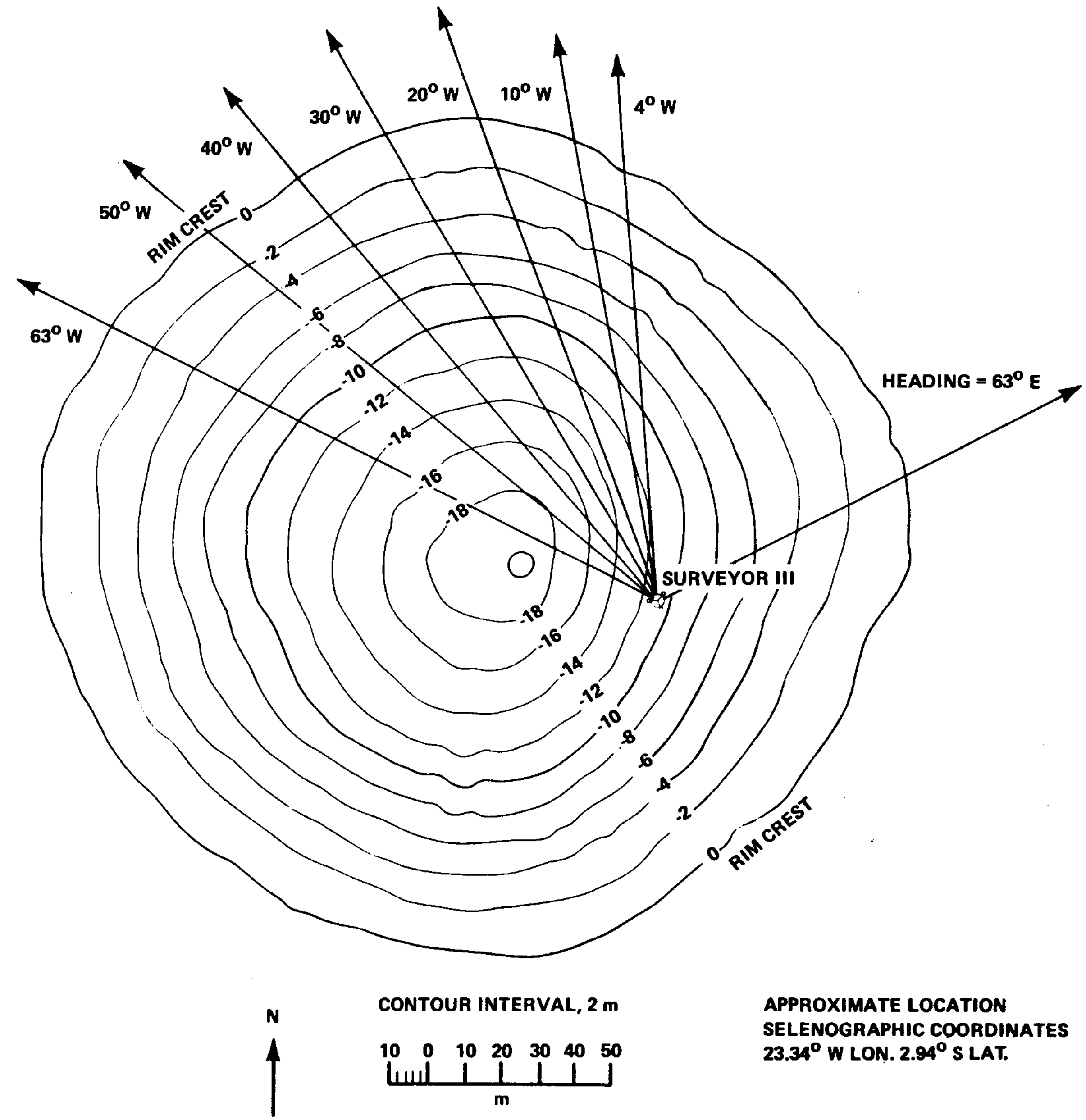

FIGURE 4 - CONTOUR MAP OF SURVEYOR III LANDING SITE PREPARED FROM PHOTOCLINOMETRIC PROFILES DERIVED FROM LUNAR ORBITER III PHOTOGRAPH H154, FRAMELET 27 (PHOTOCLINOMETRY BY H. E. HOLT AND S. G. PRIEBE) (FROM REFERENCE 2)

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