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NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

PRELIMINARY ANALYSIS OF LUNA-9 PHOTOGRAPHY

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PRELIMINARY ANALYSIS OF LUNA-9 PHOTOGRAPHY

Introduction

In response to CIA/FMSAC requirement C-DS6-83,440, this report contains the results of a preliminary analysis of Luna-9 photography. As performed by the Technical Intelligence Division of the National Photographic Interpretation Center, the objective of the analysis was to provide information about the photographic system, the spacecraft, and the lunar surface independent of previously published Soviet and U.S. data. Considering the quality of the photography, the available collateral material, and the effort to provide timely data, the derived results must be accepted as preliminary and subject to refinement by further analysis.

A. Results of Preliminary Analysis

1. Azimuthal angular field of view — 360 degrees

2. Vertical angular field of view — 30 degrees

3. Tilt of scanner rotation axis ($\pm$ 1.5°)

February 4 [redacted]	16 degrees
25X1D February 4 [redacted]	17.5 degrees
February 5	22.5 degrees
February 6	22.5 degrees

4. Axis of spacecraft movement (approximate location relative to foot containing prominent protuberance) — 35 degrees

5. Mirror data — see item B-5

6. Spacecraft dimensions (see line drawing)

height to scanner axis	2.02 feet
scanner turret	.25 x .24 feet
photometric device	.14 feet

7. Dimensions of lunar surface features (see foldout)

	Distance from capsule (feet)	Size (inches)
Crater 1	2.75	6-9 diam.
Rock 1	7-8	6
Rock 2	23	7-8
Rock 3	23	7-8

B. Photogrammetric Basis for Preliminary Results

25X1D
25X1D
25X1D

1. Ref. A-1 --- [redacted] However, the available horizon images traced the sine curves $y = c \sin\theta$ which is characteristic of the rotational motion of a rigid body on a flat surface. The apparent maximum and minimums of the curves indicate a 360 degree rotation. With an origin at the point of zero tilt (see item B-3), the constant c is computed from measurements of y values along the small axis of the format and angular values along the longer format dimension. The following sine curves can be traced:

25X1D

February 4	[redacted]	y = 0.290 sinθ
February 4		y = 0.335 sinθ
February 5		y = 0.413 sinθ
February 6		y = 0.400 sinθ

Because of image quality and the assumption that the horizon is flat, the values are only approximate numbers.

2. Ref. A-2 --- The vertical angular field of view (30 degrees) was obtained by two different solutions.

a. The angle between the points of zero tilt and apparent maximum tilt (see item B-3) together with the measured image distance between the points enabled the determination of an effective focal length. Utilizing the derived focal length and format size, the vertical field of view was computed to be approximately 30 degrees.

b. Employing ground photography, the dimension of the "photometric" device and its distance from the camera station were computed (see item B-7). Applying these derived values together with the measured image dimensions of the device (panoramic photography) to the following equation yields an effective "blow-up" focal length.

$$\frac{\text{focal length}}{\text{distance from camera}} = \frac{\text{image distance}}{\text{ground distance}}$$

The derived focal length together with the format size again yields a vertical angular field of view of approximately 30 degrees.

3. Ref. A-3 --- The derived tilt values represent the angle between the scanner rotation axis and the normal to a horizon tangent line with zero slope. Tangent lines were graphically constructed at various points on the horizon, and the tilt angle was measured directly. The tile values are mean values with an accuracy of plus or minus 1.5 degrees. The point of zero tilt was taken at the tangent point with maximum slope.

	Range (degrees)	Tilt (degrees)
February 4	15-17	16
February 4	16-19	17.5
February 5	21-24	22.5
February 6	21-24	22.5

4. Ref. A-4 [redacted]
25X1D
25X1D
To isolate the axis of spacecraft movement, traces of conjugate imagery from successive transmissions were plotted on an established base using spacecraft components (mirrors, antennas, feet) as references, assuming that the relative position of the components remained fixed. The displacement of the imagery and the near intersection of the different horizon images indicate that the movement was a rotation about an axis located in an area approximately 35 degrees to the right of the spacecraft foot displaying the prominent protuberance. The axis of rotation is approximately the same for both movements, and the second movement produced the greater amount of rotation. No evidence of movement between [redacted] could be found. The difficulties in exactly locating the axis of rotation were that a scale change [redacted] hindered overlay traces. Image displacement could not be definitely attributed to the scale change or actual spacecraft rotation. Variations in the image quality of the [redacted] considerably reduced the number of traceable images. The missing portions of the panoramas precluded comparative traces in those areas. Producing all [redacted] at the same scale and eliminating noise patterns together with densitometric image traces could perhaps enable a more precise determination of the location of the rotational axis.

25X1D
25X1D
25X1D
25X1D
25X1D

5. Ref. A-5 --- The three dihedral mirrors mounted on the capsule image six strips of the lunar surface. Mirrors one and two (see foldout and line drawing) are of similar size, are mounted on the outer edge of the capsule, and are offset by 180 degrees. Mirror three which is smaller than the other two is located closer to the scanner turret. By printing the panorama negatives in reverse, the mirror images were correlated to the conjugate lunar surface images. Plots of the images from the right face of mirror one and the left face of mirror two intersect at a point on the lunar surface approximately six feet from the capsule. Mirrors one and two each occupy approximately 3.7 degrees of the panorama, and mirror three occupies approximately 5.6 degrees.

The faces of mirrors one and two do not image equally in the panorama which is indicative of (a) rotation about the vertical axis of the mirror, (b) unequal mirror surface, (c) an angle other than 90 degrees between mirror faces. In the panorama, the faces of mirror three are of equal dimension indicating that the faces are at an equal angle with the optical axis of the scanner. Stereoscopic viewing is possible with the corrected mirror images but the quality of the stereo image is at best poor. Further work is being done on the mirror angles to determine mirror orientation and to better understand the purpose of the mirrors.

6. Ref. A-6 --- Approximate dimensions of the Luna-9 capsule with the petals closed and protective covering in place were obtained from motion picture film T-6376. The height of an average man was used as a basic scale factor. That the man and capsule are equidistant from the camera station and that both are in a vertical plane were assumed. The interior orientation of the taking camera, the camera attitude relative to a vertical datum, and an estimate of the difference in distance from the capsule to the man in a direction parallel to the optical axis were obtained. Using a mensuration base established by the above method, the maximum diameter of the capsule was computed to be 3 feet.

Employing ground photography of a Luna-9 display (Fair of Permanent Achievement, Moscow), the height of an average man was again used as a scale factor. Additional assumptions are that the Luna-9 capsule is positioned in the middle of the display and that the distance from the man imaged in the background to the camera is twice that of the capsule to the camera. Photo B-18 shows clearly that Luna-9 is in the center of the display. The primary photographs A-10 and A-12 were taken on opposite sides of the capsule. Image space distances (capsule diameters, heights of support poles, and distances between antenna end points) in both photographs agree to within an average error of plus or minus 5 percent. Since the scale and focal length remain constant between the two photos, the distance from the exposure station to the capsule is equal for both pictures. Therefore, a vertical plane through the spacecraft normal to the "air base" between the exposures stations bisects that "air base". The diameter of the Luna-9 capsule may then be ratioed directly at 1/2 the scale of the average man. The capsule diameter with petals unfolded and no protective covering was computed to be 2.18 feet (664.1 multimeters).

An article in the Soviet publication "Aviation and Space" (Issue 3, 1966, page 9) states that the camera is 60 centimeters (1.97') above the surface. That this height refers to the scanner turret and accounts for the tilt of the capsule is unknown, but the Soviet figures and those computed from ground photography very closely agree. Based on this close agreement and the satisfactory scale agreements between the various sources, the dimension 2.18 feet was selected as a base for computing all other dimensions. (see line drawing) All Luna-9 capsule dimensions were then graphically computed. If subsequent uncropped photography with a known focal length becomes available, refinement of the dimensions may be possible. Other dimensions, specifically requested, will be computed.

7. Ref. A-7 --- The derived spacecraft dimensions enabled some estimates to be made of the lunar surface from monoscopic methods. The approach involved some of the same photogrammetric techniques used in high oblique aerial photography. Given focal length, height, and orientation, then the ground coordinates or size of any object may be computed.

Mensuration of the Luna 9 capsule provides a basic height of 2.02' to ℄ of scanner axis. Since Luna 9 is in a tilted position this dimension represents a slant range rather than a height. The true height may then be computed for each scan depending on the amount of tilt.

The effective focal lenght of Luna 9 may be computed from the scale formula s=f/h. The photo distance of the photometric device is measured on the panorama, its ground distance was computed from ground photography, and the distance from the device to the exposure station is known. To solve monoscopically it is also necessary to make use of the angular field of view which was previously determined.

Several prominent lunar topographic features are dimensioned on the accompanying graphic. The dimensions were randomly selected and additional measurements for any particular feature specifically requested will be computed. Future analysis of stereoscopic coverage may give some checks on monoscopically computed dimensions.

The preliminary dimensions for selected bits of lunar topography were computed monoscopically and are approximations only.

Object	Distance from Capsule (Feet)	Size (Inches)
Crater 1	2.75	6-9 diam
Rock 1	7.8	6
Rock 2	23	7-8
Rock 3	23	7-8

REFERENCES

1. Ground Photography
   Luna 9 exhibit at the Permanent Fair of Achievement, Moscow
   (Confidential)
   Received approx. 3 May 1966

25X1D 2. [redacted]
   (Secret)
   Assorted prints and positives were received during week of 27 March. However, panoramas from 6 February were not received until week of 8 May.

3. Soviet Movie "Starry Road" T-6376 (Secret)
   Received Approx. week of 20 March

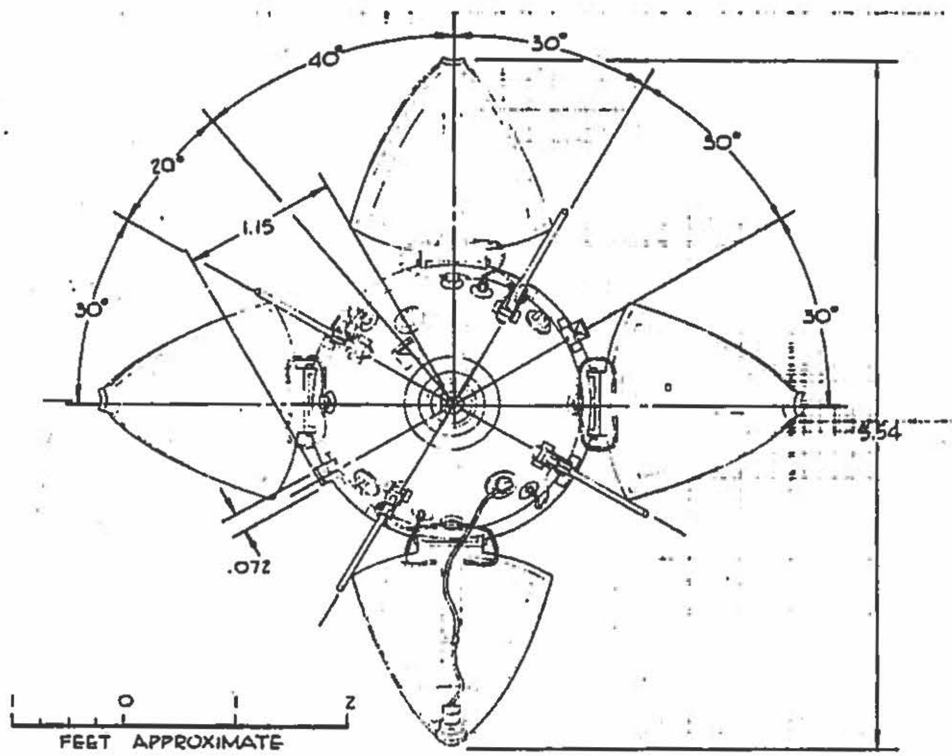
4. JPL Technical Report 32-877
   Digital Video-Data handling (Unclassified)
   Received during week of March 27

5. Stereopanoramic Surveys by M.M. Rusinov
   Leningrad Institute of Precision Mechanics and Optics
   Geodesy and Aerophotography No. 2 1965 (Unclassified)

6. Soviet newspaper accounts including Pravda, Tass, and others (Unclassified)
   All received approx. during week of 27 March

7. Soviet Bloc Research in Geophysics, Astronomy, and Space
   No. 128 U.S. Dept. of Commerce
   Clearinghouse for Federal Scientific and Technical Information (Unclassified)
   Received during week of 27 March

8. An Appreciation of Luna 9 Pictures (Unclassified)
   25X1A [redacted] (USGS)
   Astronautics and Aeronautics May 1966
   Received approx. 6 May 1966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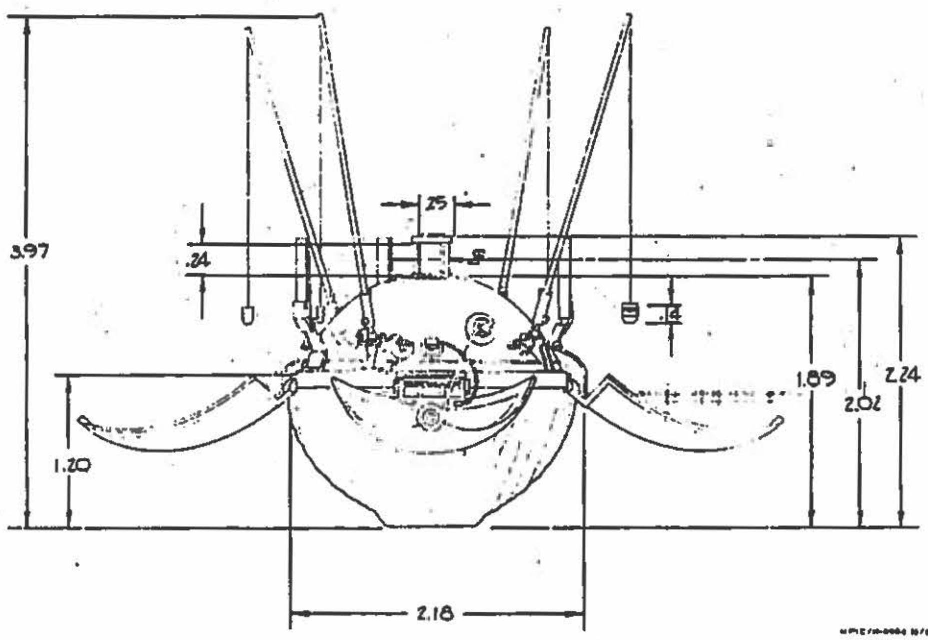
1
2
FEET APPROXIMATE

Luna 9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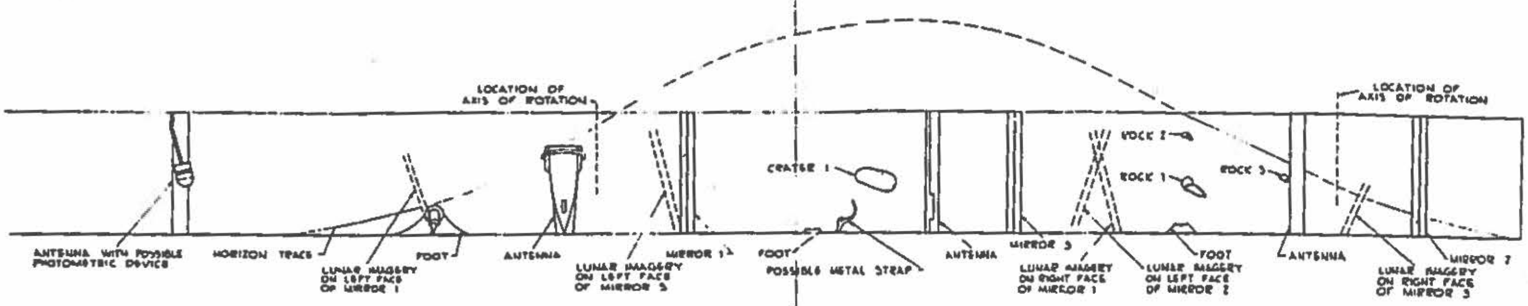

GRAPHIC PORTRAYAL OF LUNAR PANORAMA