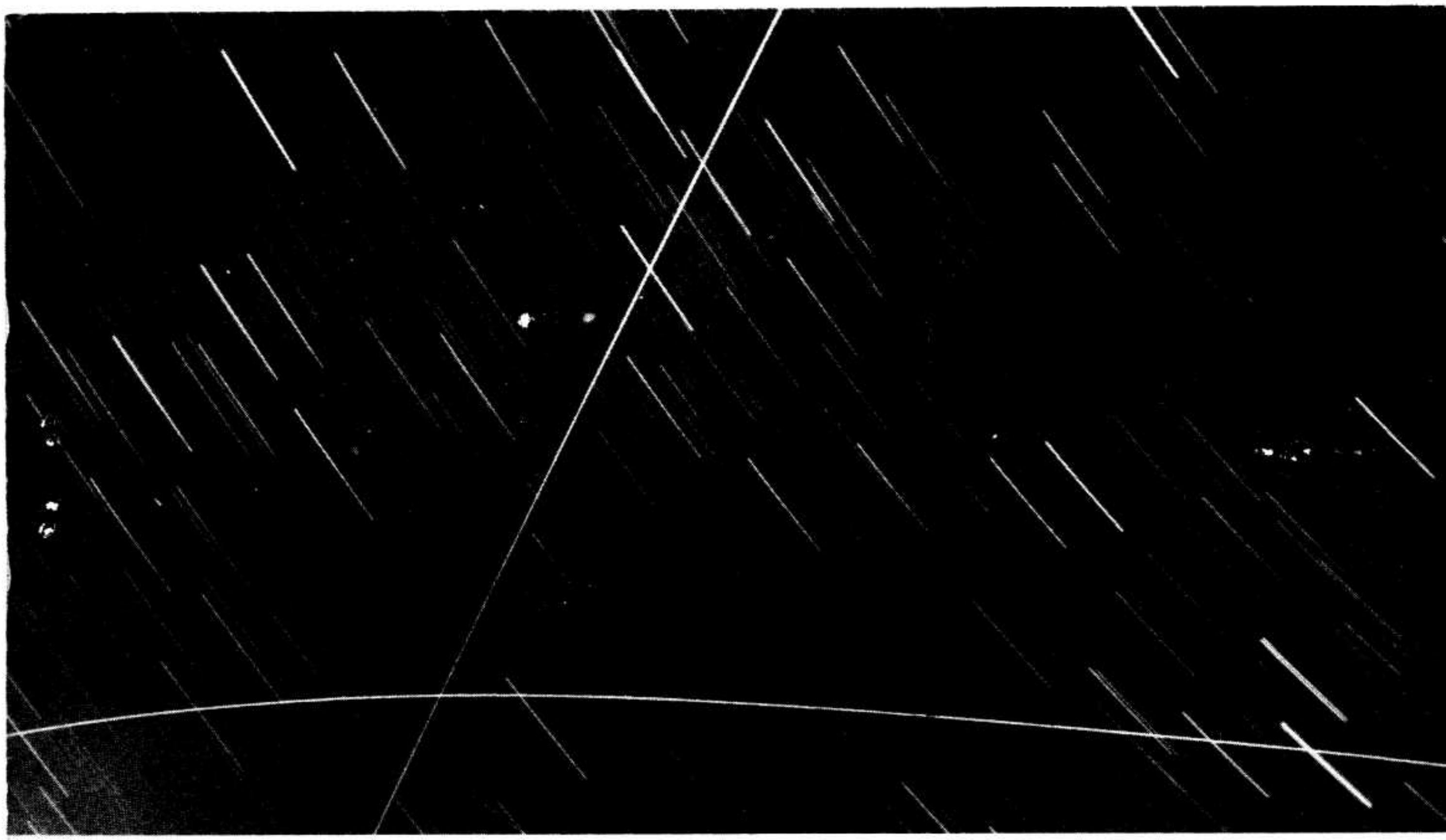

DATA USERS' NOTE
NSSDC 69-05

LUNAR ORBITER PHOTOGRAPHIC DATA

JUNE 1969

NATIONAL SPACE SCIENCE DATA CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.

LUNAR ORBITER PHOTOGRAPHIC DATA
NSSDC 69-05

Prepared by:
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June 1969

FOREWORD

The primary purpose of this *Data Users' Note* is to announce the availability of Lunar Orbiter 1-5 pictorial data and to aid the investigator in the selection of Lunar Orbiter photographs for study. In addition, this *Note* can give some guidance to the interpretation of the pictures. As background information, the *Note* includes a brief description of the mission objectives and the photographic subsystem. The National Space Science Data Center (NSSDC) can provide all forms of photographs described in the section on Format of Available Data. It is recommended, however, that the user first order the 35-mm film to facilitate selection of those frames for which high-quality reproductions are needed.

NSSDC will supply, as resources permit, limited quantities of photographs without charge where they are to be used for specific scientific studies. Charges must be made for photographs to be used for commercial or general interest purposes. All requesters should refer to the section on Ordering Procedures for specific ordering instructions. Scientists conducting an investigation that requires photographic data should inform the NSSDC of their needs and identify the nature of their study, their affiliation with a scientific organization, university, or company, and any government contracts they may have for performing the investigation. The Data Center seeks to keep informed of the results of any scientific investigations performed with the use of Lunar Orbiter photographs. We therefore request that scientists submit reprints of any published papers to the Data Center in order that the results of their studies can be made known to other users.

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LUNAR ORBITER PHOTOGRAPHIC DATA

INTRODUCTION

The five Lunar Orbiter spacecraft provided high- and medium-resolution photographs of specific lunar sites as well as broad areas at different heights above the lunar surface. The first three Lunar Orbiter photographic missions were designed primarily for the selection of primary and secondary landing sites for Apollo astronauts on the moon. The prime objectives of Lunar Orbiter IV were to perform a broad, systematic photographic survey of lunar surface features to increase the scientific knowledge of their nature, origin, and processes and to serve as a basis for selection of sites for more detailed scientific study. Lunar Orbiter V was primarily a multi-site scientific mission that included photography of previously unphotographed farside areas and additional photographs of candidate Apollo landing sites.

PHOTOGRAPHIC SUBSYSTEM

The photographic subsystem in all five missions included two roll-film cameras which simultaneously exposed two discrete frames on the common film supply. The film was Kodak High Definition Aerial Film, Type S0-243, which was preprinted along one edge with gray scales, resolution bars, identification numbers, and linearity patches. One camera had a 24-in. (610-mm) focal length narrow-angle (telephoto) lens and a focal plane shutter; the other had an 80-mm focal length wide-angle lens and a between-lens shutter. At an altitude of 46 km, the telephoto or high-resolution (HR) lens camera was designed to photograph at a resolution of 1 meter; the wide-angle, medium-resolution (MR) camera was designed to have a resolution of 8 meters at the nominal altitude. The area covered by the high-resolution exposure is centered in the medium-resolution coverage. The Lunar Orbiter film format is shown in figure 1. At the nominal 46-km altitude, the high-resolution image covered a region 16.6 × 4.1 km whereas the medium-resolution image covered a 31.6- × 37.4-km area. (See figure 2.) The camera subsystem could operate in the photographic modes illustrated in figure 3. Note that the HR coverage is always centered in the MR exposure area.

Both lenses operated at a fixed aperture of f/5.6 with controllable shutter speeds of 0.04, 0.02, and 0.01 sec. A mirror in the 610-mm lens system caused a reversal of all HR images on the film with respect to the MR photographs.

In operation, the camera lenses were first uncovered and the velocity-height (V/H) sensor activated. The film was clamped to a platen and flattened by vacuum. The image motion compensation clutch was engaged, and the platen was moved to compensate for ground speed while the shutter was open. The Kodak Bimat processor-drier developed, fixed, and dried the exposed film and provided a negative image ready for readout. The process is illustrated schematically in figure 4.

The camera could be commanded to take 1, 4, 8, or 16 consecutive exposures on an orbital pass over a target site with either a short-time interval (2.2 sec) or a long-time interval (8.8 sec)

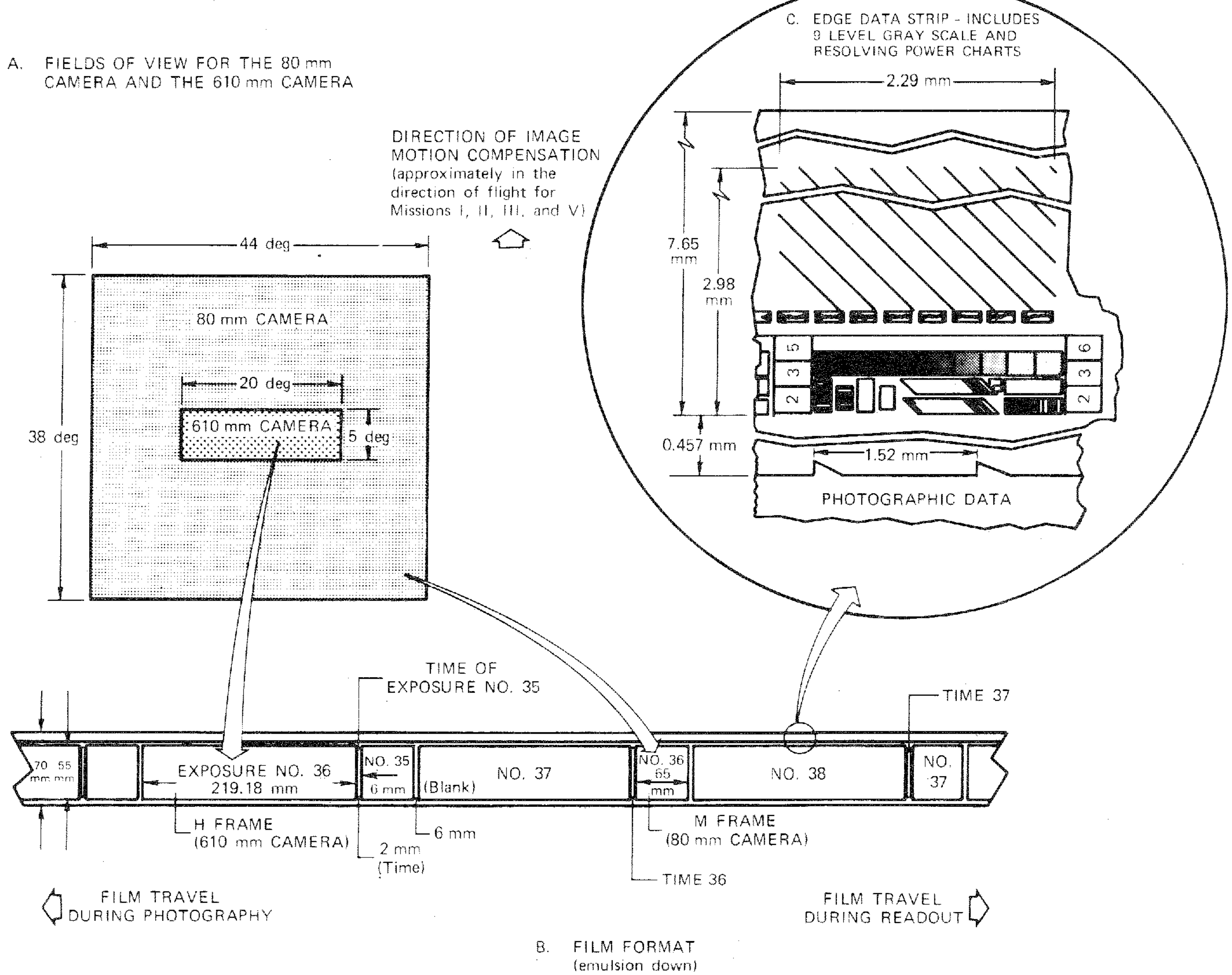


Figure 1—Edge Data Format

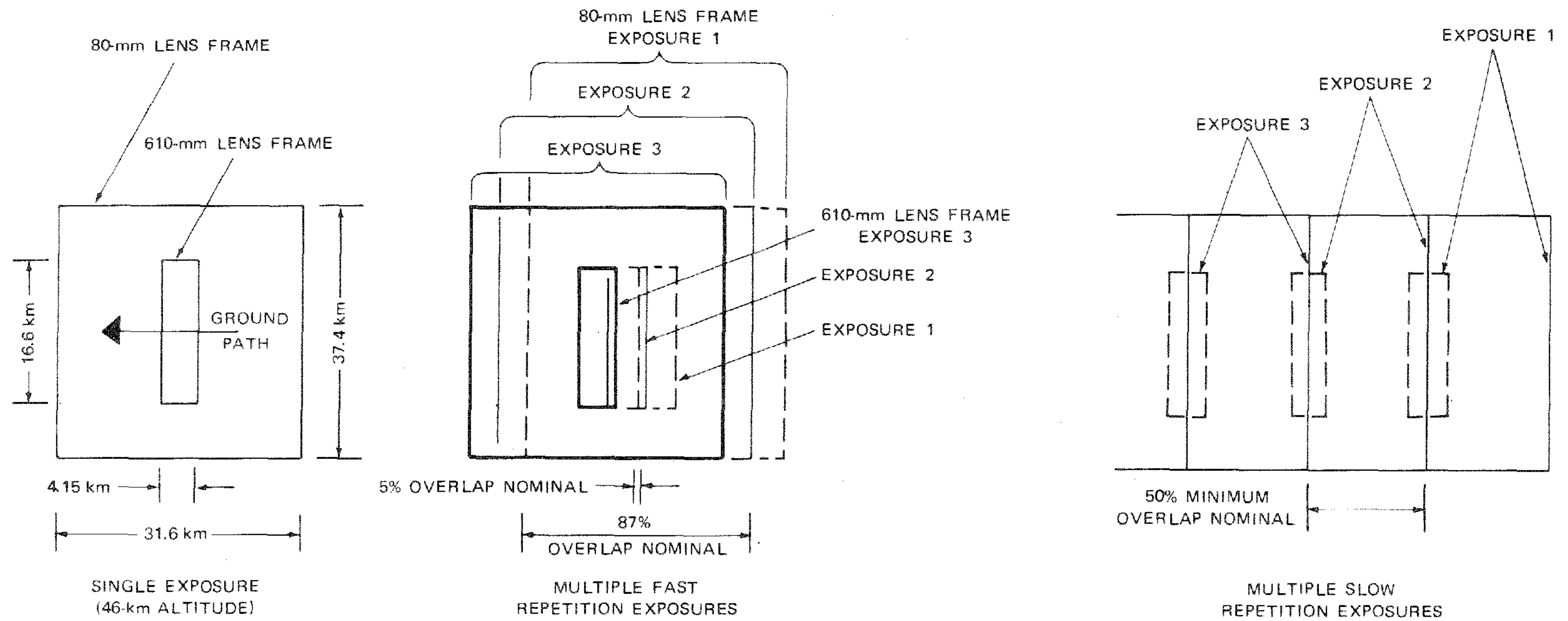
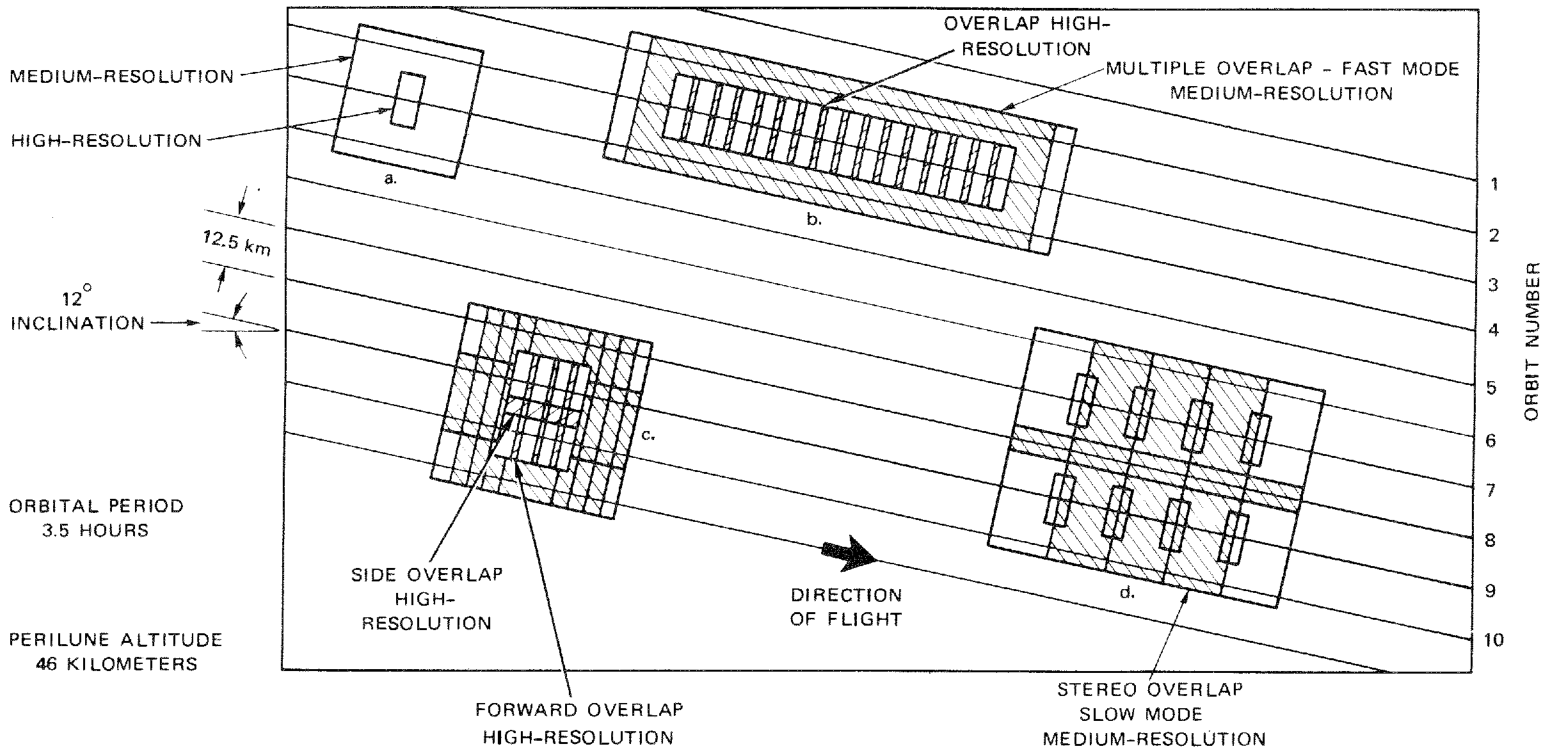


Figure 2—Photographic Overlap and Coverage for Sequencing Modes



a. SINGLE EXPOSURE AT THE 46-KILOMETER ALTITUDE; HIGH-RESOLUTION COVERAGE IS 16.6 km x 4.15 km MEDIUM-RESOLUTION COVERAGE IS 37.4 km x 31.6 km.

b. DESIGN MISSION TARGET SITE COVERAGE, 16 CONSECUTIVE EXPOSURES DURING ONE ORBITAL PASS OVER THE TARGET SITE. THE INTERVAL BETWEEN EXPOSURES (APPROXIMATELY 2.2 SECONDS) IS TIMED TO PROVIDE 5% OVERLAP OF THE HIGH-RESOLUTION FRAMES WITH APPROXIMATELY 87% OVERLAP ON MEDIUM-RESOLUTION FRAMES.

c. EIGHT TYPICAL FRAMES FROM A SITE EXAMINATION TYPE MISSION - CONTIGUOUS HIGH-RESOLUTION COVERAGE IS PROVIDED BY RAPID EXPOSURE RATE AS IN (b) TO GIVE HIGH-RESOLUTION FORWARD OVERLAP AND BY PHOTOGRAPHING ON CONSECUTIVE ORBITS (9 & 10) TO GIVE HIGH-RESOLUTION SIDE OVERLAP.

d. EIGHT TYPICAL EXPOSURES FROM A SITE SEARCH TYPE MISSION-STEREO MEDIUM-RESOLUTION COVERAGE IS PROVIDED BY INCREASING THE TIME INTERVAL BETWEEN EXPOSURES (APPROXIMATELY 8.8 SECONDS) TO OBTAIN 50% MEDIUM-RESOLUTION FORWARD OVERLAP AND BY PHOTOGRAPHING ON ALTERNATE ORBITS (7 & 9) TO OBTAIN MEDIUM-RESOLUTION SIDE OVERLAP.

Figure 3—Photographic Modes

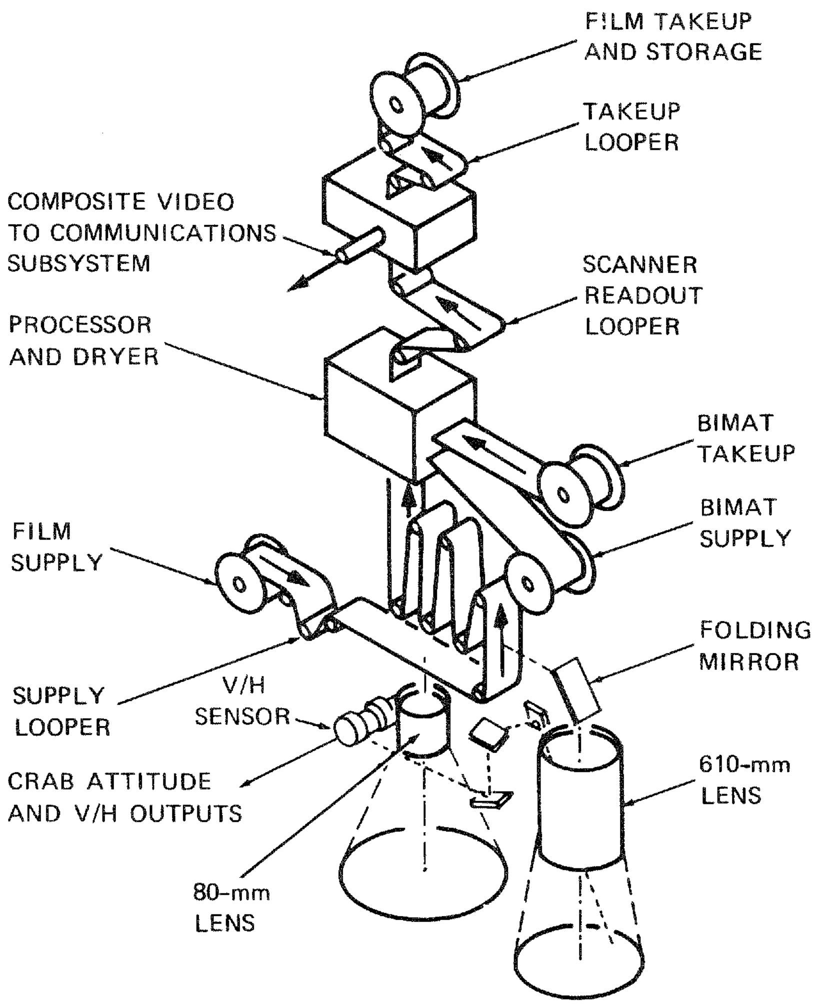


Figure 4—Photographic Subsystem Schematic

between exposures. As illustrated in figure 3, the short-time interval provides continuous high-resolution coverage with forward edge overlap. Contiguous high-resolution coverage could be obtained by repeating the photographic pattern on successive orbits. Overlap of 50 percent or more of the medium-resolution photographs allows stereo viewing, revealing surface contours not perceptible from single photographs. Stereo coverage in medium-resolution frames was obtained by overlap as shown in figure 2, and high- and medium-resolution stereo coverage was obtained on a few occasions by repeating the photographic pattern on alternate orbits.

During the readout process an electron beam scanned the negative image in 0.1-in. increments to produce variations in light intensity corresponding to the film density. A photomultiplier tube detected the transmitted beam and converted it to an analog electrical voltage for transmission by the telemetry subsystem. Ground reconstruction electronics (GRE) converted the video signals to variations of light on a kinescope tube. A 35-mm camera recorded these signals on Kodak S0-349 film as a positive photographic image. This image, called a framelet, was recorded at approximately 7.2 times the original spacecraft film scale. The original spacecraft photograph could be reassembled by placing framelets side by side. The reassembly sequence used to prepare a complete frame is illustrated in figure 5. A complete medium-resolution frame usually required reassembly of 26 framelets where a complete high-resolution frame required 86 framelets.

The camera in the photographic subsystems of each of the Lunar Orbiters underwent various tests and calibration measurements. These measurements were designed to compensate for errors caused by drift in the beam scan tube and the kinescope. The Data Center has on file reports by the USAF Aeronautical Chart and Information Center on the photometric and geometric camera calibrations for each of the Lunar Orbiter missions. NSSDC can supply these reports or portions of them to investigators performing detailed studies that require precise measurements.

FORMAT OF AVAILABLE DATA

Photographs from the five Lunar Orbiter missions are available in several forms. Film copies of the original framelets produced at the ground receiving stations were used in the Kodak automatic reassembly of subframes. The individual framelets can be provided by the Data Center as well as the reassembled subframes. The framelets are available for all missions whereas the Kodak subframes were compiled for Missions I, II, and III only.

The Army Map Service (AMS) hand-reassembled framelets from Missions II through V to improve on automatic reassembly; the Boeing Company and the Langley Research Center (LRC) photographically enhanced the Lunar Orbiter photographs to reduce the variations in light intensity inherent in the system and to minimize the conspicuous lines between framelets. No attempt has been made to remove bubbles or streaks on the film resulting from automatic processing aboard the spacecraft. The Boeing enhancements are available for selected Lunar Orbiter I photographs only. The Army Map Service prepared photographs for Missions II through V, and the Langley Research Center is processing all usable photographs from all missions. The different forms of photographs were generated in the sequence presented in the following paragraphs.

35-mm Framelets

The Data Center acquired the complete set of 35-mm negative film framelets from NASA's Langley Research Center. The negatives were produced from the original (zero-generation) positives recorded by the ground reconstruction electronics (GRE) at the ground receiving stations. The Data Center also has a set of second generation film positives which were made from these negatives.

The Data Center can provide either positive or negative film transparencies or enlarged paper prints made from the films on hand. The quality of the framelets is closest to the quality of the original GRE photographs. However, for most purposes, the Langley Research Center enhanced photographs discussed below will be the preferable format. The framelets will be useful to those investigators studying very detailed features on the lunar surface. Enlargements of specific areas or features can be provided if they are adequately identified. The framelets are numbered according to readout sequence. This number and the exact feature identification as well as the other types of identification specified in Ordering Procedures are required for requests for framelet enlargements.

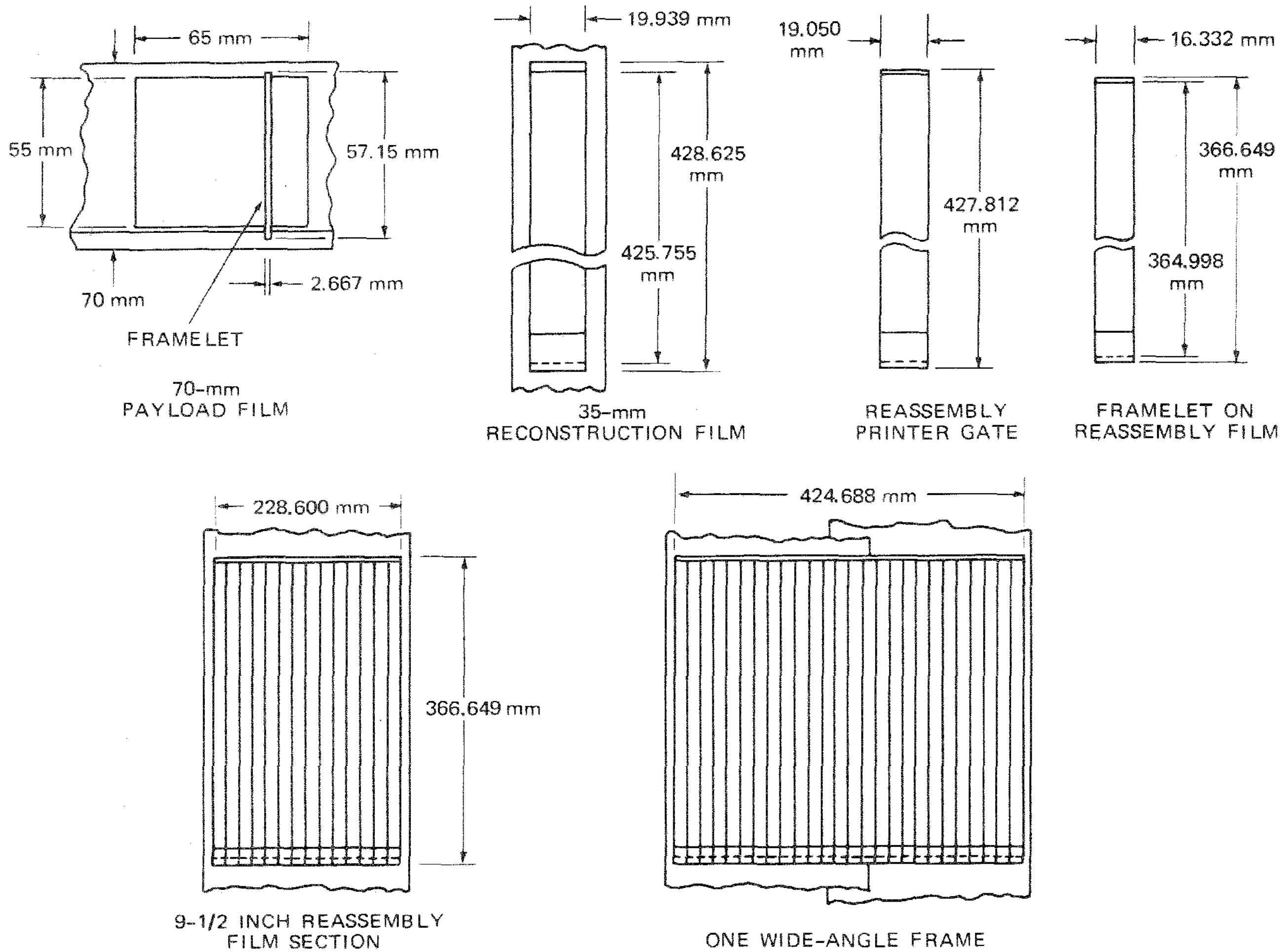


Figure 5—The 35-mm reconstructed record was reassembled on 9-1/2-in. film by photographic projection printing. The machine reassembly reduced the GRE film image by a factor of 0.89, and framelet reversal was corrected for proper orientation of high-resolution frames. Fourteen framelets were reassembled to complete one 9- x 14-in. subframe. Two framelets overlap the adjacent subframe. Approximately three subframes are required for a single medium-resolution photo and eight for each high-resolution photo.

Kodak Subframes

A subframe consists of framelets automatically reassembled side by side on 9-1/2-in. roll film. In the reassembly operation the Kodak Company took the original 35-mm framelet positives produced by the GRE and processed them using their reassembly printer. An approximately 9-1/2- X 18-in. film negative (termed a subframe) resulted from the reassembly operation. The 9-1/2- X 18-in. negative consists of a data block and the 9- X 14-in. photographic image. The data block includes the spacecraft exposure number, the readout sequence, time, and reassembly identification. Since the medium-resolution image is inverted on the spacecraft film, the reconstruction procedure corrects the photographic image but inverts the preprinted data block. Three subframes are normally required to complete a medium-resolution frame, and eight subframes are generally required to make a high-resolution frame. The Kodak reassembly printer repeated the last two framelets of the preceding subframe for registration purposes.

The Data Center can provide to the user positive or negative film copies or contact paper prints of the subframe.

Boeing Enhancements

The Boeing Company hand-reassembled second generation 35-mm paper framelets into a mosaic measuring 16- X 20-in. Third generation negative transparencies were then generated on 16- X 20-in. sheet film. These photographs have been photographically enhanced but not retouched. The purpose of enhancement was to minimize the joints between adjacent framelets and to reduce the systematic variations in light intensity caused by GRE.

In each of the Boeing prints, the northerly direction on the lunar surface is toward the printed title, which gives the frame number identification and resolution only. The Data Center can provide each high-resolution frame in this collection in two forms - a complete frame (of reduced image size) and the three component frames (labeled Part A, Part B, and Part C). The component frames contain overlapping images so that they may be assembled into a large complete high-resolution frame if desired. This format may be obtained in the form of negative or positive transparencies or contact paper prints.

AMS Full-Frame Format

The Army Map Service hand-reassembled the framelets from Missions II through V into mosaics of the high- and medium-resolution frames. Prints, measuring 20 X 24 in., were made from these mosaics. The actual exposed image on the prints measures approximately 15-1/2 X 20 in., not including the resolution charts appearing on each framelet. A complete MR frame appears on one print whereas three prints are necessary to show a complete HR frame.

Frame identification information appears on each print. The following numbered items are included: mission no., frame no., subframe no., site no., GRE no., and Kodak index (KI) no. Also appearing are the date and time of exposure, the date read out, the shutter speed, and the Army Map Service reassembly date.

NSSDC can provide fourth generation film or paper positives or fifth generation film negatives.

NASA LRC Enhancements

NASA's Langley Research Center prepared enhanced photographs from Lunar Orbiter video tapes by electronically preprocessing the video signal prior to input to the ground reconstruction electronics (GRE). Two enhancement procedures were used. One procedure involved varying the parameters of signal gain, gain function, and signal offset to optimize detail and contrast in the photographic data. The other involved an electronic mask to reduce the undesirable density gradients across the scan and framelet. It should be noted that both procedures required point by point exposure adjustments. The NASA LRC enhanced photographs are therefore not recommended for use in photometric analyses.

The enhanced photographs generated off the GRE were 35-mm positive transparencies. The positives were assembled into a 20- X 24-in. format and contact negatives were made. From these negatives, NSSDC can produce contact paper prints or film positive and negative transparencies for the user. Each LRC frame in the 20- X 24-in. format is identified by mission number, exposure number, and resolution (e.g., III $92H_1$ is Lunar Orbiter III high-resolution frame 92, part 1 of 3).

35-mm Microfilm Copies

The Data Center has microfilmed each usable Lunar Orbiter photograph onto five 100-ft reels of 35-mm film. The microfilm images were made by photographing prints generated from one of the following negatives:

1. AMS reassembled frames
2. Boeing enhancements
3. Kodak subframes (reassembled into full frames by NSSDC)

It is intended that these films be used as a tool in the selection of photographs for which high-quality reproductions can be processed. The quality of the films is also suitable for studies that involve only minimum precision. In addition, the films have been processed to allow for convenient mounting of individual frames as 35-mm slides for projection.

Photographic Support Data

Support data necessary for analysis of the photographs have been compiled by the Boeing Company. As requests for photographs are filled, the support data will be routinely provided. An example of this information is shown in figures 6a and 6b. (The information appearing on the support data printout is explained in the list of definitions on the following pages.) The complete set of support data is also available on five 7-track BCD magnetic tapes written at a density of 556 bpi.

With few exceptions, photo times, exact to 0.1 sec, were obtained from the timing lights exposed on the film. These times correspond to the actuation of the wide-angle shutter. The telephoto camera focal-plane shutter was actuated a nominal 0.040 sec earlier. When the actual exposure time was not available for a single photograph of a series, the exposure time

* PHOTO FRAME NUMBER 1 OF 20 *

FRAME 5

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	66	8	18	14	42	49.898

LONGITUDE OF NADIR POINT	= 84.5952988 DEG	LATITUDE OF NADIR POINT	= 1.6519452 DEG
LONG OF CAMERA AXIS INTERSECT	= 83.9766617 DEG	LATI OF CAMERA AXIS INTERSECT	= 1.8955593 DEG
SPACECRAFT RADIUS	= 1954.3430176 KM	SPACECRAFT ALTITUDE	= 216.2530212 KM
MEAN ALTITUDE RATE	= -0.0805724 KM/SEC	TIME FROM PERIAPSIS	= -211.9136925 SEC
HORIZONTAL VELOCITY	= 1.7993809 KM/SEC	TRUE ANOMALY	= 348.7552528 DEG
SCALE FACTOR (HIGH)	= 0.0028071 M/KM	TILT DISTANCE (HIGH)	= 56.8377981 MM
SCALE FACTOR (LOW)	= 0.0003681 M/KM	TILT DISTANCE (LOW)	= 7.4541374 MM
IMAGE MOTION COMPENSATION (V/H)	= 0.0082794 RAD/SEC	SWING ANGLE	= 99.1207190 DEG
EMISSION ANGLE	= 5.9878716 DEG	INCIDENCE ANGLE	= 68.4343653 DEG
PHASE ANGLE	= 62.9162402 DEG	NORTH DEVIATION ANGLE	= 347.7336998 DEG
TILT ANGLE	= 5.3232629 DEG	RESOLUTION CONSTANT	= 4.7155660 MTR
TILT AZIMUTH	= 291.5127907 DEG	SUN AZIMUTH AT PRINCIPAL GND PT	= 89.1509657 DEG
SUN ANGLE AT NADIR	= 67.8198824 DEG	SUN ARC AT NADIR	= 2057.3428040 KM
LONGITUDE DISTANCE TO TARGET	= -5.4047012 DEG	LATITUDE DISTANCE TO TARGET	= 1.6519452 DEG
LONGITUDE ARC LENGTH TO TARGET	= -163.9537373 KM	LATITUDE ARC LENGTH TO TARGET	= 50.1124086 KM
FORWARD OVERLAP RATIO	= 0. PCT	SIDE OVERLAP RATIO	= 0. PCT
TIME BETWEEN PHOTOS	= 0. SEC	ALPHA	= 5.4986684 DEG.

	X	Y	Z	MAGNITUDE (KM)
DIRECTION COSINES TO TARGET	-0.65144847	-0.73200285	-0.19946612	282.45207214
CAMERA AXIS	-0.00791006	-0.99995466	0.00530328	217.30718994
C1	-0.08918412	-0.98173485	0.16805620	221.10375977
C2	-0.01306745	-0.98416574	-0.17676829	219.78836060
C3	0.07362837	-0.98475005	-0.15762683	221.85581970
C4	-0.00248828	-0.98231915	0.18719751	223.19783020

	X	Y	Z	X DOT	Y DOT	Z DOT
STATE VECTOR (1950.0)	436.4858017	1734.3542023	788.0052795	-1.7226679	0.4592629	-0.2564327

LOW RESOLUTION

LONG 86.9780 DEG LATI 4.1855 DEG		LONG 85.7167 DEG LATI -1.3976 DEG	
* (1)	173.55506 KM	* (2)	
154.43155 KM		152.23408 KM	
(4) *	186.90433 KM	(3) *	
LONG 82.0407 DEG LATI 5.5012 DEG		LONG 80.7713 DEG LATI -0.5313 DEG	

HIGH RESOLUTION

LONG 84.5684 DEG LATI 3.0836 DEG		LONG 84.0179 DEG LATI 0.5765 DEG	
* (1)	77.85775 KM	* (2)	
19.83445 KM		19.71434 KM	
(4) *	78.59284 KM	(3) *	
LONG 83.9317 DEG LATI 3.2363 DEG		LONG 83.3807 DEG LATI 0.7044 DEG	

Figure 6a—Sample of Photographic Support Data

LOW RESOLUTION 5

INDEX	LONGITUDE	LATITUDE
1	86.9780455	4.1855100
2	86.8435068	3.6244842
3	86.7182198	3.0950660
4	86.5998764	2.5886792
5	86.4866037	2.0981316
6	86.3768187	1.6171070
7	86.2691240	1.1397997
8	86.1622286	0.6605971
9	86.0548763	0.1737873
10	85.9457836	-0.3267392
11	85.8335714	-0.8478348
12	85.7166796	-1.3975532
13	85.2707443	-1.3116191
14	84.8360167	-1.2293282
15	84.4083824	-1.1498137
16	83.9840097	-1.0723124
17	83.5591898	-0.9961344
18	83.1302004	-0.9206378
19	82.6931553	-0.8452043
20	82.2438545	-0.7692133
21	81.7775879	-0.6920254
22	81.2889004	-0.6129591
23	80.7712736	-0.5312581
24	80.9106913	0.0586619
25	81.0397377	0.6180544
26	81.1609154	1.1557397
27	81.2762270	1.6792233
28	81.3873386	2.1952083
29	81.4956942	2.7099817
30	81.6025963	3.2297659
31	81.7092829	3.7610530
32	81.8169851	4.3109660
33	81.9269915	4.8877217
34	82.0407152	5.5012255
35	82.5551901	5.3554496
36	83.0412931	5.2195485
37	83.5054855	5.0914457
38	83.9531813	4.9694475
39	84.3890629	4.8521373
40	84.8173170	4.7382985
41	85.2418289	4.6268460
42	85.6663351	4.5167826
43	86.0945702	4.4071641
44	86.5304136	4.2970580

HIGH RESOLUTION 5

INDEX	LONGITUDE	LATITUDE
1	84.5684233	3.0836127
2	84.5173025	2.8499792
3	84.4667883	2.6192648
4	84.4167442	2.3908436
5	84.3670359	2.1641172
6	84.3175392	1.9385067
7	84.2681236	1.7134409
8	84.2186680	1.4883597
9	84.1690454	1.2627013
10	84.1191292	1.0358946
11	84.0687885	0.8073599
12	84.0178890	0.5764987
13	83.9604273	0.5880972
14	83.9029007	0.5996966
15	83.8453007	0.6112994
16	83.7876167	0.6229073
17	83.7298393	0.6345211
18	83.6719608	0.6461444
19	83.6139688	0.6577762
20	83.5558558	0.6694217
21	83.4976101	0.6810800
22	83.4392242	0.6927562
23	83.3806868	0.7044486
24	83.4321203	0.9374793
25	83.4828901	1.1681749
26	83.5331345	1.3971450
27	83.5829878	1.6249762
28	83.6325788	1.8522423
29	83.6820354	2.0795168
30	83.7314816	2.3073676
31	83.7810411	2.5363711
32	83.8308420	2.7671145
33	83.8810120	3.0002058
34	83.9316864	3.2362819
35	83.9901657	3.2222091
36	84.0484962	3.2081808
37	84.1066885	3.1941977
38	84.1647530	3.1802556
39	84.2226982	3.1663510
40	84.2805347	3.1524840
41	84.3382730	3.1386512
42	84.3959208	3.1248491
43	84.4534893	3.1110777
44	84.5109873	3.0973328

Figure 6b—Sample of Photographic Support Data (44 Points)

was biased from the commanded time of the exposure by a value determined from a comparison of actual and commanded times for the remaining frames in the sequence. For those cases where the exposure time for the complete sequence was not available, the command times were adjusted by a comparison of actual and commanded exposure times of other sequences.

Planetary data influencing the trajectory of the spacecraft were taken from ephemeris data on magnetic tape provided by the Jet Propulsion Laboratory. It contains the most recent established positions and velocities of the sun, planets, and the moon. These include refined estimates of the planetary gravitational relationships and Eckert's corrections to the lunar ephemeris.

Scale corrections were applied to the lunar ephemeris by using new values of the radius of the earth, sine parallax, and the gravitational constants of the earth and the moon. These new values satisfied the earth-moon constraint equation relating the gravitational constants of each body.

The lunar gravitational field is represented by an expansion of spherical harmonics. The harmonic coefficients were obtained from NASA LRC and are referred to as the LRC 11/11 harmonics.

The spacecraft constants are determined and supplied by the Lunar Orbiter preflight test and checkout results.

The photo supporting data are accurate only to the extent that the input data are error free and the assumptions made in the computations are valid. For each Lunar Orbiter mission, the preflight error analysis document* describes the execution and operational errors; the computational assumptions are detailed in the appropriate documentation of the Lunar Orbiter flight path analysis and command software system. A significant assumption in these computations is that the moon is a perfect sphere of radius 1736 km.

A meaningful error analysis of the parameters listed cannot be made because of the numerous uncertainties present. However, the following sources of error are recognized:

State Vector—Errors due to noise, station location uncertainties, frequency and time biases, lunar model uncertainty, planetary ephemeris uncertainties, and effect of spacecraft attitude maneuvers on the raw tracking data.

Spacecraft Attitude—Errors due to the difference between the commanded and actual angles due to spacecraft dynamics and drift rates and the flight control limit cycle dead band of $+0.2°$.

Camera Pointing—In conjunction with the above areas, some uncertainty exists due to alignment tolerances of camera axes, sun and Canopus sensor locations, and other spacecraft constants.

*See "Mission Error Analyses" in Bibliography.

Camera-On Time—Errors due to correlation between the spacecraft clock and GMT, spacecraft clock drift, and the 0.1-sec clock interval.

Computational Noise—Errors from computational roundoff and truncation errors.

Footprint Locations—Errors due to the assumed spherical moon, the uncertainty of the actual V/H value controlling exposure, lens distortion, and the accumulative effect of all of the above sources.

Definition of Evaluation Program Output (EVAL)

The following are definitions of the parameters included in the photographic support data supplied to the users. Refer to figures 7 and 8 for a graphic display of the definitions.

Alpha—Angle that is the projection of surface normal into phase angle plane; it represents tilt of the surface toward or away from sun.

Camera Axis (slant distance)—Direction cosines and magnitude (selenographic of date) of camera axis at time of photo.

C1, C2, C3, C4—Direction cosines and magnitude (selenographic of date) of vectors from spacecraft to photo corners.

Direction Cosines to Target—Direction cosines and magnitude (selenographic of date) of vector from spacecraft to point targets.

Emission Angle—Angle between surface normal and camera axis. Also angle between photo image plane and subject plane.

Forward Overlap Ratio—Ratio of amount of overlap to telephoto frame dimension along direction of flight path.

Horizontal Velocity—That component of spacecraft velocity perpendicular to the radial line through spacecraft and in direction of flight path.

Image Motion Compensation (V/H)—Instantaneous rate of movement of image across focal plane; a function of spacecraft velocity, its height above surface (V/H ratio), and lens focal length.

Incidence Angle—Angle between surface normal and sun's rays.

Longitude (latitude) Arc Length to Target—Arc distance measured on lunar surface between meridian (parallel) through spacecraft nadir and meridian (parallel) through target (plus is east longitude or north latitude).

Longitude (latitude) of Camera Axis Intersect—Selenographic longitude (latitude) of point on lunar surface intersected by camera axis (plus is east longitude or north latitude).

Longitude (latitude) of Nadir Point—Selenographic longitude (latitude) of point on lunar surface directly below spacecraft.

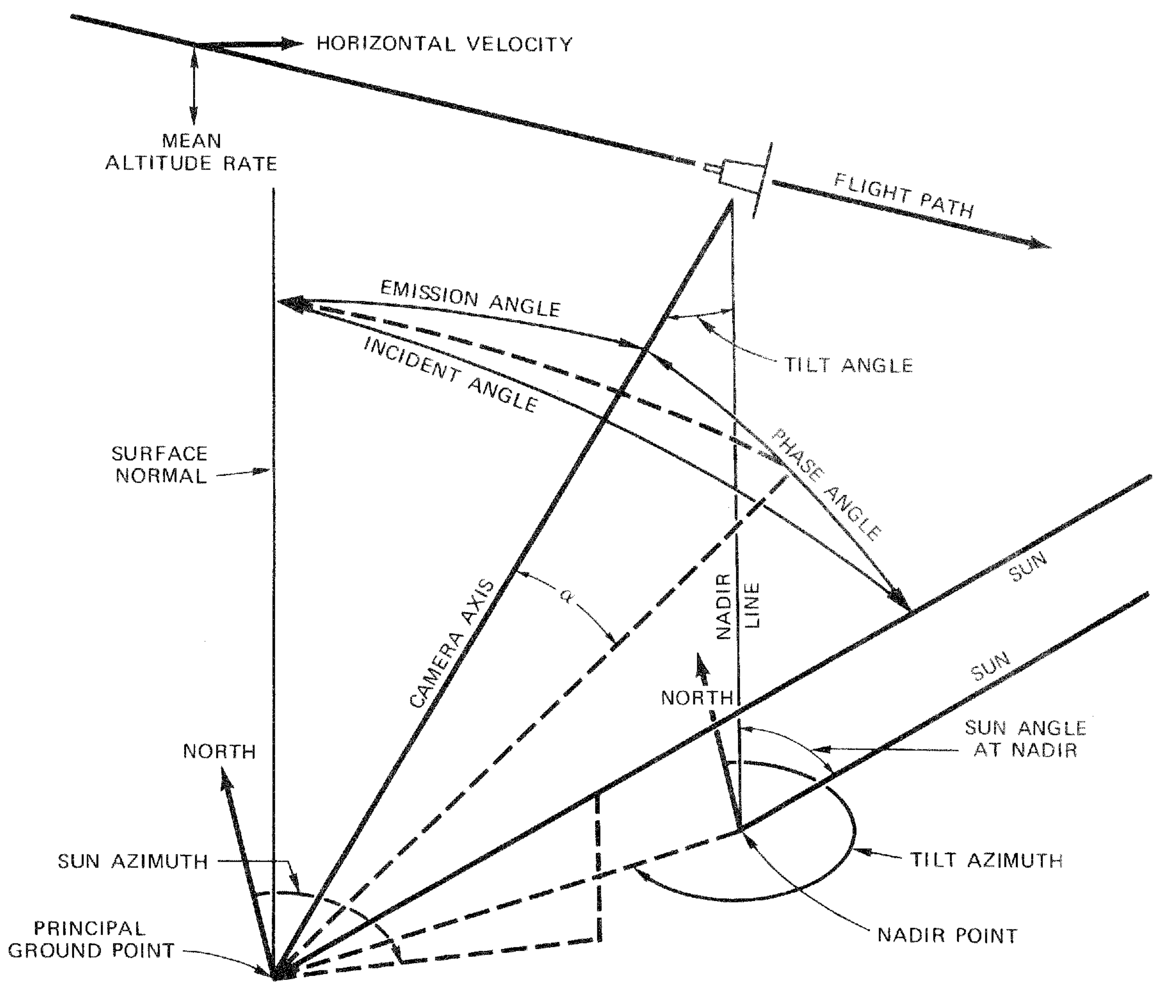


Figure 7—Geometry of Photographic Parameters

Mean Altitude Rate—Rate of change of altitude with respect to time.

Nadir—Intersection of a line between the spacecraft and the center of the moon with the lunar surface.

North Deviation Angle—Deviation of north from cross frame (cross) film axis (Y-axis) measured clockwise.

Phase Angle—Angle between camera axis and sun's rays.

Principal Ground Point—Intersection of camera axis with lunar surface.

Resolution Constant—Theoretical ground resolution of telephoto photographs. Wide-angle-lens resolution is larger by a factor of 8. Resolution constant is equal to actual altitude in ı divided by 46 (nominal altitude giving 1-meter resolution on telephoto photographs).

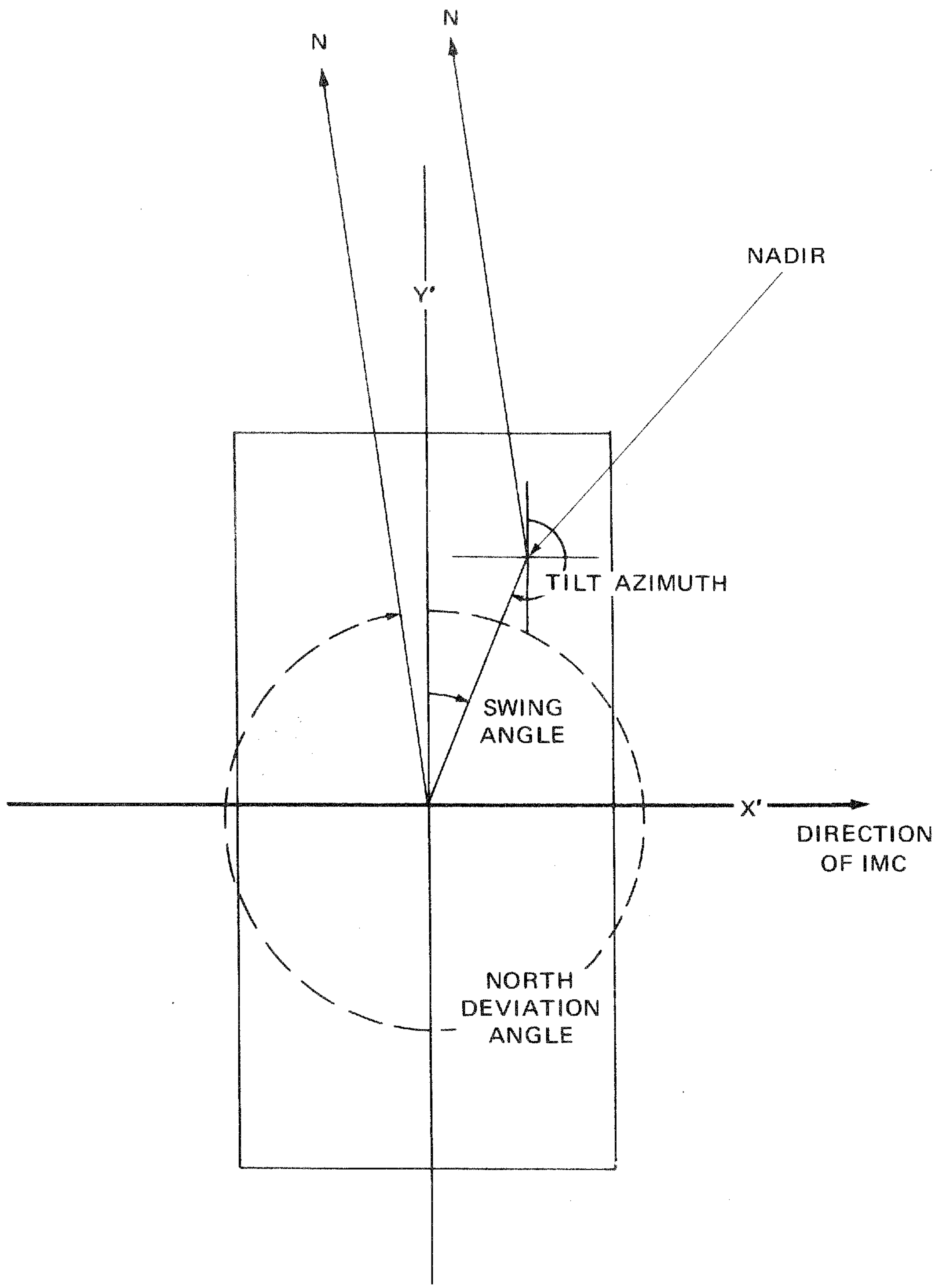


Figure 8—Camera Film Geometry

Scale Factor—Proportionality constant to relate dimensions on spacecraft film to dimensions on lunar surface (focal length/altitude). Given for both 80- and 610-mm camera systems.

Side Overlap Ratio—Ratio of amount of overlap to frame dimension perpendicular to flight path (e.g., on adjacent orbits).

Spacecraft Altitude—Altitude of spacecraft above moon surface.

Spacecraft Radius—Distance from the spacecraft to moon center.

State Vector—Spacecraft position and velocity components in selenocentric 1950.0 coordinates.

Sun Angle at Nadir—Angle between spacecraft/nadir line and sun's rays.

Sun Arc at Nadir—Arc length from nadir point to intersection on lunar surface of moon center to sun centerline.

Sun Azimuth at Principal Ground Point—Azimuth of sun's rays at camera axis intersection, measured clockwise from north.

Surface Normal—Line normal to lunar surface at point of camera axis intersection.

Swing Angle—Angle between cross-axis of film frame (the Y axis) and line from center of frame to image of nadir point. Measured positive clockwise from positive Y axis.

Tilt Angle—Angle between camera axis and spacecraft/nadir line.

Tilt Azimuth—Azimuth of principal ground point from spacecraft nadir.

Tilt Distance—Distance from image of camera axis intersect to image of nadir point measured on spacecraft film. Given for both high- and medium-resolution frames. Computed at the scale of the spacecraft film.

Time between Photos—Predicted time between exposure of current frame and preceding frame taken in film sequence based on V/H at time of current frame.

Time from Periapsis—Time in seconds before (minus) or after (plus) periapsis passage.

True Anomaly—Angle in orbital plane measured from periapsis to spacecraft in direction of motion.

Photo Footprint—Numbered asterisks that appear on printout which represent four corners of photo frames as projected on lunar surface. Adjacent to each asterisk is longitude and latitude of that corner of footprint; between asterisks is surface distance in kilometers between those corners. For those exposures where a corner of the photo is off the surface of the moon, the corner coordinate is indicated by zeros and a notation is provided in the printout data.

44 Points (figure 6b)—A listing of the latitude and longitude of 44 equally spaced angles along the photo periphery. Points 1, 12, 23, and 34 correspond to the four corners of the photo. In those cases where a point falls off the surface of the moon, the coordinate values are indicated as zero. These points are given for both the HR and MR photos.

PHOTOGRAPHIC COVERAGE AND QUALITY

Significant orbital parameters and dates covering the five Lunar Orbiter photographic missions are listed in figure 9. Wherever possible, the orbital parameters given are those attained during the initial orbit of an ellipse.

Whereas all five missions were considered highly successful, certain problems encountered by the spacecraft did affect photographic quality. The nature and extent of specific problems affecting photography are briefly discussed in the following paragraph. A number of frames were underexposed or overexposed because variations in topography and albedo conditions were not within the luminance capability of the system. A qualitative evaluation of the individual frames for all missions is tabulated in the tables beginning on page 23.

In Orbiter I the focal-plane shutter on the high-resolution complement of the camera failed to trip properly. As a result, only 13 HR frames are useful. The communications subsystem malfunctioned in Orbiter II during the readout. This reduced the number of photographs that could be read out to 208 MR and 204 HR frames. Occasional blemish characteristics, such as processor stain and pull-off lines, are also present in the photographs. A malfunction occurred in the Lunar Orbiter III spacecraft film-advance mechanism. As a result, only 156 MR and 137 HR frames were completely read out. Thirty-six HR frames and three MR frames were partially read out, and underexposure was common in the first six primary sites. The systematic blemish characteristics occur also in Mission III. A total of 199 photographs were exposed in Orbiter IV, and 196 were read out. The reduced number of photos read out resulted from readout looper failure during normal processing. The Bimat thereby had to be cut early. All systems functioned properly during the Lunar Orbiter V mission. Bubbles or streaking across the film appear in some frames as a result of Bimat processing errors.

Included with this *Data Users' Note* is an insert which contains 13 Lunar Orbiter Photo Index Maps. The maps provide a convenient index to the photographic coverage of the five Lunar Orbiter missions. The colored demarcations identify the areas of photographic coverage and the photographic sites. One site may be composed of several exposures as indicated to the right of the maps of individual missions.

Tables in the appendix categorize each frame according to the area covered, the quality, and the availability. The tables may be used in conjunction with the index maps and with the 35-mm microfilm copies (see page 9) as an aid to the selection and analysis of the photographs.

ORDERING PROCEDURES

For evaluation of the coverage and quality of individual exposures, the Data Center recommends that the user order the 35-mm microfilms as preliminary data. From these the requester can select the desired exposure and ask for the highest quality print available. The LRC enhancements will be the usual format provided unless the requester specifies otherwise. The film transparency formats will be provided only for detailed scientific studies.

Mission	I	II	III	IV	V
First Ellipse	8/14/66	11/10/66	2/8/67	5/8/67	8/5/67
Apolune	1850 km	1871 km	1802 km	6110 km	6050 km
Perilune	199 km	196 km	210 km	2700 km	202 km
Inclination	12.1°	12°	21°	85°	85°
Frames	1-42	None	None	All frames	5-22
Second Ellipse	8/21/66	11/16/66	2/12/67	–	8/7/67
Apolune	1853 km	1848 km	1847 km	–	6067 km
Perilune	57.9 km	48 km	55 km	–	100 km
Inclination	12.3°	12.2°	20.9°	–	85°
Frames	43-133	All frames	All frames		24-30
Third Ellipse	8/26/66	–	–	–	8/9/67
Apolune	1856.7 km	–	–	–	1498 km
Perilune	40.5 km	–	–	–	100 km
Inclination	12.0°	–	–	–	85°
Frames	134-215				31-216
Start of Photography	8/18/66	11/18/66	2/15/67	5/10/67	8/6/67
End of Photography	8/29/66	11/25/66	2/23/67	5/13/67	8/19/67

Figure 9—Orbital Parameters

The user should clearly specify what form of data he requires and the types of features he is studying, e.g., rilles, crater walls, bright-rimmed craters. NSSDC can then provide the most useful form or selection of data. The NSSDC 35-mm microfilms are on roll film and all photographs from each mission appear on one roll of film. As stated before, the usual request will call for the best available print for desired frames. Complete identification would include the following:

1. Format of data

   –NSSDC 35-mm microfilms

   –Best available print

   –35-mm framelet

   –Kodak subframes

   –AMS full-frames

   –Boeing enhancements

   –NASA LRC enhancements

2. Form of reproduction (one of the following)

   –Positive print

   –Positive transparency

   –Negative transparency

   –Enlargements of specific area of framelet (print or transparency)

3. Identification of each picture

   –Mission number (I, II, III, IV, or V)

   –Frame number (beginning at arabic numeral 5 up to 217)

   –Lens resolution (M-medium resolution, H-high resolution). For HR frames identify the component part, e.g., 1 of 3, 2 of 3, 3 of 3, where known.

4. Source used for identifying frames if other than this document

5. A brief description of the intended use of these photographs (See Foreword.)

The photographic support data will be routinely provided with all pictures sent out. The support data sent out will normally be Xerox copies in the form shown in figures 6a and 6b; if complete sets of photographs are ordered, the full set of support data will be supplied.

Inquiries or requests from U.S. scientists should be addressed to:

Data Services Branch
National Space Science Data Center
Goddard Space Flight Center
Code 601.4
Greenbelt, Maryland 20771

Telephone: (301) 982-6695

All requests from scientists outside the United States are handled by the World Data Center A for Rockets and Satellites. Now located contiguous to the National Space Science Data Center, WDC-A for Rockets and Satellites can assist scientists in acquiring data from U.S. national archives. Requests should be directed to:

World Data Center A for Rockets and Satellites
Goddard Space Flight Center
Code 601
Greenbelt, Maryland, U.S.A. 20771

Many general-interest requests may be satisfied with materials already available in printed form. Requests of this type should be addressed to:

Office of Public Affairs
Goddard Space Flight Center
Code 202
Greenbelt, Maryland 20771

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NOTE

A more complete Lunar bibliography is under preparation at NSSDC. Any requester having need for analytical papers or papers on specific studies may inquire about such a bibliography.

APPENDIX - QUALITY TABLES

Table 1
Lunar Orbiter Sites for Missions I, II, III, and V

Key to Abbreviations

f,s: frame repetition rate (preceded by the number of exposures taken)
- f - fast rate, 88% forward overlap
- s - slow rate, 55% forward overlap

nv: near vertical

* partial coverage lost due to photo system malfunction

cts: convergent telephoto stereo
co: conventional oblique
wo: west oblique (astronaut's view)

** repetitious exposures

Site Identification
- a. I, II, III, V - mission numbers
- b. P, S, or A - primary, secondary, or alternate sites
- c. Arabic number in site ID - site number
- d. a, b, or c - additional passes over site
- e. Arabic numbers 5-217 - exposure numbers

Notes: All missions have identical exposure numbering systems. The appropriate mission number must therefore accompany the exposure number for positive identification. Mission I high-resolution frames are useful only where noted.

Site	Exposure Number(s)	Photo Mode	Location
IP-1	52-67	16 f, nv	Western Fecunditatis and Central Highlands
IP-2	68-83	16 f, nv	Highlands bordering SE Tranquillitatis
IP-3	85-100	16 f, nv	SW Mare Tranquillitatis
IP-4	105-112	8 s, nv	Central Highlands
IP-5	118-133	16 f, nv	SW Sinus Medii
IP-6	141-148	8 s, nv	Northern Central Highlands
IP-7	157-172	16 f, nv	Mare area between Lansberg and Fra Mauro
IP-8.1	176-183	8 f, nv	SW Oceanus Procellarum
IP-9.2a	184-199	16 f, nv	N of Flamsteed and SW of
IP-9.2b	200-215	16 f, nv	Kepler
IIP-1*	5-20	16 f, nv	In SE Mare Tranquillitatis
IIP-2	35-42	8 f, nv	In SE Mare Tranquillitatis
IIP-3a	43-50	8 f, nv	S of Arago; E of Manners; in
IIP-3b	51-58	8 f, nv	SW Mare Tranquillitatis
IIP-4	59-66	8 f, nv	NE Central Highlands; S of Ariadaeus Rille
IIP-5	67-74	8 f, nv	SW Mare Tranquillitatis
IIP-6a	76-83	8 f, nv	SW Tranquillitatis; E of Sabine;
IIP-6b	84-91	8 f, nv	SW of Maskelyne
IIP-7a	96-103	8 f, nv	NW Sinus Medii; S of Pallas
IIP-7b	104-111	8 f, nv	

Table 1 (continued)

Site	Exposure Number(s)	Photo Mode	Location
IIP-8a	113-120	8 f, nv	SW Sinus Medii; approximately
IIP-8b	121-128	8 f, nv	one degree west of (0, 0)
IIP-8c	129-136	8 f, nv	
IIP-9	138-145	8 f, nv	Intermaria lowlands of Sinus Aestuum
IIP-10a	146-153	8 f, nv	SE Oceanus Procellarum
IIP-10b	154-161	8 f, nv	
IIP-11a	163-170	8 f, nv	Due S of Copernicus in an
IIP-11b	171-178	8 f, nv	interray area
IIP-12a	179-186	8 f, nv	SE Oceanus Procellarum
IIP-12b	187-194	8 f, nv	
IIP-13a	197-204	8 f, nv	SE Oceanus Procellarum; SW of
IIP-13b	205-212	8 f, nv	Kepler; NNE of Flamsteed
IIIP-1*	5-20	16 f, nv	SE Mare Tranquillitatis
IIIP-2a*	25-32	8 f, nv	Western Mare Fecunditatis and
IIIP-2b*	33-36	4 f, cts	Eastern Central Highlands
IIIP-3*	40-43	4 s, nv	
IIIP-4*	44-51	8 f, nv	
IIIP-5a*	52-59	8 f, cts	SW Tranquillitatis; E of Sabine
IIIP-5b*	60-67	8 f, nv	and SW of Maskelyne
IIIP-6*	68-71	4 s, nv	SW Mare Tranquillitatis
IIIP-7a	86-93	8 f, cts	West Central Sinus Medii
IIIP-7b	94-101	8 f, nv	
IIIP-8	124-131	8 f, nv	S of Copernicus in an interray area
IIIP-9a	137-144	8 f, cts	Lowland between Mare Cognitum
IIIP-9b	145-152	8 f, nv	and Oceanus Procellarum
IIIP-9c	153-160	8 f, nv	
IIIP-10	163-170	8 f, cts	SW of Kepler in SE Procellarum
IIIP-11	173-180	8 f, nv	S of Kepler and Encke in SE Procellarum
IIIP-12b.2	181-184	4 f, nv	N of Flamsteed and SW of Kepler
IIIP-12a	185-200	16 f, nv	
IIIP-12b.1	201-204	4 f, nv	
IIIP-12c	205-212	8 f, cts	
V-1	33-36	4 f, nv	Petavius
V-2.1	37	nv	Petavius B
V-3.1	38	wo	View of Apollo site IP-1
V-4	40	nv	Stevinus A
V-5.1	41	co	Messier
V-6	42	wo	View of Apollo site IP-1
V-8a	44-47	4 f, cts	Apollo site IP-1
V-8b	48-51	4 f, cts	
V-9.1	52	wo	View of Apollo site IIP-2
V-10	54	co	Altai Scarp
V-11a	55-58	4 f, cts	Apollo site IIP-2
V-11b	59-62	4 f, cts	

Table 1 (continued)

Site	Exposure Number(s)	Photo Mode	Location
V-12	63	nv	Censorius
V-13	64	wo	View of Apollo site IIP-6
V-14	66-69	4 f, nv	Littrow
V-15.1	70	nv	Dawes
V-16a	71-74	4 f, cts	Apollo site IIP-6
V-16b	75-78	4 f, cts	
V-18	80-83	4 f, nv	Dionysius
V-19	84	nv	Abulfeda
V-21	86-89	4 f, nv	S of Alexander
V-22	90-93	4 f, nv	Sulpicius Gallas Rilles
V-23.2	94-97	4 f, nv	Hyginus Rilles
V-24	98-101	4 f, nv	Hipparchus
V-25	102	co	Alpine Valley
V-26.1	104-107	4 s, nv	Hadley Rille
V-27a	108-111	4 f, cts	Apollo site IIP-8
V-27b	112-115	4 f, cts	
V-28	116-119	4 f, nv	Alphonsus
V-29	120-123	4 f, nv	Rima Bode II
V-30	125-128	4 f, nv	Tycho
V-31	129-132	4 f, nv	Rille E of Plato
V-32	133-136	4 s, nv	Eratosthenes
V-33	137	nv	Copernicus CD
V-34	138-141	4 f, nv	Fra Mauro
V-35	142-145	4 s, nv	Copernicus Secondaries
V-36	146-149	4 f, nv	Copernicus H
V-37	150-157	8 f, nv	Copernicus
V-38	159-162	4 f, nv	Imbrian Flows
V-40	164-167	4 f, nv	Tobias Mayer Dome
V-41	168	nv	Vitello
V-42a	169-172	4 f, cts	Apollo site IIIP-11
V-42b	173-176	4 f, cts	
V-43.2	177-180	4 f, nv	Gassendi
V-45.1	182-185	4 f, nv	Jura Domes
V-46	186-193	8 f, nv	Harbinger Mountains
V-48	194-201	8 f, nv	Aristarchus
V-49	202-205	4 f, nv	Cobra Head
V-50	206-209	4 f, nv	Aristarchus
V-51*	210-217	8 f, nv	Marius Hills
IS-1	5-24	16 f, nv; 4 f, nv	
IS-2	25-27		I-26 and 27 H are useful
IS-3	28,30,35-40		Farside (west): I-30,36,38, and 40 H are useful
IS-4	29,33,34		IS-29 H is useful

Table 1 (continued)

Site	Exposure Number(s)	Photo Mode	Location
IS-5	31,32,44		I-31 H is useful
IS-6	41,50,51		I-41 H is useful
IS-7	42,46-49		I-42 H is useful; SE Tranquillitatis
IS-8	84		Dionysius
IS-9	102,115-117,136		Farside (east); I-102,115,117 and 136 H are useful; 102 and 117 earth-moon
	102 and 117	co	
IS-10	103		
IS-12	113,114		
IS-13	134,135		Gambart
IS-14	137,139,140		
IS-15	138		
IS-16	149,151		Grooves and chains radial to Copernicus
IS-17	150		
IS-18	153-156		
IS-19	173		
IS-20	174		
IS-21	175		
IIS-1	21-24	4 f, cts	
IIS-2a	25-28	4 f, cts	
IIS-2b	29-32	4 f, cts	
IIS-3	33	nv	Farside
IIS-4	34	co	Farside (north)
IIS-5	75	co	Farside (south)
IIS-6	92		
IIS-7	93	wo	Sinus Medii
IIS-8	94		
IIS-9	95		
IIS-10.2	112		
IIS-11	137		
IIS-12	162	co	Copernicus
IIS-13	195		
IIS-14	196		Farside
IIS-15	213	co	Marius
IIS-16	214		
IIS-17	215	co	Reiner Gamma
IIIS-1*	21-24	4 f, nv	Messier and Messier A
IIIS-2*	37	co	Near zero phase (farside)
IIIS-5*	72	co	Moltke
IIIS-6*	73	co	Rima Hyginus
IIIS-7*	74-77	4 s, nv	Vicinity of Dembowski
IIIS-8*	78	co	Theophilus
IIIS-9	79	co	Delambre
IIIS-10	80-83	4 s, nv	

Table 1 (continued)

Site	Exposure Number(s)	Photo Mode	Location	
IIIS-11	84	wo	View of Apollo site IIIP-7	
IIIS-13	85	co	Murchison and Pallas	
IIIS-14	102	co		
IIIS-15	103-106	4 s, nv	N of Mösting, near Schröter	
IIIS-16	107	nv	Mösting	
IIIS-17	108-111	4 s, nv	Floor of Hipparchus	
IIIS-18	112-115	4 s, nv	Mösting C	
IIIS-19	116-119	4 s, nv	Flammarion	
IIIS-21	120	wo	View of Apollo site IIIP-8	
IIIS-21.5	121	co	Farside	
IIIS-22	122	nv	S of Copernicus; SE of Reinhold	
IIIS-20	123	co	Hortensius Domes	
IIIS-23	132-135	4 s, nv	Fra Mauro formation	
IIIS-24	136	wo	View of Apollo site IIIP-9	
IIIS-25	161	wo	View of Apollo site IIIP-10	
IIIS-26	162	co	Kepler	
IIIS-27	171	wo	View of Apollo site IIIP-11	
IIIS-28	172	wo	View of Apollo site IIIP-12	
IIIS-29	213	co	Damoiseau	
IIIS-30	214	co	Cavalerius; Luna 9 area	
IIIS-31	215	nv	Floor of Helvelius	
VA-1**	5-12		Principal Ground Pt deg:	110 W, 69 N
VA-2**	13-20		(in selenographic	103 W, 13 N
VA-3	21		coordinates)	179 W, 84 S
VA-4	22			115 W, 27 S
VA-6	24			119 W, 26 N
VA-7.1	25			128 W, 59 N
VA-8	26			127 W, 27 S
VA-10	28			132 W, 26 N
VA-11.2	29			145 W, 59 N
VA-12	30			140 W, 26 S
VA-13	31			135 W, 28 N
VA-14	32			138 W, 25 N
VA-15	39			158 W, 38 N
VA-16.1	43			151 W, 48 S
VA-17.1	53			175 W, 49 N
VA-18	65			170 W, 47 S

Table 1 (continued)

Site	Exposure Number(s)	Photo Mode	Location
VA-19	79		Principal Ground Pt, deg: (in selenographic coordinates) 168 E, 39 N
VA-20	85		160 E, 39 N
VA-21	103		152 E, 39 N
VA-22	124		144 E, 39 N
VA-23	158		128 E, 38 N
VA-24	163		122 E, 38 N
VA-25	181		110 E, 42 N
IS-3	102,117		Photographs of the earth taken from the vicinity of the moon. Site IS-3 photographs include the eastern limb of the moon's farside
VA-9	27		

Table 2
Lunar Orbiter IV Exposures

(1)	(2)	S	A	B	C	D	N	F	G	H
(3)		S	A	B	C	D	N	F	G	H
(4)		-72	-42	-14	+14	+42	+72	0	Apolune +33	-33
6	88	5-8	7-12	13-16	17-20	21-24		25		
7	82		26	27	28	29	30			
8	75	32	33	34	35	36				
9	69		38	39	40	41	42			
10	62	44	45	46	47	48		51		
11	55		52	53	54	55	56			
12	49	58	59	60	61	62				
13	42		64	65	66	67	68			
14	35	70	71	72	73	74		75		
15	29		76	77	78	79	80			
16	22	82	83	84	85	86				
17	15		88	89	90	91	92			
18	8	94	95	96	97	98		99		
19	2		100	101	102	103	104			
20	-4	106	107	108	109	110				

(1) Orbit number
(2) Approximate perilune long., deg.
(3) Latitude band*
(4) Approximate lat., deg.

*A - South temperate; B - South equatorial; C - North equatorial; D - North temperate; S - South polar; N - North polar; F - Film-set (including farside and blanks); G - Recovery north; H - Recovery south.

Table 2 (continued)

Orbit number	Approximate perilune long., deg.	S -72	A -42	B -14	C +14	D +42	N +72	F 0	G (Apolune) +33	H (Apolune) -33
21	-11		112	113	114	115	116			
22	-17	118	119	120	121	122		123		
23	-25		124	125	126	127	128			
24	-30	130	131	132	133	134				
25	-37		136	137	138	139	140			
26	-43		142	143	144	145		146, 147		
27	-51		148	149	150	151	152			
28	-56	154	155	156	157	158				
29	-64		160	161	162	163	164		165	
30	-71	166	167	168	169	170				
31	-77		172	173	174	175	176		177	
32	-83	179	180	181	182	183				178
33	-90		186	187	188	189	190		191, 192	184, 185
34	-96	193	194	195	196					

1 Orbit number
2 Approximate perilune long., deg.
3 Latitude band*
4 Approximate lat., deg.

* A - South temperate; B - South equatorial; C - North equatorial; D - North temperate; S - South polar; N - North polar; F - Film-set (including farside and blanks); G - Recovery north; H - Recovery south.

Table 3
Quality of Individual Frames
(A Categorization of Degradations in and Availability* of Lunar Orbiter Photographs)

Mission	Category	Exposure Number(s)
I		All exposure numbers: 5-215
M Frames	A	5-42, 44, 46-100, 102, 103, 105-151, 153-215
	G	43, 45, 101, 104, 152
H Frames	A	26, 27, 29, 30, 31, 36, 38, 102, 115, 117, 136
	C	5 (double exposure), 40 (portion smeared)
	E	Frames which are significantly smeared: 6-25, 28, 32-35, 37, 39, 41, 42, 44, 46-100, 103, 104, 106, 108-135, 137-151, 153-215
	G	43, 45, 101, 152
II		All exposure numbers: 5-215
M Frames	A	5, 7, 9, 11-167, 169-215
	B	168
	H	6, 8, 10
H Frames	A	13-168, 170-215
	B	6-11, 169
	H	5, 12

Categories

Percent of Frame Read Out	Nondegraded Frame	Slightly Degraded Frame	Significantly Degraded Frame
100	A	C	E
>0,<100	B	D	F

G: no exposure, H: no readout

*Enhancements are available for Categories A, B, C, D. Exceptions are IV-23H, IV-99H, IV-25M, IV-75M, and IV-42M.

Table 3 (continued)

Mission	Category	Exposure Number(s)
III		All exposure numbers: 5-215
M Frames	A	5, 9, 11, 13, 15, 17, 19, 25, 31, 33, 63, 66, 68, 78-215
	B	50, 53, 58, 60, 70, 73
	H	6-8, 10, 12, 14, 16, 18, 20-24, 26-30, 32, 34-49, 51, 52, 54-57, 59, 61, 62, 64, 65, 67, 69, 71, 72, 74-77
H Frames	A	79-215
	B	6, 10, 12-21, 26, 27, 32-35, 37, 40, 42, 44, 46, 52, 54, 60, 62, 64, 65, 67-70, 72, 75
	H	5, 7-9, 11, 22-25, 28-31, 36, 38, 39, 41, 43, 45, 47-51, 53, 55-59, 61, 63, 66, 71, 73, 74, 76, 77, 78
IV		All exposure numbers: 5-196
M Frames	A	8-12, 52, 83, 84, 86, 89, 91, 92, 95, 96, 98, 100-104, 106-109, 112-116, 118-122, 124-128, 130-134, 136-140, 142-152, 154-158, 160-170, 172-175, 179-183, 186-194
	B	17, 97
	C	21, 23, 38, 42, 44, 51, 53, 58, 59, 60, 71-74, 76-79, 82, 88, 90, 94, 99, 110, 123, 177, 178, 184, 185
	D	85
	E	Frames which are significantly fogged: 25, 27, 29, 30, 32, 33, 34, 39, 40, 42, 46, 48, 55, 56, 62, 64, 65, 66, 68, 70, 75, 80
	F	Frames which are significantly fogged: 19, 28, 35, 36, 41, 45, 47, 54, 61, 67
	G	13-16, 26, 31, 37, 43, 49, 57, 63, 69, 87, 93, 111, 117, 129, 135, 141, 153, 159, 171, 176
	H	5-7, 18, 20, 22, 24, 50, 81, 105, 195, 196

Table 3 (continued)

Mission	Category	Exposure Number(s)
IV		
H Frames	A	5, 9, 11, 12, 17, 18, 70, 74, 76-79, 82-84, 88-92, 94-98, (99 - predominantly in shadow) 100-104, 106-110, 112-116, 118-122 (123 - predominantly in shadow) 124-128, 130-134, 136-140, 142-145, (146, 147 - both predominantly in shadow) 148-151, 154-158, 160-170, 172-195
	B	6, 8, 10, 24, 152, 196
	C	27, 38, 39, 44, 46, 53-56, 58-62, 64-68, 71-73, 80, 85, 86
	D	23, 45, 52
	E	Frames which are significantly fogged: 28, 29, 32-36, 40-42, 47, 48
	F	Frames which are significantly fogged: 20, 22, 30
	G	13-16, 25, 26, 31, 43, 49, 50, 57, 63, 69, 75, 81, 87, 93, 105, 111, 117, 129, 135, 141, 159, 171
	H	7, 19, 21, 37, 51, 153
V		All exposure numbers: 5-217
M Frames	A	5-22, 24-216
	G	23
	H	217
H Frames	A	5-22, 24-42, 44-64, 66-216
	B	27**, 217
	G	23

**Completely read out, but only one composite frame.

Table 4
Summary of Lunar Orbiter Useful and Nonuseful Frames

	Category					
	A and C		B and D		E through H	
Mission	M Frames	H Frames	M Frames	H Frames	M Frames	H Frames
I	206	13	0	0	5	197
II	207	202	1	7	3	2
III	151	137	6	35	54	39
IV	123	137*	3	9	67	46
V	211	211*	0	1	2	3

*These totals include frames which are predominantly in shadow.

Table 5
Summary of Lunar Orbiter Frames Only Partially Read Out

M Frames			H Frames		
Mission	Exposure Number	Percent Readout	Mission	Exposure Number	Percent Readout
II	168	50	II	6	27
III	50	3		7	15
	53	3		8	36
	58	83		9	23
	60	93		10	27
	70	52		11	27
	73	86		169	89
IV	17	32	III	6	31
	19	36		10	74
	28	89		12	47
	35	71		13	23
	36	21		14	48
	41	64		15	12
	45	39		16	51
	47	11		17	12
	54	68		18	33
	61	68		19	13
	67	39		20	32
	85	50		21	11
	97	89		26	22
				27	1
				32	19
				33	9
				34	5
				35	22
				37	61
				40	65
				42	75
				44	75
				46	89
				52	92
				54	96
				60	71
				62	74
				64	2
				65	81
				67	6
				68	84
				69	18
				70	75
				72	77

Table 5 (continued)

M Frames			H Frames		
Mission	Exposure Number	Percent Readout	Mission	Exposure Number	Percent Readout
			III	75	83
			IV	6	93
				8	59
				10	93
				20	54
				22	34
				23	1
				24	9
				30	4
				45	5
				52	74
				152	98
				196	38
			V	217	96

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