TECHNICAL PUBLICATION

ANALYSIS OF LUNA-13 PHOTOGRAPHY

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NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

SECRET

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PREFACE

This report is an analysis of Luna-13 photography published in response to CIA/FMSAC requirement C-DS7-84, 314 for information concerning the facsimile photographic system, the Luna-13 capsule, and the lunar surface. The study is based primarily on contact prints of the intercepted facsimile photographs of the lunar surface.

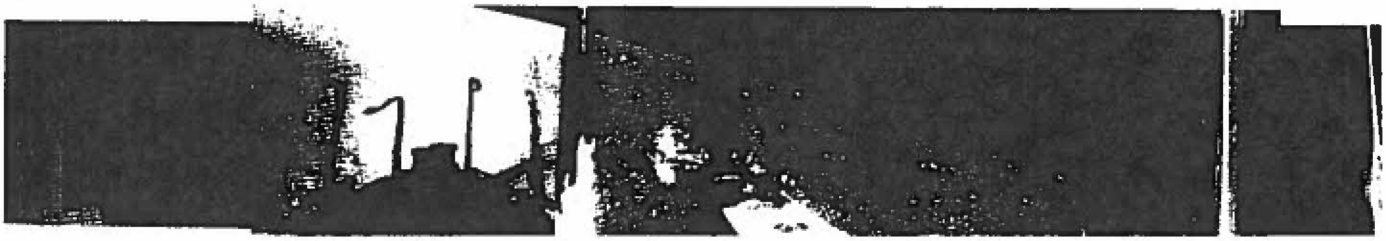


FIGURE 1. LUNAR PANORAMA.

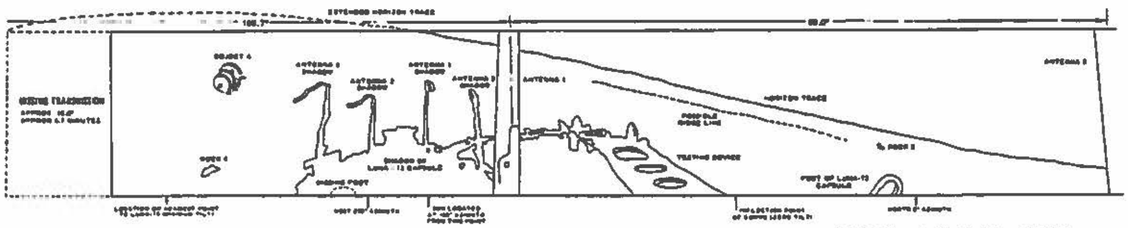
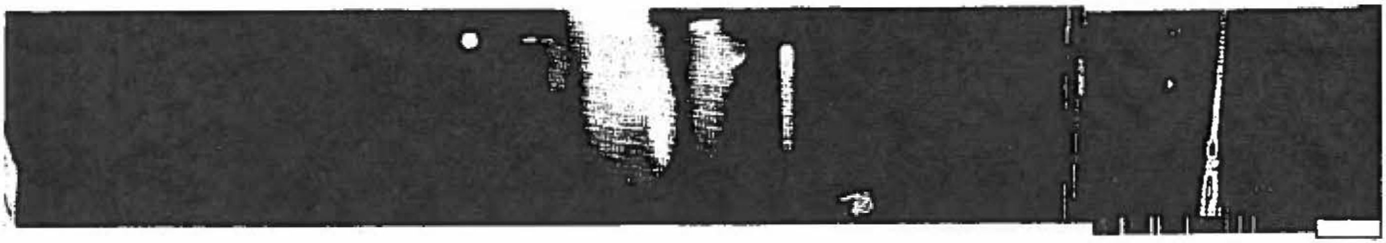


FIGURE 2. GRAPHIC PORTRAYAL OF LUNAR PANORAMA.



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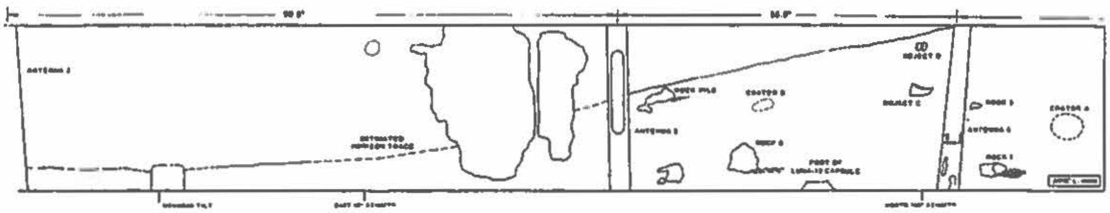

ANTENNA 2
ESTIMATED HORIZON TRACE
ROCK PILE
ANTENNA 3
CRATER B
ROCK 2
FOOT OF LUNA-13 CAPSULE
OBJECT D
OBJECT C
ROCK 3
ANTENNA 4
ROCK 1
CRATER A

GEOMETRIC ANALYSIS

1. Angular Fields of View

a. Azimuthal. Since none of the 4 separate transmissions (one on 25, one on 26 and two on 27 December) provide a complete panorama, a mosaic has been constructed using photographs from all 4 transmissions (Figure 1). Even using all available photography, the mosaic contains a gap of about 16.6 degrees or 4.7 minutes (time) of missing imagery (Figure 2). The imagery in this gap is shown, however, in Soviet sources.[1]

A short definition of terms used in this report is provided for future reference:

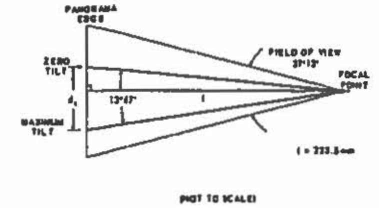
> Maximum tilt of optical axis--the least amount of lunar surface is imaged.
>
> Minimum tilt of optical axis--the greatest amount of lunar surface is imaged.
>
> Zero tilt of optical axis--maximum slope and inflection point of horizon trace.
>
> System tilt--angle of the vertical axis of the capsule with respect to terrain vertical. Note that system tilt is not defined with respect to local vertical in the strict geodetic sense, but with respect to the local terrain surface regardless of any slope of the surface.

The amount of imagery missing was determined by visually locating the maximum tilt and the inflection point on the horizon trace. This established a scale of 90 degrees which was then used to compile the mosaic.

Table 1. Final Set of Equations for Scaling in the Azimuth Direction

Linear Distance on Image (inches)	Time (minutes)	Angular Distance on Image (degrees)
1.0	1.75	6.16
.571	1.0	3.53
.162	.283	1.0

b. Vertical. The interior orientation of the imaging system was determined by graphic methods after the system tilt was measured at the inflection point. The graphic solution shown in Sketch A was accomplished in the following way. The rays which image the maximum tilt and the inflection point are separated by a finite distance (d_1). These rays must also pass through a point source which must be on the optical axis. This defines the focal point.



Sketch A

The field of view (27 degrees 12 minutes) and the effective focal length (223.5 millimeters) were then measured directly.

2. Tilt of Vertical Axis (System Tilt)

To obtain the point of maximum slope, tangent lines were constructed at various points along the horizon trace, and the tilt angle was measured directly. The location of the inflection point was checked mathematically by fitting a third order polynomial curve to the horizon trace in the general area. The coordinate of the inflection point was determined by taking the second derivative and setting it

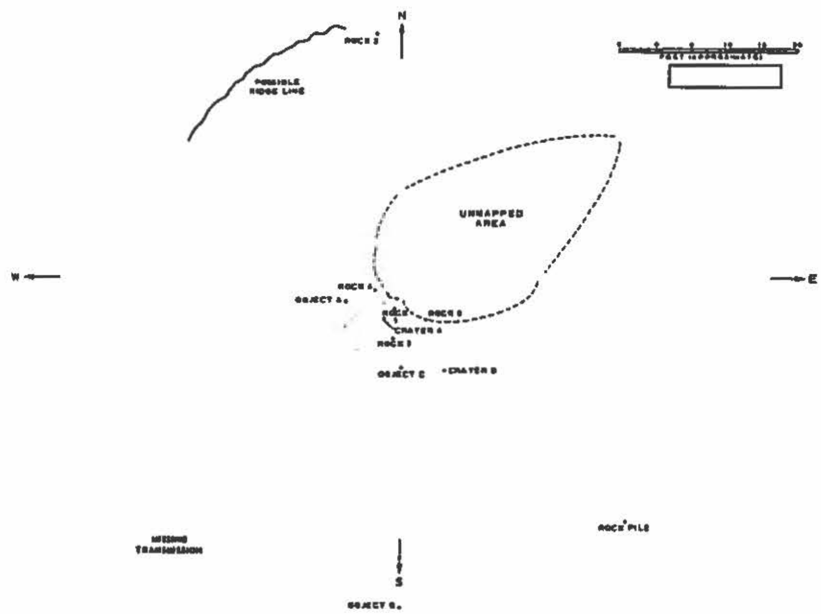


FIGURE 3. PLANIMETRIC MAP.

equal to zero. No noticeable variation in tilt was detected in the 4 transmissions. The value of the tilt is 13 degrees 47 minutes (plus or minus 1.5 degrees).

AREA COVERAGE

An approximate planimetric map (Figure 3) and table (Table 2) have been compiled showing location of the Luna-13 capsule, prominent lunar features, and possible objects from the vehicle or capsule lying on the surface.

Table 2. Key to Items in Figure 3

Item	Range (Feet)	Azimuth (Degrees)	Length (Inches)	Dimensions (Inches) Height/Depth	Diameter
Rock 1	4	191	6	1.5	-
Rock 2	36	354	11	5	-
Rock 3	8	188	2.5	1.5	-
Rock 4	4	245	2	1	-
Rock 5	6	151	-	5.5	-
Rock pile	45	156	48 (4 ft)	17	-
Crater A	6	203	-	1	7.5
Crater B	14	155	-	2	11
Object A	8	248	32 (2.7 ft)	4.5	4.5
Object B	45	160	18	12	-
Object C	12	180	10	6	-
Ridge line	35	303-348	360 (30 ft)	-	-

A polar coordinate system was used to designate location with the Luna-13 capsule as the origin of the system. The azimuth was established by locating a line on the imagery where shadows are falling parallel to the scan lines or directly away from the camera. This indicates that the sun was directly behind the capsule. The azimuth and elevation of the sun above the lunar surface were calculated from announced Soviet coordinates of Luna-13 (18-52N 62-03W) and the times indicated on the transmissions (Sketch B). A bright piece of imagery of undetermined nature and origin appears at an azimuth of approximately 90 degrees and at an elevation of approximately 17 degrees above the lunar horizon. The angular position of this imagery is close to that computed for the sun. A dimensional check yields a predicted image distance of 2.8 millimeters, using the formula:

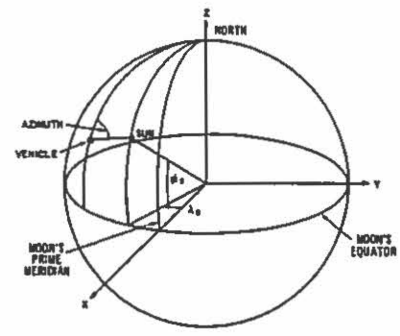
$$\text{Image distance} = \frac{\text{focal length x object distance}}{\text{height}}$$

Where: focal length = 223.5 millimeters;

object distance = sun's diameter, 864,000 nautical miles; and

Height = distance from moon to sun, 92,900,000 nautical miles.

The actual measured dimension is 8.5 millimeters, which is considerably larger than the predicted image distance. This may not be significant because of the unknown electronic imaging system.



Sketch B

VEHICLE AND CAPSULE OBJECTS

Three objects, designated A, B, and C, have been tentatively identified as parts of the Luna-13 capsule or spacecraft. An artist's concept of these objects is shown in Figure 4.

POSITION OF ANTENNA RIBBONS

By analyzing the imagery of the shadows of the antenna ribbons it was possible to assign some rough dimensions to the ribbons and to approximate the angle formed by two of these ribbons and their respective antennas. The estimated width of a ribbon is 1.5 inches.

Table 3. Antenna Ribbons

Antenna Ribbon	Length (feet)	Angle (degrees)
1	no data	no data
2	1.09	no data
3	1.19	62
4	.77	67

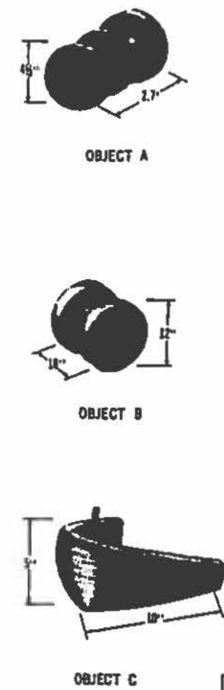


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FIGURE 4. ARTIST'S CONCEPT OF OBJECTS ADJACENT TO THE LUNA-13 CAPSULE.

LUNA-13 CAPSULE

The Luna-13 capsule shown in Figure 5 is a sketch derived from a drawing published in Soviet Life, May 1967. It was desirable to accomplish mensuration of the Luna-13 capsule without making any assumptions, thus making a completely independent solution. Although it was possible to establish strong angular geometry through both the derived interior orientation and the shadow relationships, there was no available data from which to scale. Therefore an assumption was made that the height of Luna-13 capsule was the same as that of Luna-9. This assumption is arbitrary and cannot be validated by available material; however, it was necessary after efforts to establish independence were unsuccessful. Because of the assumption regarding the mensuration of Luna-13, it is impossible to assign any meaningful tolerances to the dimensions.

GAMMA RAY DEPLOYMENT ARM

The identifiable portions of the gamma ray deployment arm both on the image itself and on its shadow are shown in Figure 6.

An accurate slope of the lunar surface could not be determined; however, by making some additional assumptions it was possible to estimate the slope. The distance from the end of the probe to the capsule can be measured directly on the imagery and also estimated from the published Soviet sketch. Although neither of these sources of imagery is optimum for mensuration, there should be some correlation between the two. However, on the facsimile photographs, the position of the arm appears to be approximately 2 feet farther from the capsule than it does on the Soviet sketch.

All of the mensuration of the lunar surface was accomplished assuming level terrain, an assumption that can result in serious errors in monoscopic mensuration of high oblique imagery. The discrepancies between these two sources are possibly due to a change of slope of the lunar surface between the end of the probe and the capsule. If this is the case, it is then possible to estimate the lunar slope at the arm at 2.5 degrees. However, it should be noted that many other unknown parameters could have affected the disagreement between the two sources, and the figure of 2.5 degrees for the lunar slope is only an estimate.

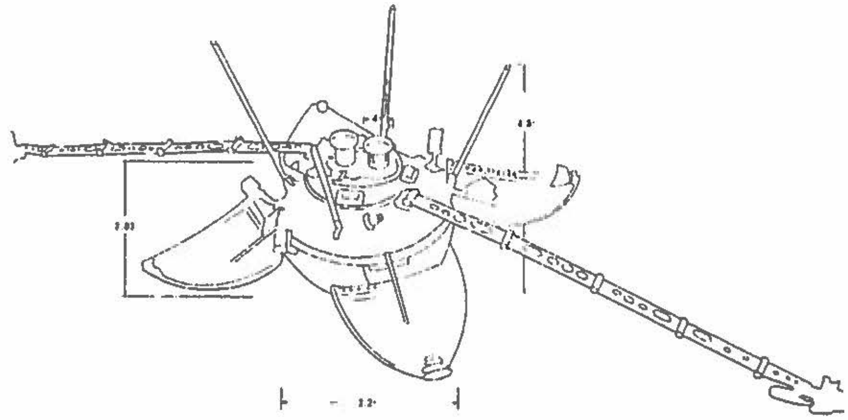

FIGURE 5. LUNA-13 CAPSULE. SKETCH BASED ON A DRAWING PUBLISHED IN SOVIET LIFE.

FIGURE 6. SHADOW-OBJECT RELATIONSHIP OF GAMMA RAY ARM.

STEREO VIEWING

Four photogrammetrists with previous stereo plotting experience (three on first-order photogrammetric plotting instruments) were asked to view certain pieces of duplicate coverage imaged at different times (Figure 7).

The results of the test were inconclusive. All of the individuals obtained a feeling of depth, but could not get a definite three-dimensional effect as a true stereo view should produce. An additional problem occurred when the images were reversed and pseudoscopic vision would be expected. Some individuals professed to receive a very slight pseudoscopic effect on certain scenes; others could not determine which arrangement was stereoscopic and which was pseudoscopic. All agreed that if these were designed to be stereo photographs they were exceedingly poor.

A further investigation involved examining imagery of the lunar surface with respect to parts of the capsule. With stereo some apparent displacement of one with respect to the other should occur; however, none was discernible. The conclusion is that the imagery was obtained from a monoscopic system.

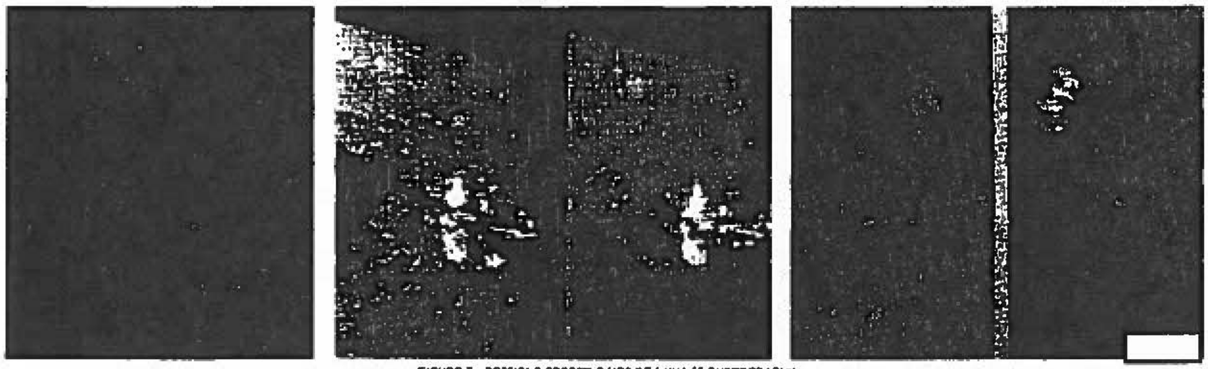

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FIGURE 7. POSSIBLE STEREO PAIRS OF LUNA-13 PHOTOGRAPHY.

REFERENCES

DOCUMENTS

1. *Soviet Life*, "Luna-13 Reporting New Achievement of Soviet Science," May 67 (Unclassified)
2. NSA. *Telemetry Report*, S/O/Rugn/R11-67 (SECRET)
3. NPIC. R-5032/66, *Analysis of Luna-9 Photography*, Jul 66 (SECRET/[redacted]

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REQUIREMENT

CIA/FMSAC. C-DS7-84,214

NPIC PROJECT

66134/67