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DATA USERS NOTE

APOLLO 16 LUNAR PHOTOGRAPHY

MAY 1973

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

NSSDC 73-01

DATA USERS NOTE
APOLLO 16 LUNAR PHOTOGRAPHY

by

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FOREWORD

The purposes of this Data Users Note are to announce the availability of Apollo 16 pictorial data and to aid an investigator in the selection of Apollo 16 photographs for study. As background information, the Note includes a brief description of the Apollo 16 mission and mission objectives. The National Space Science Data Center (NSSDC) can provide photographic and supporting data as described in the section on Description of Photographic Objectives, Equipment, and Available Data. The section also includes descriptions of all photographic equipment used during the mission. The availability of any data received by NSSDC after publication of this Note will be announced by NSSDC in a Data Announcement Bulletin.

NSSDC will provide data and information upon request directly to any individual or organization resident in the United States and, through the World Data Center A for Rockets and Satellites, to scientists outside the United States. All requesters should refer to the section on Ordering Procedures for specific instructions and for NSSDC policies concerning dissemination of data.

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APOLLO 16 LUNAR PHOTOGRAPHY

INTRODUCTION

Apollo 16 (1972-031A) was launched from Cape Kennedy, Florida, at 1754 UT (12:54 EST) on April 16, 1972. The major components of the Apollo spacecraft were a Command Module (CM), the primary vehicle for translunar coast (TLC) and transearth coast (TEC); the Lunar Module (LM), which transported the astronauts and equipment to the lunar surface; and the Service Module (SM), which carried the major power equipment and also housed the Scientific Instrument Module (SIM). The SM also carried a subsatellite for release in lunar orbit. This was the second of the three J-series missions, which carried the Lunar Roving Vehicle (LRV) to the moon for increased mobility of the astronauts during periods of extravehicular activity (EVA). The J-series spacecraft, which was designed to remain in the lunar environment longer than the earlier G and H missions, also carried an enhanced science equipment complement.

The total length of the Apollo 16 mission was 11.1 days, the total time spent in lunar orbit was 147.5 hr, and the total EVA time was 20.2 hr. Astronaut John W. Young was the commander of the mission, Thomas K. Mattingly was the Command Module pilot, and Charles M. Duke was the Lunar Module pilot.

Lunar orbit insertion (LOI) took place on April 20, 1972, at 1524 UT. At that time, the Apollo spacecraft was in an orbit of 315 x 107 km; after two revolutions, the orbit was lowered to 107 x 20 km. After separation of the LM from the Command and Service Modules (CSM), the orbit of the CSM was circularized to 107 x 109 km. The LM descent was delayed about 5-3/4 hr because of a problem in the Service Module propulsion system. This problem decreased the time spent on the moon to 71 hr. The LM landed in the lunar highlands north of Descartes Crater at about 8°59'S and 16°30'E on April 21 at 0223 UT. Before liftoff from the moon at 0125 UT on April 24, astronauts Young and Duke collected approximately 96 kg of lunar materials during lunar excursions that covered about 27 km. After the LM rejoined the CSM in lunar orbit and before the start of TEC, the subsatellite was released in lunar orbit.

MISSION OBJECTIVES

The Apollo 16 spacecraft carried astronauts to the lunar surface to continue and expand the exploration and investigation of the lunar environment begun in the four previous manned landings (Apollo 11, 12, 14, and 15) and the three previous flyby missions (Apollo 8, 10, and 13).

The primary scientific objectives were: (1) to geologically survey and sample surface features in a preselected area of the Descartes region, (2) to emplace and activate surface experiments, and (3) to conduct orbital science experiments including photographic tasks from lunar orbit. The spacecraft carried 10 lunar surface experiments and 12 lunar orbital experiments as well as equipment used for the SM, CM, and surface photographic tasks. For a complete listing of the Apollo 16 experiment package, see Appendix A.

The photographic tasks were devised to acquire precisely oriented mapping camera photographs and high-resolution panoramic camera photographs of the lunar surface from orbit and to document geologic features and operational tasks on the surface and in flight. The photographs also were planned as support for a wide variety of scientific and operational experiments to achieve a maximum data return.

DESCRIPTION OF PHOTOGRAPHIC OBJECTIVES, EQUIPMENT, AND AVAILABLE DATA

The Apollo 16 mission returned more photographs than any previous lunar mission. The dominant photographic mission was to record lunar surface features, with additional coverage of spacecraft maneuvers and views of deep space and earth. During the 3-day period in the lunar environment, the sunrise terminator advance provided opportunity for observing and photographing targets on an expanded total surface area under a range of lighting conditions suitable for observation.

The photographic tasks of the Apollo 16 mission were divided among the Service Module, the Command Module, the Lunar Module, and the lunar surface. Table 1 has a complete listing of the photographic equipment used. Each camera type that was used during the mission is described in the remainder of this section, with information also provided on the photography obtained and the availability of photographic and supporting data from the National Space Science Data Center (NSSDC). The arrangement of the discussions is based on the locations of the cameras within the spacecraft and their photographic tasks. The SM cameras are discussed first, followed by the CM cameras, and finally the LM and lunar surface cameras. It should be noted that Hasselblad and Maurer cameras were used in both the Command Module and the Lunar Module. While the cameras are discussed separately in this document, the listings of data from the same camera type are necessarily combined.

TABLE 1. SUMMARY OF APOLLO 16 PRIMARY PHOTOGRAPHIC EQUIPMENT

CAMERA	FOCAL LENGTH (mm)	APERTURE OPENING	FORMAT (mm)	FOCUS (m)	SHUTTER SPEED (sec)	FIELD OF VIEW (deg)	CASSETTE CAPACITY	EK FILM TYPE	FILM RESOLUTION AT 1000:1 CONTRAST	ASA RATING
SERVICE MODULE PHOTOGRAPHY										
Mapping	76	f/4.5	115 x 115	infinity	automatic 0.067 to 0.004	74 x 74	460 m	3400 (B/W)	200 lines/mm	80 AEI 20
35-mm Stellar	76	f/2.8	24 x 32	infinity	1.5	18.0 hor. 24.0 vert.	156 m	3401 (B/W)	100 lines/mm	170 AEI 20
Panoramic	610	f/3.5	115 x 1150	infinity	variable, automatic	11 fore, aft x 108 across	2060 m	3414 (LBW)	630 lines/mm	AEI 6
COMMAND MODULE PHOTOGRAPHY										
70-mm Hasselblad										
lens a	80	f/2.8 to f/22	52 x 52	1 to infinity	0.002 to 1.0	37.9 side 51.8 diag.	58.5 m 49.2 m	2485 (VHBW) SO-368 (CEX)	50 lines/mm 80 lines/mm	6000 64
lens b	250	f/5.6 to f/45	52 x 52	2.6 to infinity	0.002 to 1.0	12.5 side 17.6 diag.	58.5 m 49.2 m	2485 (VHBW) SO-368 (CEX)	50 lines/mm 80 lines/mm	6000 64
lens c	105 UV	f/4.3 to f/8	52 x 52	infinity	0.002 to 20	29.4 side 41.0 diag.	---	SO-368 (CEX) II a-0	80 lines/mm 95 lines/mm	64 ---
16-mm Maurer DAC										
lens a	10	T1.8 to T22	8 x 10	0.2 to infinity	0.001 to 0.167 and T-time	54.9 hor. 41.1 vert. 65.2 diag.	43 m	SO-168 (HCEX)	80 lines/mm	160
lens b	18	T1.0 to T22	8 x 10	0.03 to infinity	1,6 12,24 fps	32.6 hor. 23.4 vert. 39.2 diag.	43 m	SO-164 (B/W) 2485 (VHBW) SO-368 (CEX)	170 lines/mm 50 lines/mm 80 lines/mm	20 6000 64
lens c	75	T2.4 to T22	8 x 10	1.1 to infinity		7.9 hor. 5.7 vert. 10.0 diag.	43 m	SO-368 (CEX)	80 lines/mm	64

TABLE 1. (continued)

CAMERA	FOCAL LENGTH (mm)	APERTURE OPENING	FORMAT (mm)	FOCUS (m)	SHUTTER SPEED (sec)	FIELD OF VIEW (deg)	CASSETTE CAPACITY	EK FILM TYPE	FILM RESOLUTION AT 1000:1 CONTRAST	ASA RATING
COMMAND MODULE PHOTOGRAPHY (continued)										
35-mm Nikon	55	f/1.2 to f/16	24 x 36	---	0.001 to 1.0, B or T time	36.0 hor. 24.0 vert.	2.6 m	2485(VHBW)	50 lines/mm	6000
Westinghouse TV	---	f/4 to f/44	8 x 10*	0.5 to infinity	30 fps	---	---	---	200 TV lines/pic	---
LUNAR SURFACE AND LUNAR MODULE PHOTOGRAPHY										
70-mm Hasselblad										
lens a	500	f/8.0 to f/11	52 x 52	10^3 (1 km)	0.002 to 1.0, B-bulb	6.2 side 8.8 diag.	49.2 m	3401(B/W)	100 lines/mm	80-125
lens b	60	f/11	52 x 52	0.9 to infinity	0.002 to 1.0, B-bulb	46.9 side 63.4 diag.	49.2 m	SO-168(HCEX) 3401(B/W)	80 lines/mm 100 lines/mm	160 80-125
16-mm Maurer DAC	10	T1.8 to T22	8 x 10	0.15 to infinity	variable	54.9 hor. 41.1 vert. 65.2 diag.	43 m	SO-368(CEX)	80 lines/mm	64
FAR UV Camera/ Spectrograph	76	f/1	32 x 32	---	automatic	20	10 m	NTB-3 electrono-graphic	---	---
RCA TV	---	f/2 to f/22	8 x 10*	0.6 to infinity 0.5 to infinity	30 fps	---	---	---	200 TV lines/pic	---

*NSSDC image area film format.

Distributed with this Data Users Note are six photography indexes, i.e., Apollo 16 footprint maps. These maps indicate the areas of photographic coverage for the following cameras:

1. Panoramic camera photography, composite for all revolutions.

2. Mapping camera photography, revolutions 3/4, 18, 29, 39, 59, and 60.

3. Mapping camera photography, revolutions 17, 28, 38, 47, and 63.

4. Mapping camera photography, revolutions 25, 26, 27, 37, and 48.

5. Hasselblad camera photography, magazines NN, PP, QQ, and RR (250-mm lens, color) and magazine OO (105-mm lens, B/W).

6. Maurer camera photography, magazines BB, EE, N, and O (16-mm lens, color); Hasselblad camera photography, magazine V (250-mm lens, color) and magazine SS (250-mm lens, B/W).

Samples of Apollo 16 photography are included in Appendix B of this Note, and a form for ordering Apollo 16 photographic and supporting data follows Appendix B.

Service Module Photography

The Service Module photographic tasks were to obtain:

1. High-quality lunar surface metric photographs with simultaneous stellar photographs.

2. Data on the altitude of the Command and Service Modules above the lunar surface.

3. High-resolution panoramic photographs of the lunar surface in both stereoscopic and monoscopic modes.

Tasks (1) and (2) were accomplished using the assembly of the Fairchild mapping (metric) camera, a stellar camera, and the RCA ruby laser altimeter; and task (3) using the Itek optical bar panoramic camera.

Mapping Camera System

- Mapping Camera System Operation and Photography

The mapping camera system (MCS), shown in Figure 1, contained three major components:

- Mapping (metric) camera.
- Stellar camera.
- Laser altimeter.

The fixed angle between the optical axis of the mapping camera and the optical axis of the stellar camera was nominally 96° with the stellar camera pointing 6° above the horizon on the right side of the spacecraft when the mapping camera was pointing vertically towards the lunar surface and the spacecraft was moving forward. The laser altimeter transmission and receiving optical axes were nominally parallel to the mapping camera optical axis. The actual angular orientation between the mapping and stellar cameras and the location of the altimeter subpoint in the mapping camera frame are given as part of the preflight calibration data.

During camera operation, the MCS was mechanically deployed outside the SIM bay to provide a clear field of view for the stellar camera. The stellar lens glare shield was extended during the deployment process. The midpoint of exposure of the mapping camera, stellar camera, and laser altimeter was synchronized to ±1 msec. Although the altimeter can be operated independently of the camera, this mode was not employed on Apollo 16.

Apart from changes in the flight plan caused by spacecraft anomalies, operation of the MCS was near normal throughout the Apollo 16 mission. Mapping camera deployment and retraction were slow, but they had no effect on the photography. A few mapping camera frames were overexposed. Stellar photography was obtained for all mapping camera passes and for laser altimeter dark-side passes. Altimeter output gradually decreased during the mission. A total of 2372 laser firings were taken, but only 69 percent are considered valid. A higher percentage of dark-side readings were good because a smaller output was required for ranging against nonilluminated surfaces.

Exposed film from both mapping and stellar cameras was accumulated in the removable film record container that was recovered from the SIM bay by the Command Module pilot (CMP) by EVA during the transearth coast.

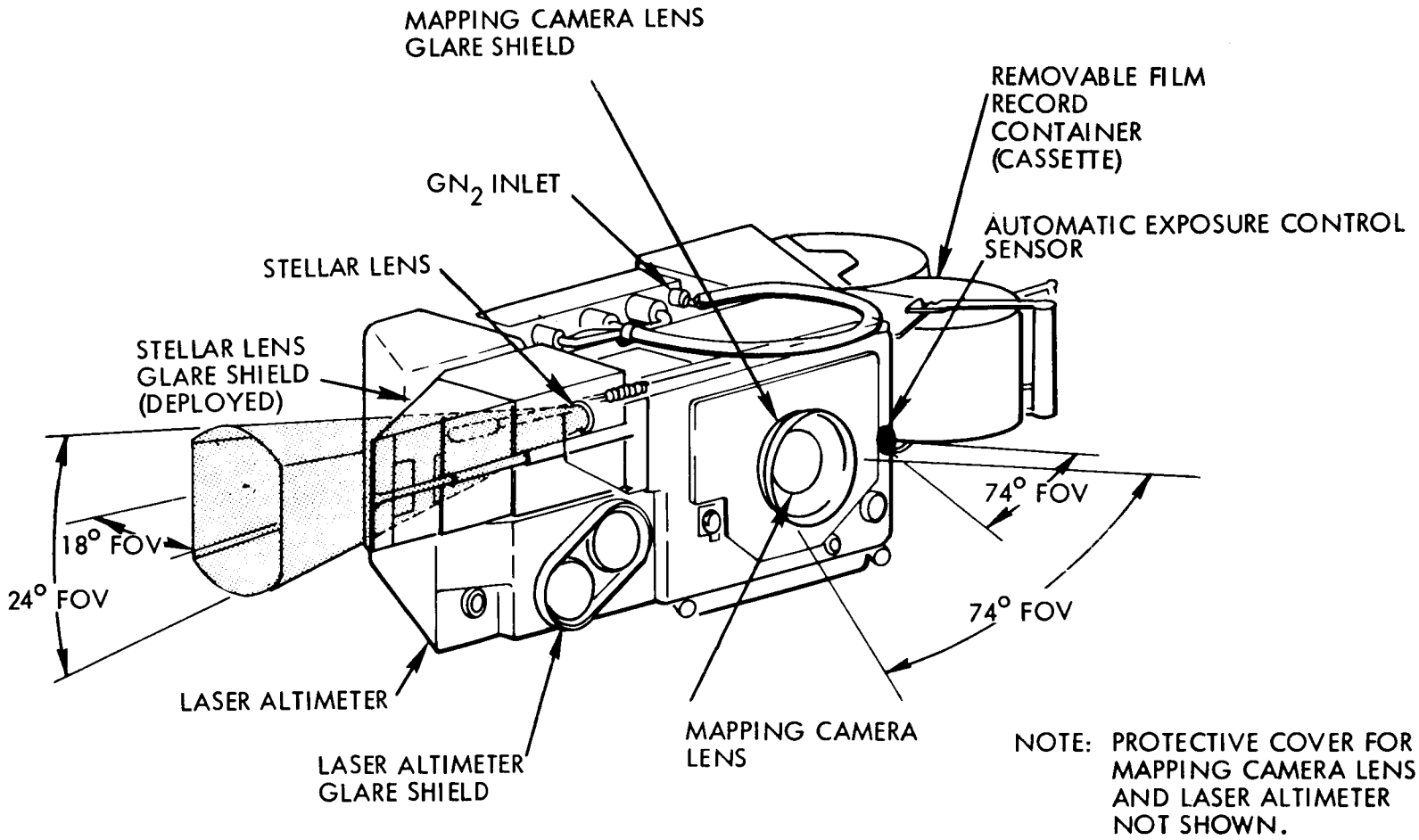

Figure 1. SIM bay Mapping Camera System - Mapping Camera/Stellar Camera/Laser Altimeter Detail

Mapping Camera - The objectives of the mapping camera photography were to provide:

1. Data for establishing a unified selenodetic reference system.

2. Imagery suitable for photomapping at scales as large as 1:250,000.

3. Imagery at approximately 20-m ground resolution suitable for synoptic interpretation of geologic relationships and surface material distribution.

The mapping camera had a f/4.5 lens of 76-mm (3-in.) focal length, and a picture format of 115 x 115 mm (4.5 x 4.5 in.) on 127-mm (5-in.) roll film. The 74° field of view covered approximately 170 x 170 km (92 x 92 n.m.) from the nominal altitude of 111 km (60 n.m.).

As shown in Figure 2, there were four naturally illuminated fiducials (v notches in the midpoint of each side) and eight artificially illuminated fiducials (points of light outside the picture format). The optical axis was located with respect to these fiducials by the preflight calibration data. The glass focal plane of the camera contained a reseau (array of crosses) that was imaged on each frame. The calibrated dimensions of the reseau provide a means of checking film distortion after processing. The reseau and the film were moved together during the exposure to assure sharp imagery by compensating for the forward motion of the spacecraft. There were five discrete forward motion compensation (FMC) rates (plus OFF) that were manually selected by the CMP according to spacecraft altitude. The position of the reseau with respect to the fiducials is variable from frame to frame. The format also contains a binary coded decimal data block in which spacecraft time, shutter open time, and altimeter distance reading are recorded.

The camera operated at full aperture at all times. An exposure sensor automatically set the shutter speed at one of seven speeds between 1/15 and 1/250 sec.

The overlap between successive frames was 78 percent. By using alternate frames, this was reduced to the standard 57 percent.

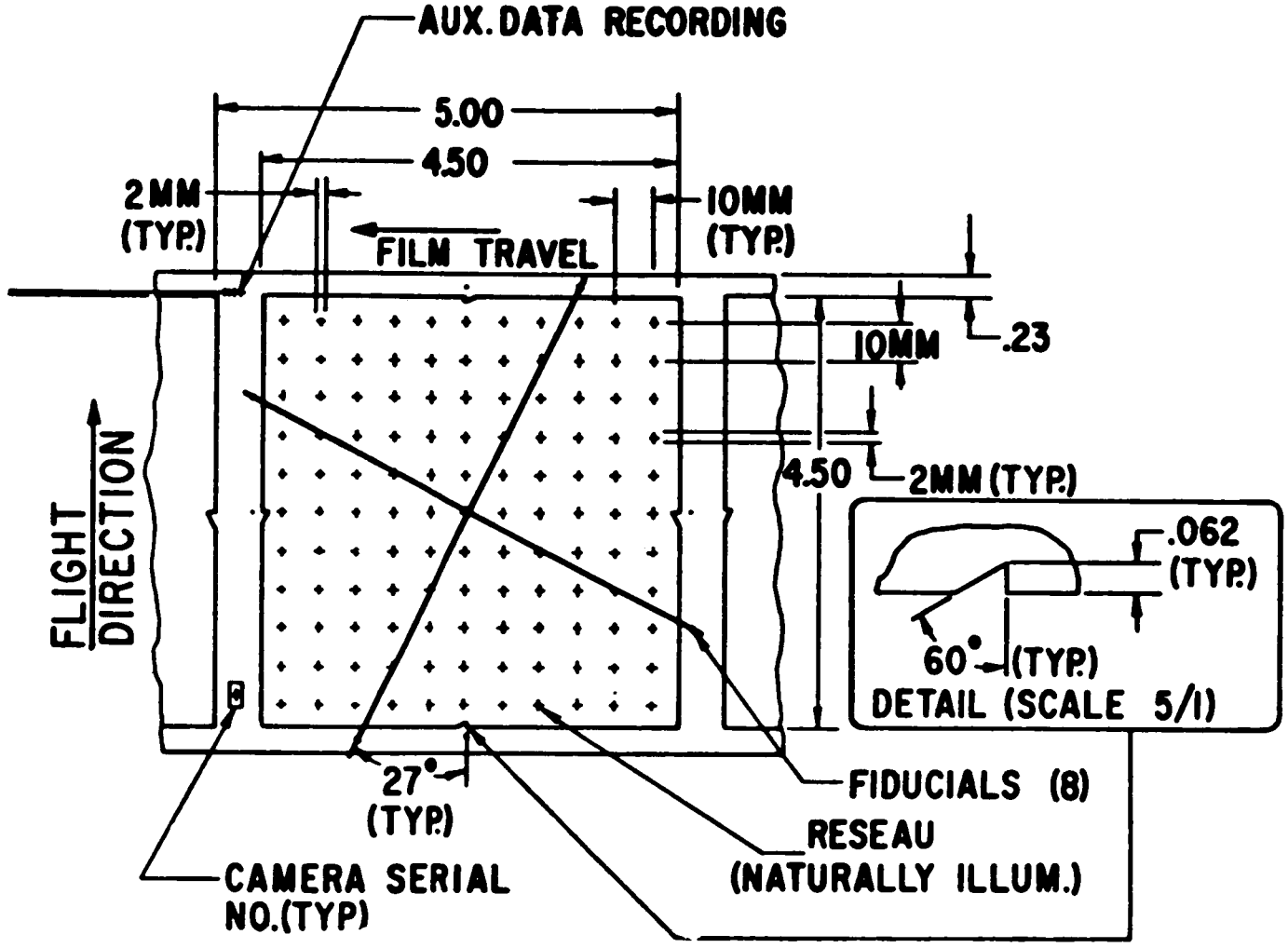

Figure 2. Mapping Camera Film Format

Stellar Camera - The objective of the stellar camera was to photograph the star field in synchronism with mapping camera and laser altimeter pulses. By measurement of the position of identified star images, the orientation of the stellar camera in the celestial coordinate system could be determined. By means of the preflight calibration, this orientation was transferable to the mapping camera or to the laser altimeter.

The stellar camera carried a f/2.8 lens of 76-mm focal length and has a picture format of 24 x 32 mm (0.96 x 1.25 in.) on 35-mm roll film. As shown in Figure 1, the field of view was 24° horizontally and 18° vertically.

The stellar film format is shown in Figure 3. There were four naturally illuminated fiducials. The fixed glass focal plane contained a reseau that was edge illuminated to record on each frame.

The exposure time for the stellar camera was fixed at 1.5 sec, and the midpoint of this exposure was synchronized with the midpoint of the mapping camera and laser altimeter to ±20 msec.

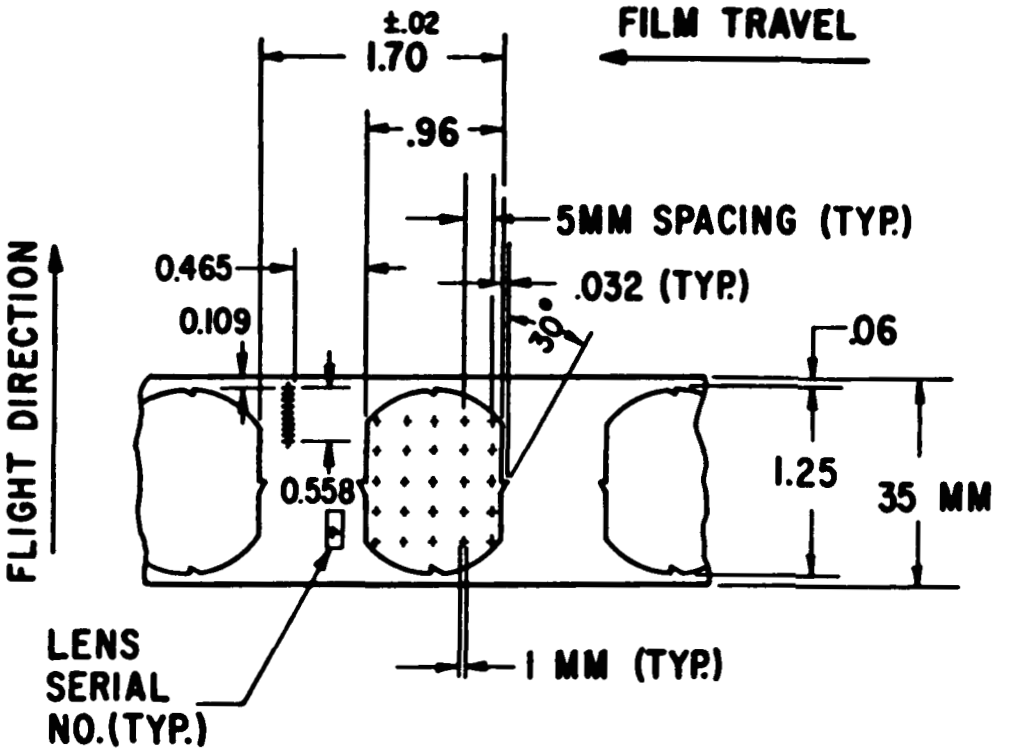

Figure 3. Stellar Camera Film Format

Laser Altimeter - The objectives of the laser altimeter were to provide:

1. A measured distance in each stereo mode of the metric camera photography.

2. Lunar surface profiles on the dark side.

3. Additional data for use in orbit and gravity field analysis.

Figure 4 is a block diagram of the altimeter. When a signal was received from the mapping camera, the ruby laser was activated and the light pulse was transferred to the transmission optics that had an angular field of 300 μrad illuminating an area 30 m in diameter on the lunar surface from a nominal altitude of 100 km. A portion of the output was used to start the range counting clock. The return pulse reflected from the lunar surface was applied to the photomultiplier tube through the receiver telescope that had an angular field of 200 μrad. The output of the photomultiplier stopped the range counter that had a least count of 1 m. The altitude was recorded both on the mapping camera film and on the spacecraft data system.

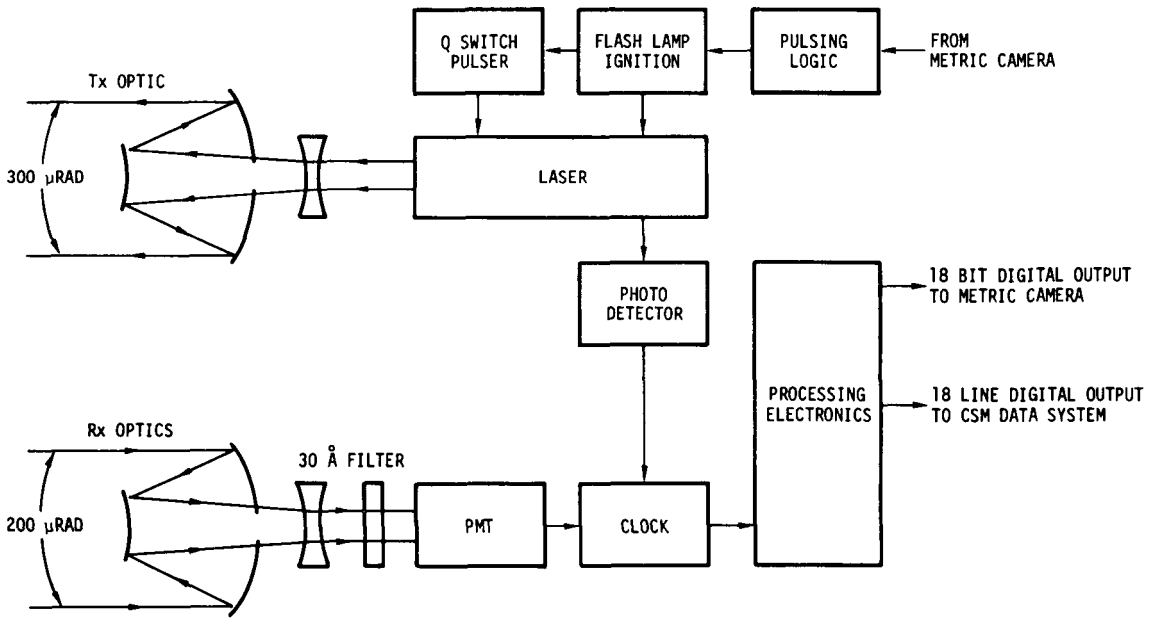

Figure 4. Laser Altimeter Block Diagram

- Mapping Camera System Photographic and Supporting Data

NSSDC has on hand five canisters containing mapping camera photographs in the form of second generation master positives and a duplicate set in the form of second generation direct negatives. Table 2 gives a summary of mapping camera coverage correlating the frame numbers with revolution numbers. The complete set of mapping camera photography contains 3481 frames, but only 2491 frames are considered usable. Some frames are blank as a result of exposure during operation with the laser altimeter on the dark side. Individual mapping camera frames can be obtained (1) as 5- x 5-in. negative or positive film duplicates or positive contact paper prints or (2) as 8- x 10-in. paper enlargements. In response to special requests, enlargements in other format sizes can be prepared. The 4.5- x 4.5-in. image area on the 5-in. film is enlarged to approximately 7.5 x 7.5 in. on the 8- x 10-in. enlargements. Strips of consecutive frames or the complete set of mapping photography can be obtained as contact positive or negative film duplicates on 5-in. rolls or as 5-in. roll contact paper prints. Orders for individual frames should specify the frame number (e.g., AS16-0028). A photographic catalog of the mapping camera photographs is available on 16-mm roll film or on microfiche.

Mapping camera supporting data are available on 16-mm microfilm. Figure 5 is a sample of the mapping camera supporting data. (For an explanation of all items in this figure see "Apollo 15 Photograph Evaluation (APE) Data Book" MSC-06886.) In addition, a one-line frame index for this photography is available on 16-mm microfilm or microfiche. One-line frame indexes for the panoramic camera, Hasselblad, Nikon, and Maurer photography are included on this same roll of 16-mm microfilm; the microfiche index also includes the panoramic camera frame data. The parameters listed for each frame of mapping camera photography are: orbit revolution number, approximate spacecraft altitude, latitude and longitude (in deg) of the principal point of the frame, tilt and azimuth of the camera, sun elevation (in deg), and a brief description of the features contained. Figures 6 and 7 are sample pages of the mapping camera frame indexes. Figure 6 is a sample of the indexes listed by frame number, and Figure 7 is a sample of the mapping camera frames listed by longitude bands. Users will receive paper prints of the supporting data frames appropriate for the photographs requested. In cases of requests for a significant quantity or a complete set of mapping camera photography, film copies of the supporting data will be supplied to the requester on 16-mm roll film.

The 35-mm stellar photography (3560 frames) has been contact printed onto 70-mm film and is available in that format. The stellar photographs, however, have marginal value outside of their use in the analysis of the mapping camera photographs and the laser altimeter data.

TABLE 2. SUMMARY OF USABLE APOLLO 16 MAPPING CAMERA PHOTOGRAPHS

REV	ATTITUDE	NASA PHOTO NO. AS16-	NO. FRAMES	START		STOP	
				LAT	LONG.	LAT	LONG.
3/4	VERT.	0001-0026	26	9.3N	165.1W	7.2N	168.1E
17	VERT.	0027-0174	148	8.9N	179.1W	9.3S	0.7W
18	VERT.	0313-0452	140	9.4N	179.2W	9.3S	0.1W
25	FWD OBLIQUE	0453-0585	133	9.0N	170.0E	8.6S	9.7W
26	SOUTH OBLIQUE	0587-0717	131	5.7N	169.0E	12.2S	8.6W
27	NORTH OBLIQUE	0719-0850	132	12.2N	168.6E	5.8S	9.9W
28	VERT.	0853-0999	147	8.5N	169.2E	9.1S	13.3W
29	VERT.	1144-1290	147	9.1N	168.3E	9.1S	14.1W
37	NORTH OBLIQUE	1292-1423	132	12.2N	156.4E	5.7S	22.0W
38	VERT.	1551-1691	141	9.5N	160.8E	9.6S	22.9W
39	VERT.	1840-1986	147	9.6N	159.8E	9.4S	22.7W
47	VERT.	2069-2217	149	9.4N	150.2E	9.4S	31.6W
48	SOUTH OBLIQUE	2357-2499	143	6.2N	149.0E	12.7S	30.2W
59	S/C MNVR	2501-2532	32	-	-	9.2S	43.0W
60	VERT.	2692-2845	154	10.6N	137.6E	10.2S	46.5W
63	VERT.	2852-2999	148	10.3N	135.8E	10.1S	48.3W
TEC		3000-3440	441	13.8N	115.5E	-	-
		TOTAL	2491				

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	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	23	17	32	21.928
CTE			6	23	38	22.066

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1809.7816423	-153.7889492	-388.8553495	-.2779283	-1.4163573	-.7380224
SELENOGRAPHIC	1769.5738946	503.0610952	-256.3336359	.4235995	-1.5584014	-.1412026

LONGITUDE OF NADIR POINT	15.8695878 DEG	LATITUDE OF NADIR POINT	-7.9322475 DEG
	15 DEG, 52 MIN, 10.5160946 SEC		-7 DEG, 55 MIN, 56.0910702 SEC
LONG OF CAMERA AXIS INTERSECT	16.1574231 DEG	LATI OF CAMERA AXIS INTERSECT	-11.3281226 DEG
	16 DEG, 9 MIN, 27.4429893 SEC		-11 DEG, 19 MIN, 41.2419169 SEC
SPACECRAFT RADIUS	1857.4630862 KM	SPACECRAFT ALTITUDE	119.3730898 KM
SCALE FACTOR	.0004733 M/KM	AZIMUTH OF VELOCITY VECTOR	269.9594889 DEG
MEAN ALTITUDE RATE	.0009769 KM/SEC	HORIZONTAL VELOCITY	1.6210777 KM/SEC
TILT AZIMUTH	175.2432213 DEG	TILT ANGLE	40.1539783 DEG
SIGMA TILT AZIMUTH	.0003101 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	46.2360115 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	75.5602388 DEG
LONGITUDE OF SUBSOLAR POINT	58.2314984 DEG	LATITUDE OF SUBSOLAR POINT	1.5621846 DEG
	58 DEG, 13 MIN, 53.1943701 SEC		1 DEG, 33 MIN, 43.8646603 SEC
ALPHA	-26.2597094 DEG	SWING ANGLE	180.1129051 DEG
EMISSION ANGLE	43.5617009 DEG	SIGMA SWING ANGLE	.0003101 DEG
PHASE ANGLE	52.9074211 DEG	NORTH DEVIATION ANGLE	186.3263643 DEG
PMI	.0952567 DEG	X-TILT	-40.1538808 DEG
SIGMA PMI	.0002617 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	175.0954952 DEG	Y-TILT	-.0728061 DEG
SIGMA KAPPA	.0002617 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-40.1538806 DEG	HEADING	-94.8430761 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.82807409	-.17981502	-.53099736	160.203606

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.17029104+00	-.87539912+00	-.45241291+00
.51697893+00	.31148503+00	-.79730747+00
.83880221+00	-.36946677+00	.39952865+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99642891+00	-.84426938-01	.12707064-02
.65345320-01	-.76151684+00	.64484267+00
-.53474396-01	.64262289+00	.76431423+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-7.942	18.299
********	.000
********	.000
-8.348	13.461

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-9 HR, 23 MIN, 43.1 SEC	DECLINATION	56 DEG, 40 MIN, 23.9 SEC

Figure 5. Sample of Mapping Camera Supporting Data

APOLLO 16
MAPPING CAMERA PHOTOGRAPHS
3 INCH (7.62CM) FOCAL LENGTH

NASA PHOTO NO. AS16-	REV	ALT. KM.	PRINCIPAL POINT LAT.	PRINCIPAL POINT LONG.	CAMERA TILT	CAMERA AZ	SUN EL.	DESCRIPTION
2441	48	118	7.7 S	43.7 E	40		73	GOCLENIUS, RILLES, GUTENBERG
2442	48	118	8.3 S	42.7 E	40		72	GUTENBERG, GOCLENIUS
2443	48	118	8.2 S	41.3 E	40		70	GUTENBERG, GOCLENIUS
2444	48	118	8.5 S	40.2 E	40		69	GUTENBERG, G, GOCLENIUS
2445	48	118	8.6 S	38.9 E	40		68	GUTENBERG, G, GAUDIBERT
2446	48	118	8.9 S	37.7 E	40		67	GUTENBERG G, GAUDIBERT
2447	48	118	8.8 S	36.5 E	40		66	CAPELLA, ISIDORUS
2448	48	118	9.3 S	35.3 E	40		65	CAPELLA, ISIDORUS
2449	48	118	9.5 S	34.0 E	40		63	CAPELLA, ISIDORUS
2450	48	119	9.5 S	32.5 E	40	170	62	CAPELLA, ISIDORUS, MADLER
2451	48	119	9.8 S	31.3 E	40		61	ISIDORUS, MADLER
2452	48	119	9.9 S	30.2 E	40		60	MADLER, THEOPHILUS
2453	48	119	10.2 S	28.8 E	40		58	MADLER, THEOPHILUS
2454	48	119	10.0 S	27.6 E	40		57	THEOPHILUS, CYRILLUS, MADLER
2455	48	119	10.3 S	26.3 E	40		56	THEOPHILUS, CYRILLUS, MADLER
2456	48	119	10.4 S	24.9 E	40		55	THEOPHILUS, CYRILLUS
2457	48	119	10.6 S	23.3 E	40		53	CYRILLUS, THEOPHILUS, KANT

Figure 6. Sample of Mapping Camera Frame Index Ordered by Frame Number

APOLLO 16
MAPPING CAMERA PHOTOGRAPHS
INDEXED BY LONGITUDE 10 TO 20 E

NASA PHOTO AS16-	DESCRIPTION	PRINCIPAL POINT LAT.	PRINCIPAL POINT LONG.	REV	ALT KM	CAMERA TILT	CAMERA AZ	SUN EL
2181	APOLLO 16 LANDING SITE	8.9 S	13.8 E	47	119	VERT		43
2182	DOLLOND, B, C, ANDEL	8.3 S	12.5 E	47	119	VERT		42
2183	DOLLOND C ANDEL	8.4 S	11.3 E	47	119	VERT		41
2184	ANDEL, HIND	8.5 S	10.2 E	47	119	VERT		40
2460	KANT, D, E, CYRILLUS, B	11.0 S	19.7 E	48	119	40	170	50
2461	DESCARTES, APOLLO 16 LANDING SITE	11.0 S	18.7 E	48	119	40		49
2462	DESCARTES, APOLLO 16 LANDING SITE	11.1 S	17.4 E	48	119	40		47
2463	DESCARTES, APOLLO 16 LANDING SITE	11.4 S	16.2 E	48	119	40		46
2464	DESCARTES, APOLLO 16 LANDING SITE	11.7 S	14.8 E	48	119	40		45
2465	ANDEL, ABULFEDA	11.6 S	13.3 E	48	119	40		43
2466	ANDEL, ABULFEDA	11.4 S	12.3 E	48	119	40		42
2467	ANDEL, ABULFEDA	11.5 S	11.0 E	48	119	40		41
2793	ZOLLNER, F, KANT, E, G	7.5 S	20.0 E	60	120	VERT		62
2794	ZOLLNER, ALFRAGANUS, C	8.0 S	18.7 E	60	121	VERT		61
2795	ZOLLNER, TAYLOR	7.9 S	17.6 E	60	121	VERT		60
2796	ALFRAGANUS C	8.4 S	16.5 E	60	121	VERT		59
2797	DOLLOND, B, C	8.4 S	15.3 E	60	121	VERT		58
2798	ANDEL, DOLLOND, B, C	8.5 S	13.9 E	60	121	VERT		56
2799	ANDEL, DOLLOND, B, C	8.5 S	12.6 E	60	122	VERT		55
2800	ANDEL, DOLLOND C	8.6 S	11.2 E	60	122	VERT		54

Figure 7. Sample of Mapping Camera Frame Index Ordered by Longitude

The stellar photographs do not have the same number identification as companion mapping camera photographs. The correlation between the mapping and stellar frame numbers is as follows:

Mapping	Stellar	Remarks
0001-1094	0080-1173	Add 79 to mapping frame number to get stellar frame number.
1095-3481	1175-3561	Add 80 to mapping frame number to get stellar frame number.

Note: Stellar frame number 1173 was also numbered 1174.

Panoramic Camera

- Panoramic Camera Operation and Photography

The objectives of the panoramic camera were to provide:

1. High-resolution (2 to 3 m) coverage of all areas overflown by the spacecraft in sunlight for detailed interpretation of surface features.

2. Photographic imagery suitable for the compilation of topographic maps of limited areas at scales as large as 1:10,000.

As shown in Figure 8, the panoramic camera was rigidly mounted in the SIM bay structure. The principal components of the camera are shown in Figure 9. The scan angle was 108° across the flight line. When operating in the stereo mode, the camera alternated between 12.5° forward and 12.5° aft of the nadir to provide a 25° convergent angle between successive frames.

The panoramic camera carried the film supply and take-up reels, power supply, drive mechanism, telemetry, and film shuttle rollers. The gimbal structure assembly was pivoted about a transverse axis so that it could rock fore and aft to provide the 25° stereo convergence between frames. This rocking motion was also used to compensate for spacecraft forward motion during the actual camera exposure. The gimbal structure also carried skew rollers to lead the film around the roller cage. The roll frame assembly, which was mounted on a longitudinal axis in the gimbal structure, carried the folded optical system in the lens barrel and the roller cage around which the film passed during the exposure.

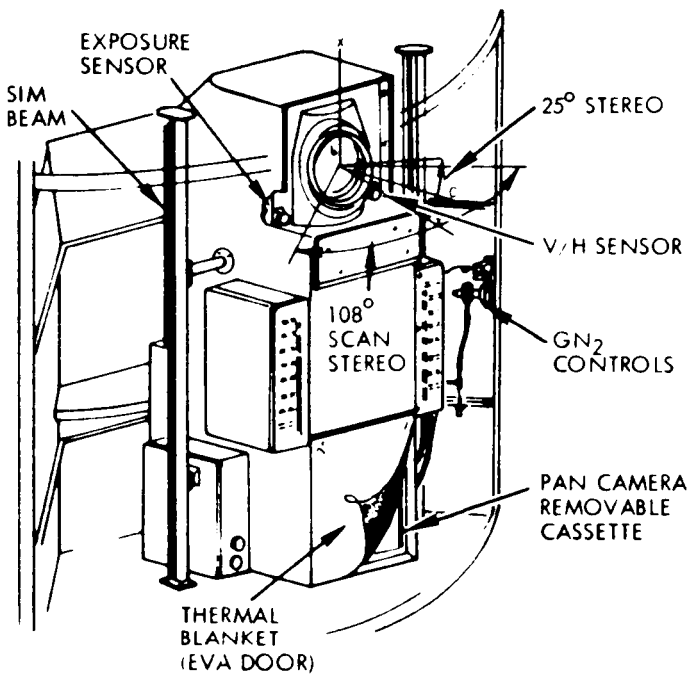


Figure 8. Panoramic Camera Enclosure and SIM Mounting

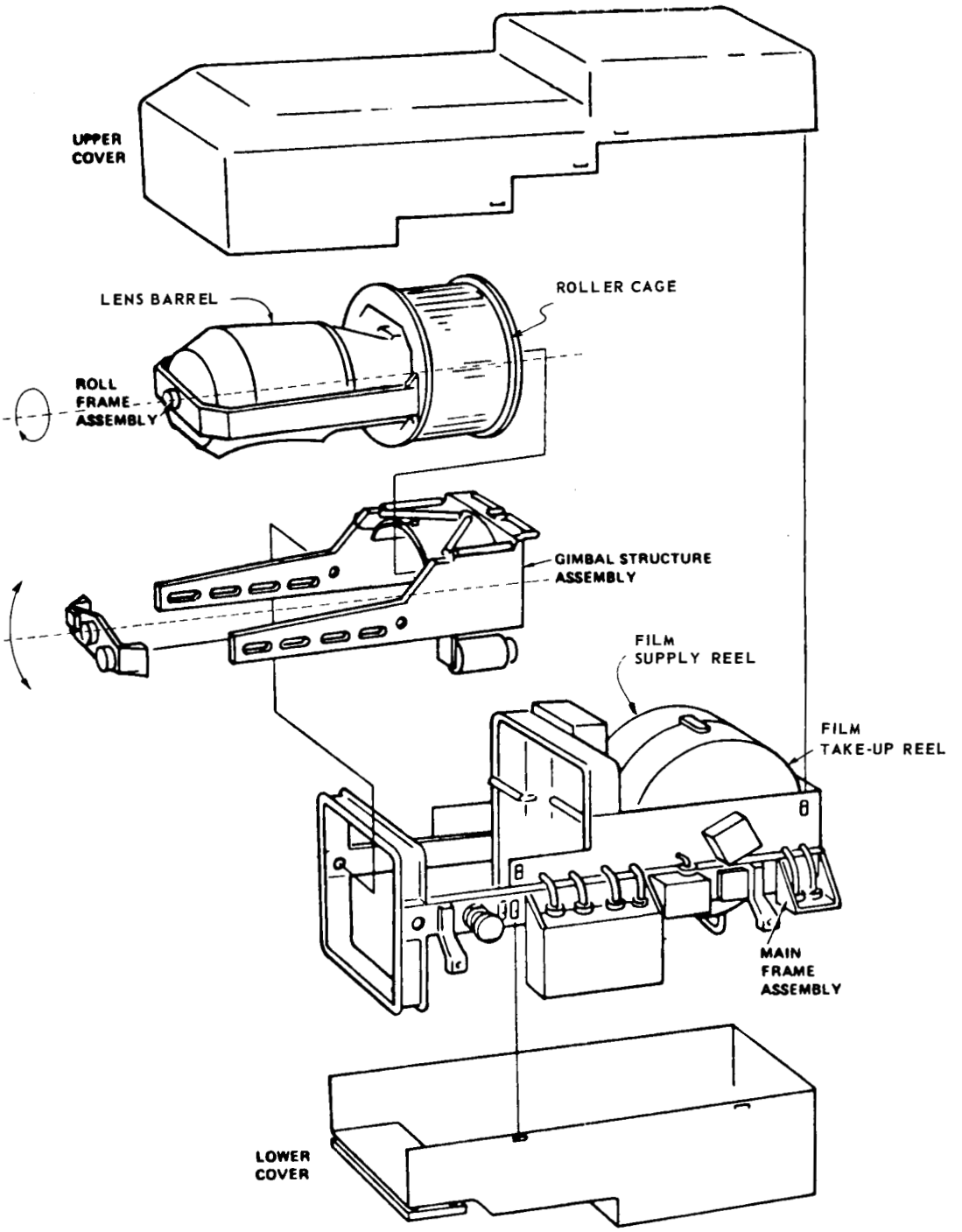


Figure 9. Principal Components of the Panoramic Camera

During camera operation, the roll frame assembly rotated continuously. Film was exposed during the 108° scan centered on the nadir. During the remaining part of the rotation, the film was transported and the gimbal structure tilted from the forward to the aft position (or vice versa) to provide the 25° stereo convergence.

A velocity/height (V/H) sensor on the main frame sensed the rate of apparent ground motion and governed the rotation rate of the roll frame assembly. An exposure sensor mounted on the gimbal structure recorded the scene brightness and adjusted the film exposure by varying the slit width in the optical system.

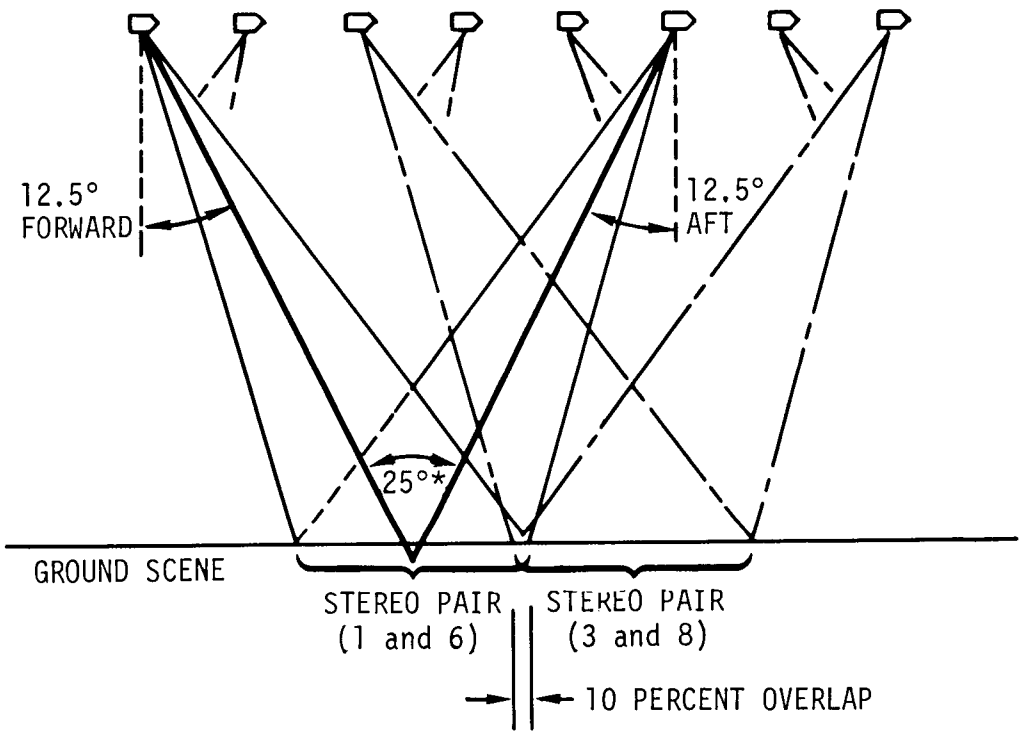
Typical stereo coverage is illustrated in Figure 10. A stereo pair is made up from the forward-looking frame at exposure station 1 and the aft-looking frame from exposure station 6. The typical lunar surface footprint for a single frame is shown in Figure 11.

The quality of most of the stereo photographs is good even though some anomalies occurred during camera operation. The exposure sensor indicated low light levels throughout the mission. As a result, all of the panoramic frames away from the terminator were somewhat overexposed. However, the overexposure was compensated for during the film processing. Approximately 1425 panoramic frames were acquired in lunar orbit, and about 175 frames were exposed during transearth coast. Primarily due to the shortened stay in lunar orbit, the total coverage was about 10 percent less than that outlined in the nominal mission.

- Panoramic Camera Photographic and Supporting Data

NSSDC has 18 canisters containing second generation master positives for a total of 1586 usable panoramic frames. The photographs are stored on 5-in. roll film, and each frame has an image area of 115 x 1150 mm (4.5 x 45 in.). A summary of the panoramic camera coverage is given in Table 3. Individual frames, which should be requested by frame number (e.g., AS16-PAN-4692), can be obtained as 5- x 48-in. contact negative or positive film copies or as 5- x 48-in. contact paper prints. Complete magazines or a complete set of panoramic photography can be obtained as contact positive 5-in. roll film or paper or as negative roll film reproductions. A rectified version of the panoramic camera photography in a 9 1/2- x 80-in. format will be prepared. The availability of this version will be announced when NSSDC is ready to distribute it.

Supporting data for the panoramic photographs, in a 16-mm microfilm format, are available from NSSDC. A sample of the panoramic camera supporting data is presented in Figure 12. (For an explanation of all items in the figure, see "Apollo 15 Photographic Evaluation (APE) Data Book," MSC-06886). A complete one-line index can also be obtained on



*CONVERGENCE ANGLE

Figure 10. Panoramic Camera Photography Stereo Coverage and Overlap (25° Convergence Angle)

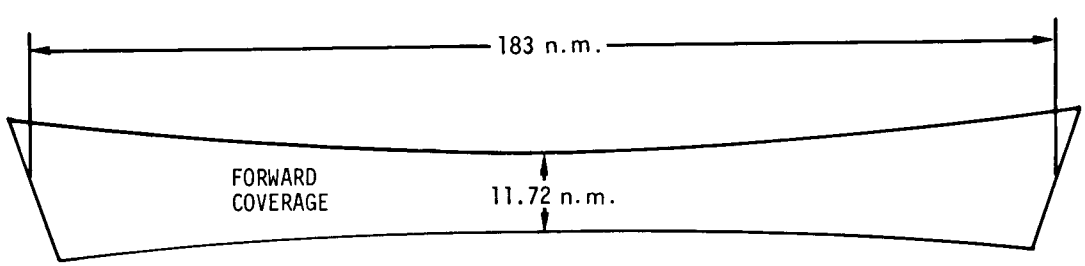


Figure 11. Lunar Surface Footprint for Panoramic Camera Photograph taken from 111-km Orbit

TABLE 3. SUMMARY OF USABLE APOLLO 16 PANORAMIC CAMERA PHOTOGRAPHS

REV	NASA PHOTO NO. AS16-	NO. FRAMES	START		STOP	
			LAT	LONG.	LAT	LONG.
3	4091-4094	4	8.8N	166.9W	8.8N	168.9W
17	4095-4347	253	9.0N	179.9E	1.8S	89.6E
18	4348-4613	266	1.9S	89.8E	9.2S	1.7W
28	4614-4627	14	9.0S	18.3E	9.1S	12.6E
38	4628-4716	89	8.7S	9.5E	9.3S	22.0W
39	4717-4911	195	9.2N	158.5E	1.6N	91.7E
47	4912-5203	292	9.4N	150.2E	3.1S	52.6E
63	5204-5506	303	0.5S	59.2E	9.9S	47.8W
TEC	5507-5677	171				
	TOTAL	1587				

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	2	2	31.703
CTE			5	8	8	32.336

STATE VECTOR	X (KM)	Y (KM)	Z -(KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1539.0613745	-774.1505279	-679.8604852	-.8627568	-1.2463885	-.5575039
SELENOGRAPHIC	1771.3469376	455.1893105	-292.1676780	.3682426	-1.5779354	-.0542403

LONGITUDE OF NADIR POINT	14.4116738 DEG	LATITUDE OF NADIR POINT	-9.0763481 DEG
14 DEG, 24 MIN,	42.0256233 SEC	-9 DEG, 4 MIN,	34.8530388 SEC
LONG OF CAMERA AXIS INTERSECT	15.2580534 DEG	LATI OF CAMERA AXIS INTERSECT	-9.0224589 DEG
15 DEG, 15 MIN,	28.9923191 SEC	-9 DEG, 1 MIN,	20.8520794 SEC
SPACECRAFT RADIUS	1852.0878040 KM	SPACECRAFT ALTITUDE	113.9978076 KM
SCALE FACTOR	.0052095 M/KM	AZIMUTH OF VELOCITY VECTOR	268.0192691 DEG
MEAN ALTITUDE RATE	-.0079367 KM/SEC	HORIZONTAL VELOCITY	1.6258521 KM/SEC
TILT AZIMUTH	86.3777199 DEG	TILT ANGLE	12.5438533 DEG
SIGMA TILT AZIMUTH	.0009206 DEG	SIGMA TILT ANGLE	.0002001 DEG
SUN ELEVATION AT PRIN GRND PNT	26.3250637 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	83.7396965 DEG
LONGITUDE OF SUBSOLAR POINT	78.2916054 DEG	LATITUDE OF SUBSOLAR POINT	1.5461907 DEG
78 DEG, 17 MIN,	29.7794437 SEC	1 DEG, 32 MIN,	46.2665448 SEC
ALPHA	-13.3710010 DEG	SWING ANGLE	87.9586166 DEG
EMISSION ANGLE	13.3814269 DEG	SIGMA SWING ANGLE	.0009205 DEG
PHASE ANGLE	77.0447102 DEG	NORTH DEVIATION ANGLE	181.4946497 DEG
PHI	-12.5361348 DEG	X-TILT	.4432718 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	178.3704205 DEG	Y-TILT	12.5357532 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.4432718 DEG	HEADING	-91.5310155 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002049 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.98542671	-.02943353	.16753470	116.975693

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.7053279E+00	-.6632724E+00	-.2501643E+00
-.1477985E+00	.4827409E+00	-.8632014E+00
.6933022E+00	-.5718661E+00	-.4385213E+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.9758123E+00	-.2608114E-01	-.2170487E+00
.2843684E-01	-.9995656E+00	-.7736475E-02
-.2167528E+00	-.1372154E-01	.9761300E+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
-3.043	15.579	-6.177	15.587
-14.799	15.925	-11.806	15.753
-14.532	15.088	-11.703	14.975
-3.380	14.763	-6.330	14.819

Figure 12. Sample of Panoramic Camera Supporting Data

16-mm microfilm, along with the one-line indexes for the mapping camera, Hasselblad, and Nikon photographs and the complete Maurer index, or on microfiche (with the mapping camera index). The information included in the index for each panoramic camera frame is as follows: latitude and longitude of the principal point (center) of the frame (in deg), sun elevation (in deg), approximate altitude of the spacecraft, camera attitude, orbit revolution number, frame number of the accompanying stereo photograph, and a brief description of the features shown in the photograph. The panoramic camera indexes are listed two ways: by frame number and by frame number within longitude bands. Samples of these indexes are given in Figures 13 and 14. The appropriate panoramic camera supporting data will be sent with each request for individual frames. Requesters ordering large quantities of individual frame reproductions or the full complement of panoramic camera photography will routinely be furnished with 16-mm roll film reproductions of the supporting data and indexes. Requesters who wish to preview the imagery on the panoramic frames can order the complete panoramic photography catalog on 35-mm microfilm.

Command Module Photography

The Command Module photographic tasks were to obtain:

1. Photographs of diffuse galactic light of selected celestial regions.

2. Photographs of the solar corona after spacecraft sunset and prior to spacecraft sunrise.

3. Photographs of a comet if conditions permitted (none obtained).

4. Photographs of the zodiacal light.

5. Photographs of lunar surface areas of prime scientific interest.

The Command Module photographic equipment included a Hasselblad electric camera (HEC) with 80-mm and 250-mm focal length lenses, as well as a 105-mm focal length ultraviolet lens; a 16-mm Maurer data acquisition camera (DAC) with 10-mm, 18-mm, and 75-mm focal length lenses; a Nikon 35-mm camera; and a Westinghouse color TV camera.

APOLLO 16
PANORAMIC CAMERA PHOTOGRAPHS
24 INCH (60.96CM) FOCAL LENGTH

NASA PHOTO NO. AS16-	CAMERA LOOK	STEREO FRAME AS16-	PRINCIPAL POINT LAT.	PRINCIPAL POINT LONG.	ALT KM.	REV NO.	SUN EL.	DESCRIPTION
4558	FWD	4563	9.3 S	15.7 E	112	18	17	DESCARTES
4560	FWD	4565	9.3 S	15.1 E	111	18	16	DESCARTES, APOLLO 16 LANDING
4562	FWD	4567	9.3 S	14.4 E	111	18	15	DOLLOND, B, ABULFEDA
4564	FWD	4569	9.3 S	13.6 E	111	18	15	DOLLOND B, ABULFEDA
4566	FWD	4571	9.2 S	13.0 E	111	18	14	ANDEL, DOLLOND C
4568	FWD	4573	9.1 S	12.4 E	110	18	13	ANDEL
4570	FWD	4575	9.1 S	11.6 E	110	18	12	ANDEL, W OF
4572	FWD	4577	9.1 S	10.9 E	110	18	11	ANDEL, W OF
4574	FWD	4579	9.2 S	10.3 E	110	18	11	RITCHEY, E OF
4576	FWD	4581	9.2 S	9.8 E	110	18	11	RITCHEY, E OF
4578	FWD	4583	9.2 S	9.1 E	110	18	10	RITCHEY
4580	FWD	4585	9.3 S	8.3 E	110	18	9	RITCHEY, HIPPARCHUS C
4582	FWD	4587	9.3 S	7.8 E	110	18	9	HIND
4584	FWD	4589	9.2 S	7.2 E	110	18	8	HIND
4586	FWD	4591	9.2 S	6.6 E	110	18	8	HIPPARCHUS
4588	FWD	4593	9.3 S	5.9 E	109	18	7	HALLEY, HIPPARCHUS
4590	FWD	4595	9.3 S	5.2 E	109	18	6	ALBATEGNIUS, HIPPARCHUS
4592	FWD	4597	9.2 S	4.6 E	109	18	6	ALBATEGNIUS, HIPPARCHUS
4594	FWD	4599	9.3 S	4.0 E	109	18	5	ALBATEGNIUS, HIPPARCHUS
4596	FWD	4601	9.2 S	3.3 E	108	18	4	ALBATEGNIUS, HIPPARCHUS J

Figure 13. Sample of Panoramic Camera Frame Index Ordered by Frame Number

APOLLO 16
PANORAMIC CAMERA PHOTOGRAPHS
INDEXED BY LONGITUDE 10 TO 20 E

NASA PHOTO NO. AS16-	CAMERA LOOK	STEREO FRAME AS16-	DESCRIPTION	PRINCIPAL POINT LAT.	PRINCIPAL POINT LONG.	ALT KM.	REV NO.	SUN EL.
4546	FWD	4551	KANT, G	9.1 S	19.6 E	112	18	21
4548	FWD	4553	ZOLLNER, KANT D	9.1 S	19.1 E	112	18	20
4550	FWD	4555	ZOLLNER, KANT D	9.2 S	18.6 E	112	18	19
4552	FWD	4557	ZOLLNER, W OF	9.3 S	17.9 E	112	18	19
4554	FWD	4559	DESCARTES, E OF	9.3 S	17.1 E	112	18	18
4556	FWD	4561	DESCARTES, E OF	9.3 S	16.5 E	112	18	17
4558	FWD	4563	DESCARTES	9.3 S	15.7 E	112	18	17
4560	FWD	4565	DESCARTES, APOLLO 16 LANDING SITE	9.3 S	15.1 E	111	18	16
4562	FWD	4567	DOLLOND, B, ABULFEDA	9.3 S	14.4 E	111	18	15
4564	FWD	4569	DOLLOND B, ABULFEDA	9.3 S	13.6 E	111	18	15
4566	FWD	4571	ANDEL, DOLLOND C	9.2 S	13.0 E	111	18	14
4568	FWD	4573	ANDEL	9.1 S	12.4 E	110	18	13
4570	FWD	4575	ANDEL, W OF	9.1 S	11.6 E	110	18	12
4572	FWD	4577	ANDEL, W OF	9.1 S	10.9 E	110	18	11
4574	FWD	4579	RITCHEY, E OF	9.2 S	10.3 E	110	18	11
4614	FWD	4619	TAYLOR	9.1 S	16.7 E	115	28	28
4615	AFT		KANT D, ZOLLNER	9.0 S	18.3 E	115	28	30
4616	FWD	4621	DESCARTES	9.0 S	15.9 E	115	28	27
4617	AFT		ZOLLNER, W OF	9.1 S	17.6 E	115	28	29
4618	FWD	4623	APOLLO 16 LANDING SITE	9.0 S	15.2 E	115	28	27

Figure 14. Sample of Panoramic Camera Frame Index Ordered by Longitude in 10° Increments

Command Module Hasselblad Electric Camera

• CM Hasselblad Camera Operation and Photography

The 70-mm Hasselblad electric camera in the Apollo 16 Command Module was used to document spacecraft operations and maneuvers and to obtain (1) photographs of preselected surface targets, terrain features, the moon during transearth coast, and the solar corona and (2) UV images of the earth and moon. Normally fitted with an 80-mm focal length f/2.8 Zeiss planar lens, the HEC also used a bayonet mount 250-mm focal length lens fitted for long-distance earth or moon photography and a 105-mm focal length f/4.3 Zeiss UV Sonnar lens for the UV photographs.

Most of the Hasselblad photographs are of good quality, although, because of time constraints, the coverage was somewhat less than that planned. The 80-mm lens with color film was used primarily to document spacecraft operations and maneuvers. Attempts to photograph the solar corona with this lens did not succeed because of a procedural error. The 250-mm lens and color exterior film were used to photograph 756 frames of 13 lunar surface targets. These included various views of the Descartes and Vogel Crater regions, low-sun-angle views of the landing site, targets of opportunity, and a few crew option photographs. Except for a few frames that are underexposed or show detectable smears, the quality of these photographs is good. Photographs of nine target areas very near the terminator were exposed using the 250-mm lens and very high-speed black and white film. Most of the 103 frames of near terminator photography are of good quality.

Eighty-three high-quality ultraviolet photographs of the earth and moon were obtained using the 105-mm focal length UV lens. An astronaut aimed the camera through the right side window of the Command Module, which had an annealed-fused silica covering to prevent blockage of UV radiation. Lexan and cardboard shields covered the window when the camera was not in use. A filter wheel containing four filters permitted the passing of UV bands. These corresponded to 4000 A (upper UV wavelength), 3150 to 3900 A, 2700 to 3300 A, and 2550 to 2700 A. All the filters performed well except for the last one.

• CM Hasselblad Camera Photographic and Supporting Data

NSSDC has a total of 2664 Hasselblad frames available for distribution. This number includes both orbital and surface exposures; the 83 ultraviolet photographs are not yet available from NSSDC. Table 4 lists the NSSDC inventory of Hasselblad photographs by magazine. The table distinguishes between frame numbers for the orbital and surface photographs and also notes which frames are color and which are black and white. Color reproductions in the form of positive or negative contact film copies in a user-specified format can be obtained by those

TABLE 4. SUMMARY OF APOLLO 16 HASSELBLAD FILM MAGAZINES

MAG.	NASA PHOTO NO. AS16-	LENS mm	NUMBER OF PHOTOS				FILM TYPE
			SURFACE	ORBIT	OTHER	TOTAL	
M	105-17053 17236	500	184			184	3401 (B/W)
K	106-17237 17418	60	182			182	3401 (B/W)
C	107-17419 17583	60	165			165	SO-168 (Color)
I	108-17584 17745	60	162			162	3401 (B/W)
G	109-17746 17864	60	119			119	3401 (B/W)
H	110-17865 18032	60	168			168	3401 (B/W)
J	111-18033 18192	60	160			160	3401 (B/W)
L	112-18193 18278	500	86			86	3401 (B/W)
A	113-18279 18382	60	86	18		104	SO-168 (Color)
B	114-18383 18470	60	88			88	SO-168 (Color)
D	115-18471 18562	60	92			92	SO-168 (Color)
E	116-18563 18724	60	162			162	SO-168 (Color)
F	117-18725 18856	60	132			132	SO-168 (Color)
NN	118-18857 19022	80, 105 250		130	10 EO 26 TLC	166	SO-368 (Color)
RR	119-19023 19184	250		162		162	SO-368 (Color)
V	120-19185 19344	250		160		160	SO-368 (Color)
PP	121-19345 19457	250		77	36 TEC	113	SO-368 (Color)
QQ	122-19458 19612	80, 250		98	57 TEC	155	SO-368 (Color)
SS	124-19822 19925	80, 250		104		104	2485 (B/W)
*00	151-20100 20182	105		10	48 TLC 25 TEC	83	IIa-0 (UV)
		TOTALS	1786	759	202	2747	

*These UV photographs are not yet available for distribution.

requesters performing detailed scientific investigations. The black and white frames, which have an image area of 52 x 52 mm, are available as contact positive or negative film copies on 4- x 5-in. film sheets or as enlarged 8- x 10-in. prints. Enlargements in other sizes can be produced in response to special requests. Complete magazines or complete sets of Hasselblad photography can be produced as positive or negative contact film duplicates on 70-mm roll film or as positive contact paper prints on 70-mm roll paper. The Hasselblad photography can be ordered by individual frame, magazine, or complete set. Requests should be identified precisely, i.e., Apollo 16 Hasselblad color frame AS16-117-18730. A photographic catalog from which a user can select desired frames is available on 16-mm roll film or microfiche.

NSSDC has available one-line indexes for the Hasselblad photography that give frame parameters including longitude and latitude of the principal point, tilt and azimuth, sun elevation, approximate altitude of the spacecraft, general mission activity at the time the photograph was taken, camera lens used, and outstanding features of the photographs. These indexes list the photographs three ways: sequentially by NASA frame number, by frame number within a specified longitude range for orbital photography, and chronologically according to lunar surface activities, i.e., pre-EVA, EVA 1, EVA 2, and EVA 3, for those photographs taken while on the lunar surface. Samples of each of these index types are included in Figures 15 through 18. The Hasselblad 70-mm, Nikon 35-mm, Maurer 16-mm, mapping, and panoramic camera indexes are all on one roll of 16-mm microfilm. This roll of indexes will be provided routinely with requests for a complete set, complete magazines, or a large number of individual photographs. Otherwise, paper copies of the index will be provided with selected individual frames. The Hasselblad photography is also available on microfiche which includes the Maurer photography.

Command Module Maurer Camera

- CM Maurer Camera Operation and Photography

The 16-mm Maurer data acquisition camera documented spacecraft maneuvers and experiment operations and performed some landmark tracking tasks. It also acquired backup photography for some of the Hasselblad camera tasks. The Maurer movie camera could be bracket mounted in the Command Module window, or it could be handheld for photographing nearby targets outside the CM and for use inside the CM. Some of the spacecraft maneuvers documented were spacecraft docking and undocking, jettison of the LM, and retrieval of the panoramic and mapping camera film cassettes. The camera used 10-, 18-, and 75-mm focal length lenses and several different film types to acquire photographs.

APOLLO 16
HASSELBLAD 70MM (FILM WIDTH) PHOTOGRAPHS
MAGAZINE G (AS16-109) FILM TYPE 3401

NASA PHOTO NO. AS16- 109	PRINCIPAL POINT LAT.	LONG.	CAMERA TILT	AZ	ALT KM.	LENS MM.	SUN EL.	MISSION ACTIVITY	DESCRIPTION
17786					60	24		EVA 1	STA 1, PAN
17787					60	24		EVA 1	STA 1, PAN
17788					60	24		EVA 1	STA 1, PAN
17789					60	24		EVA 1	STA 1, PAN
17790					60	24		EVA 1	STA 1, PAN
17791					60	24		EVA 1	STA 1, PAN
17792					60	24		EVA 1	STA 1, PAN
17793					60	24		EVA 1	STA 1, PAN
17794					60	24		EVA 1	STA 1, SPL 372 RAKE, 354 SOIL
17795					60	24		EVA 1	STA 1, SPL 372 RAKE, 354 SOIL
17796					60	24		EVA 1	STA 1, SPL 371 ROCK, 363 SOIL
17797					60	24		EVA 1	STA 1, SPL 371 ROCK, 363 SOIL
17798					60	24		EVA 1	STA 1, SPL 364 ROCK, 356 SOIL
17799					60	24		EVA 1	STA 1, SPL 362 ROCK, 002 ROCK, 369 SOIL
17800					60	24		EVA 1	STA 1, SPL 362 ROCK, 002 ROCK, 369 SOIL
17801					60	24		EVA 1	STA 1, SPL 352 SOIL, 357 SOIL
17802					60	24		EVA 1	STA 1, SPL 353 ROCK, 368 SOIL
17803					60	24		EVA 1	STA 1, SPL 353 ROCK, 368 SOIL
17804					60	24		EVA 1	STA 1, SPL 353 ROCK, 368 SOIL
17805					60	24		EVA 1	STA 1, SPL 353 ROCK, 368 SOIL

Figure 15. Sample of Surface Hasselblad Camera Frame Index Ordered by Frame Number

APOLLO 16
HASSELBLAD 70MM (FILM WIDTH) PHOTOGRAPHS
MAGAZINE SS (AS16-124) FILM TYPE 2485

NASA PHOTO NO. AS16- 124	PRINCIPAL POINT LAT.	LONG.	CAMERA TILT	AZ	ALT KM.	LENS MM.	SUN EL.	MISSION ACTIVITY	DESCRIPTION
19822	7.8 N	165.0 W	10	180	115	250	2	REV 1	LEBEDINSKY, W RIM
19823	.0	169.7 W	70	195	115	250	2	REV 1	CONGREVE
19824	1.6 N	167.4 W	55	200	115	250	2	REV 1	CONGREVE
19825	4.5 N	166.0 W	30	205	115	250	2	REV 1	LEBEDINSKY, S OF
19826	5.8 S	173.0 W	60	205	120	250	7	REV 1	ICARUS
19827	4.3 S	17.2 E	60	275	308	250	3	REV 2	TAYLOR, ALFRAGANUS
19828	6.3 S	17.5 E	55	275	308	250	3	REV 2	TAYLOR, ALFRAGANUS
19829	7.7 S	17.5 E	50	275	308	250	3	REV 2	ZOLLNER, 16 SITE (IN SHADOW)
19830	9.5 S	18.3 E	45	275	309	250	4	REV 2	KANT, G, 16 SITE (IN SHADOW)
19831	11.4 S	17.8 E	50	275	308	250	3	REV 2	KANT, D, DESCARTES
19832	9.0 S	15.4 E	VERT		21	250	10	REV 11	APOLLO 16 LANDING SITE (PARTIAL
19833	6.7 S	3.7 E	10	325	108	250	5	REV 18	HIPPARCHUS
19834	6.8 S	3.2 E	10	330	108	250	4	REV 18	HIPPARCHUS, J
19835	6.9 S	2.6 E	10	330	108	250	4	REV 18	MULLER, E OF
19836	7.1 S	2.2 E	10	330	108	250	3	REV 18	MULLER, E OF
19837	7.4 S	1.5 E	10	340	108	250	3	REV 18	MULLER
19838	5.6 S	1.8 E	30	350	108	250	3	REV 18	MULLER, N OF
19839	11.3 S	.9 W	30	175	110	250	6	REV 24	PTOLEMAEUS, S WALL
19840	11.7 S	.9 W	30	175	110	250	6	REV 24	PTOLEMAEUS, S WALL
19841	12.0 S	1.1 W	35	180	110	250	6	REV 24	PTOLEMAEUS, S WALL

Figure 16. Sample of Orbital Hasselblad Camera Frame Index Ordered by Frame Number

APOLLO 16
HASSELBLAD 70MM (FILM WIDTH) PHOTOGRAPHS
INDEXED BY LONGITUDE 10 - 20 E

NASA PHOTO NO. AS16-	MAG	FILM TYPE	REV	ALT KM.	SUN EL.	LENS MM.	CAMERA TILT	CAMERA AZ	PRINCIPAL POINT LAT.	PRINCIPAL POINT LONG.	DESCRIPTION
121-19398	PP	SO-368	29	115	23	250	65	195	19.6 S	14.0 E	GEBER, B
121-19399	PP	SO-368	29	115	23	250	65	190	19.8 S	13.4 E	GEBER, B
121-19400	PP	SO-368	29	115	23	250	65	195	19.8 S	13.2 E	AZOPHI, ABENEZRA
121-19401	PP	SO-368	29	115	22	250	65	195	20.2 S	12.7 E	AZOPHI, ABENEZRA
121-19402	PP	SO-368	29	115	22	250	65	195	19.5 S	12.7 E	AZOPHI, ABENEZRA
121-19403	PP	SO-368	29	115	22	250	65	195	18.8 S	12.5 E	AZOPHI, ABENEZRA
121-19404	PP	SO-368	29	115	22	250	65	195	19.1 S	12.9 E	ABENEZRA, A
121-19405	PP	SO-368	29	115	21	250	65	195	19.4 S	11.6 E	ABENEZRA, A
121-19406	PP	SO-368	29	115	21	250	65	195	19.3 S	11.3 E	ABENEZRA, A
124-19827	SS	2485	2	308	3	250	60	275	4.3 S	17.2 E	TAYLOR, ALFRAGANUS
124-19828	SS	2485	2	308	3	250	55	275	6.3 S	17.5 E	TAYLOR, ALFRAGANUS
124-19829	SS	2485	2	308	3	250	50	275	7.7 S	17.5 E	ZOLLNER, 16 SITE (IN SHADOW)
124-19830	SS	2485	2	309	4	250	45	275	9.5 S	18.3 E	KANT, G, 16 SITE (IN SHADOW)
124-19831	SS	2485	2	308	3	250	50	275	11.4 S	17.8 E	KANT, D, DESCARTES
124-19832	SS	2485	11	21	10	250	VERT		9.0 S	15.4 E	APOLLO 16 LANDING SITE (PARTIAL)
131-20148	UV	IIA-O	27	114	27	105	20	270	8.0 S	16.6 E	(UV) APOLLO 16 LANDING SITE, 4000A
131-20149	UV	IIA-O	27	114	26	105	20	270	8.0 S	16.4 E	(UV) APOLLO 16 LANDING SITE, 4000A
131-20150	UV	IIA-O	27	114	26	105	20	270	7.8 S	15.8 E	(UV) APOLLO 16 LANDING SITE, 3350A
131-20151	UV	IIA-O	27	114	25	105	20	270	7.8 S	15.1 E	(UV) APOLLO 16 LANDING SITE, 3350A
131-20152	UV	IIA-O	27	114	25	105	20	270	7.6 S	14.5 E	(UV) APOLLO 16 LANDING SITE, 2650A

Figure 17. Sample of Orbital Hasselblad Camera Frame Index Ordered by Longitude in 10° Increments

APOLLO 16
HASSELBLAD 70MM (FILM WIDTH) PHOTOGRAPHS
LUNAR SURFACE - CHRONOLOGICAL LISTING

NASA PHOTO NO. AS16	MAG	FILM TYPE	SUN EL.	LENS MM.	EVA	DESCRIPTION
109-17750	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17751	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17752	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17753	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17754	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17755	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17756	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17757	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17758	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17759	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17760	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17761	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17762	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17763	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17764	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17765	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17766	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17767	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17768	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1
109-17769	G	3401	24	60	1	LRV TRAVERSE, ALSEP TO STA 1

Figure 18. Sample of Surface Hasselblad Camera Frame Index Ordered Chronologically Indicating Activity

• CM Maurer Camera Photographic and Supporting Data

The Maurer photography is available on two 16-mm film reels. One reel contains 1450 ft of color film and the other contains 350 ft of rather poor quality B/W imagery. An NSSDC summary, by magazine, of available Maurer films is given in Table 5. A sample of the index for the CM and LM Maurer photography is given in Figure 19.

NSSDC has removed the cabin and earth-looking footage from the Maurer coverage and deposited this portion of the photography with the Technology Application Center, Albuquerque, New Mexico. Since the films mainly provide photography that is supplementary to sample documentation and experiment deployment and operation, they are not recommended for classroom or general interest purposes. NSSDC can supply the films on a 3-month loan basis to support scientific investigations. Special arrangements may be made for those who require permanent retention. The indexes will be provided routinely on 16-mm microfilm with all requests for Maurer photography. The complete index, by magazine, for the Maurer camera photography is available on 16-mm microfilm and on a microfiche card.

Nikon Camera

• Nikon Camera Operation and Photography

The 35-mm Nikon camera, with a focal length of 55 mm and a relative aperture of f/1.2, was designed for through-the-lens viewing and metering. A very high-speed black and white (VHBW) film, 2485, was used for the Nikon photography. The Command Module pilot operated the camera manually when targets of interest were in view. The mission objectives for the Nikon camera included dim light photography of diffuse galactic light of celestial regions, the zodiacal light, and the north galactic pole. Analysis of the extent, locations, configurations, and light levels of astronomical sources can provide some information on the location of interplanetary and interstellar concentrations of matter. The Nikon camera also exposed photographs of the gegenschein from lunar orbit to attempt to confirm the possible accumulation of matter at the Moulton point and to help assess the contribution to the gegenschein of light that may be reflected from the region of the Moulton point.

TABLE 5. NSSDC SUMMARY OF MAURER COVERAGE

MAGAZINE	FILM	LENS FOCAL LENGTH (mm)	DESCRIPTION
AA	SO-368	18	Transposition and docking
BB	SO-368	75, 18 and 229*	SIM bay door jettison, sextant photography, rendezvous and docking, and TEC view of moon
CC	SO-368	18	LM undocking and separation
EE	SO-368	18	Near-vertical strip on lunar surface from 134°E to 32°W
FF	SO-368	10	TEC EVA to retrieve film canisters
GG	SO-368	18	Entry into earth's atmosphere
HH**	2485	18	Sunrise solar corona
II**	SO-164	18	Mass spectrometer boom viewed in mirrors from CM
MM**	2485	18	Dim light photography
N	SO-368	10	CSM viewed from LM after separation, LM descent
O	SO-368	10	Surface photographs taken during LM ascent; LM and CSM rendezvous; SIM bay inspection
P	SO-368	10	EVA 1
Q	SO-368	10	EVA 2; LRV traverse to LM
R	SO-368	10	EVA 2; LRV traverse
T	SO-368	10	EVA 3; LRV traverse

*Sextant - camera combination.
**Black and white.

MAG.	FILM	LENS F/L (mm)	FRAMES Per Sec	DESCRIPTION
AA	SO368	18	12	Transposition and docking. (GET 3:09) Particles flaking from LM. S-IVB, after separation, at edge of field of view. (GET 4:15)
BB	SO368	75	12	SIM Bay door jettison. (GET 69:59)
		229*	1	Sextant photography: oblique view of landmark J-2 (8.9°S, 24.5°E), REV 3.
		229*	1	Sextant photography: landmark 16-3 (9.0°S, 15.5°E), Apollo 16 landing site, REV 12.
		229*	1	Sextant photography: landmark 16-3 (9.0°S, 15.5°E), Apollo 16 landing site, REV 13.
		229*	1	Sextant photography: near landmark F-1 (1.9°N, 88.3°E) Smyth's Sea, REV 51.
		229*	1	Sextant photography: landmark 16-3 (9.0°S, 15.5°E), Apollo 16 landing site, REV 51.
		18	6	Saenger, NW rim, viewed in mirror, REV 52.
		18	6	Smyth's Sea (3.5°N, 9.1°E to 2.5°N, 87.5°E), viewed in mirror, REV 52.
		18	6	Rendezvous, LM viewed in mirror from CSM; background: Schubert B to eastern Sea of Fertility, REV 52.
		18	6	LM inspection, viewed in mirror from CM; background: Sea of Fertility, REV 53.
		18	6	Docking, LM viewed in mirror from CM; REV 53.
				Transearth coast views of moon: Eastern limb, Border, Smyth's Seas, Joliot. Eastern Sea of Tranquility, Fertility. Sunset terminator at Tsiolkovsky. Full-disc view of eastern hemisphere, Humboldt Sea to Southern Sea.

*Focal length of sextant-camera combination is 9 inches (229 mm).

Figure 19. Sample of Maurer Camera Film Index

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

NATIONAL SPACE SCIENCE DATA CENTER
CODE 601

TELEPHONE
301-982-6695

May 1973

Dear Colleague:

This Apollo 16 Data Users Note has been prepared by the National Space Science Data Center (NSSDC) with important contributions being provided by Mr. George Esenwein and Mr. Leon Kosofsky, Lunar Programs Office, NASA Headquarters. The purpose of this document is to provide you with substantial information on the photography taken during the Apollo 16 mission and to aid you in the selection of Apollo 16 photographs for study. Six index maps indicating the areas covered by the photographs are being sent with this Note.

It should be noted that this information package is quite different from those for the Apollo 11 through Apollo 14 missions. NSSDC, with the aid of the Mapping Sciences Laboratory, Johnson Space Center, prepared photographic proof print catalogs and frame index data in the form of printed documents for these earlier flights. The volume of photography and data increased so greatly with Apollo 15, however, that, starting with that mission, they have been prepared in microform. They are therefore not included with this package. A complete description of the microform photographic catalogs and supporting data available from NSSDC can be found in this Note under the discussions of each of the camera types in the section "Description of Photographic Objectives, Equipment, and Available Data." An order form is provided at the end of the Data Users Note for your use in ordering all forms of Apollo 16 data available from NSSDC.

Your comments on the contents of the Apollo 16 documentation and on the services offered by NSSDC are invited.

Very truly yours,

James I. Vette

James I. Vette
Director, NSSDC

• Nikon Camera Photographic and Supporting Data

Table 6 is a summary of the Nikon photography that was taken during the Apollo 16 mission. Much of the film either was not used or was used for calibration purposes. NSSDC can provide the available frames in the form of negative or positive copies on 35-mm roll film. Individual frames can be provided in the form of 8- x 10-in. paper print enlargements or 3-1/4- x 4-in. or 2- x 2-in. slides. The indexes will be provided routinely on 16-mm microfilm when a large number of individual photographs, a complete set of photography or complete magazines are requested. The Nikon photograpy index is also available on a microfiche card.

Westinghouse TV Camera

The Westinghouse TV camera in the Command Module could be handheld or bracket mounted. This camera was operated at variable f-stops from 4 to 44 using a zoom lens. A 5-cm black and white video monitor, which could be mounted on the camera or at various locations within the CM, aided the crew in focus and exposure adjustments. A camera ring sight also enabled the crew to direct the camera lens at the desired target.

The scanning rate for the Westinghouse TV camera was the commercial 30 fps, 525 scan lines/frame. Scan conversion for black and white monitors was not required. The resolution of the camera was 200 TV lines/picture height (limited by S-band equipment) with an aspect ratio of 4:3 and a range of operation from 5 to 12,000 f-c. Color was achieved by using a rotating disk driven by a synchronous 600-rpm motor.

All of the TV coverage was recorded on 16-mm kinescope roll film. The parts of the film that involve surface activities and lunar liftoff are stored at NSSDC. These films total approximately 34,932 ft. Table 7 is a summary of the TV coverage available. All of this film or specified parts of it can be obtained on a 3-month loan basis. Special arrangements can be made for those who require permanent retention.

Lunar Surface and Lunar Module Photography

The lunar surface and Lunar Module photographic tasks were to obtain:

1. Documentary metric and stereo photographs of emplaced experiments and their operation.

2. Documentary metric and stereo photographs of collected samples and surrounding areas.

TABLE 6. NSSDC SUMMARY OF NIKON DATA

MAGAZINE DESIGNATION	MAGAZINE NO.	FRAME NO.	DESCRIPTION
W (Y on film)	128	Unnumbered	Calibration frames
X	129	20044-20079	Skylab contamination experiment, unused frames
Y (X on film)	130	20080-20093	Some unused, unnumbered frames are calibration frames
XX	127	19992-20026	Some unused, useful imagery listed:
		19992-20012	Zodiacal light
		20014-20019	Earthshine
		20021-20024	Gum Nebula
YY	-	Unnumbered	Calibration frames
ZZ	126	19933-19977	Some unused, useful imagery listed:
		19949	Galactic cluster
		19950-19954	Gegenschein/Moulton point
		19956-19957	Water droplet inside cabin
		19959-19963	Gum Nebula
		19966-19971	Gegenschein/Moulton point
		19972	Galactic cluster in Virgo
		19975-19977	Gegenschein calibration

TABLE 7. NSSDC SUMMARY OF APOLLO 16 TV KINESCOPE FILM LOG

MSC FILM IDENT. NO.	GMT DAY/HR:MIN	COVERAGE
-146	112/1800-1831	EVA 1
-147	112/1831-1916	EVA 1
-148	112/1915-1948	EVA 1
-149	112/1948-2024	EVA 1
-150	112/2024-2126	EVA 1
-151	112/2126-2157	EVA 1
-152	112/2157-2240	EVA 1
-153	112/2240-2331	EVA 1
-155	113/1650-1716	EVA 2
-156	113/1716-1834	EVA 2
-157	113/1834-1853	EVA 2
-158	113/1853-1936	EVA 2
-159	113/1936-2018	EVA 2
-160	113/2018-2110	EVA 2
-161	113/2109-2132	EVA 2
-162	113/2131-2207	EVA 2
-163	113/2206-2307	EVA 2
-164	113/2307-2342	EVA 2
-165	114/1545-1658	EVA 3
-166	114/1658-1728	EVA 3
-167	114/1728-1800	EVA 3
-168	114/1800-1921	EVA 3
-169	114/1921-1957	EVA 3
-170	114/1957-2042	EVA 3
-171	114/2041-2108	EVA 3
-172	115/0124-0129	LM Liftoff
-173	116/0534-0551	Sun Angle #1*
-174	116/0551-0616	Sun Angle #2
-175	117/0626-0658	Sun Angle #2
-176	117/0657-0712	Sun Angle #2
-177	118/0611-0627	Sun Angle #3
-178	118/0627-0654	Sun Angle #3
-192	119/0618-0648	Sun Angle #4
-193	119/0648-0658	Sun Angle #4

*Taken by lunar surface TV camera subsequent to LM liftoff.

3. 360° panoramas of the landing site area.

4. Motion picture photographs of the Lunar Roving Vehicle.

5. Lunar Module descent and ascent sequence photographs.

Carried on the Lunar Module were three Hasselblad electric data cameras (HEDC), two 16-mm Maurer data acquisition cameras; a far UV camera/spectrograph; and an RCA color TV camera.

Lunar Module Hasselblad Electric Data Cameras

• LM Hasselblad Camera Operation and Photography

The Lunar Module carried two Hasselblad electric data cameras with 60-mm focal length lenses and one Hasselblad electric data camera with a 500-mm focal length lens. Each of the cameras had a reseau plate, which provided metric capability. The 60-mm cameras could be handheld in the LM or bracket mounted on a remote control unit on the Lunar Roving Vehicle for EVA photography. The 60-mm cameras were used for photography through the LM window and for documentation of surface activities, sample sites, and experiment installation. These cameras exposed pictures both in color and in black and white. The 500-mm camera, which used black and white film, was used to photograph distant objects from selected points during three EVA periods. Photography from this camera covers the CSM in orbit, scenes of earthrise, and EVA scenes including Stone Mountain, Smoky Mountain, South Ray, North Ray, Baby Ray, and Wreck Craters (For catalog of lunar surface photography, see Batson, et al., 1972).

• Hasselblad Camera Photographic and Supporting Data

The LM Hasselblad cameras exposed more than 1700 frames. The NSSDC inventory in Table 4 gives the complete listing of all Apollo 16 Hasselblad photography that is available from NSSDC. This table also distinguishes between the orbit and surface Hasselblad photographs. As in the case of CM Hasselblad photography, individual black and white photographs, with an image area of 52 x 52 mm on the 70-mm film, can be produced as contact positive or negative film copies on 4- x 5-in. film sheets or as enlarged 8- x 10-in. prints. Enlargements in other format sizes can be prepared for special requests. Complete magazines or complete sets of Hasselblad photography can be produced as positive or negative contact film duplicates (70-mm roll film) or as positive contact paper prints (70-mm roll paper). Color reproductions in the form of positive or negative film copies in a user-specified format will be

provided only to those persons performing specific detailed scientific investigations. Requesters should specify complete frame numbers, e.g., AS16-109-17752, for all photographs requested. A photographic catalog of all Hasselblad photography is available from NSSDC on 16-mm roll film or microfiche.

NSSDC has available one-line indexes that give frame parameters including longitude and latitude of the principal point, tilt and azimuth, sun elevation, approximate altitude of the spacecraft, general mission activity at the time the photograph was taken, camera lens used, and outstanding features of the photographs. These indexes list the photographs three ways: sequentially by NASA frame number; by frame number within a specified longitude range for orbital photography; and chronologically according to lunar surface activities, i.e., pre-EVA, EVA 1, EVA 2, and EVA 3, for those photographs taken while on the lunar surface. Samples of each of these index types are included in Figures 15 through 18. The indexes will be provided routinely on 16-mm microfilm when a large number of individual photographs, a complete set of photography, or complete magazines are requested. Paper copies of the index will be provided with selected individual frames. The Hasselblad and Maurer indexes are also available on microfiche. (For catalog of lunar surface photography, see Batson, et al., 1972). More complete supporting data will not be available.

Lunar Module Maurer Cameras

- LM Maurer Camera Operation and Photography

Two 16-mm Maurer cameras with 10-mm focal length lenses were carried in the Lunar Module. One was mounted in the LM right-hand window, and the other was either handheld or mounted on the LRV during EVAs. The former recorded low-altitude views of the landing site, landing site views during descent and ascent, and maneuvers with the CSM. The latter camera was used to document surface experiments and geologic investigations.

- LM Maurer Camera Photographic and Supporting Data

All 16-mm Maurer film is available as 16-mm film duplicates. NSSDC has one reel containing 1450 ft of color film and one reel containing 350 ft of black and white film. A summary of the Maurer films is given in Table 5. It should be noted that the LM Maurer films as well as the CM Maurer films are not recommended for classroom or general use. NSSDC can supply the films on a 3-month loan basis to support scientific investigations. Special arrangements may be made for those who require permanent retention.

The complete index, by magazine, for the Maurer camera photography, is available on one roll of 16-mm microfilm, and on microfiche together with the Hasselblad index. In addition to the Maurer camera photography index, one-line frame indexes for the panoramic camera, mapping camera, and Nikon and Hasselblad photography are included on the microfilm. The indexes will be provided routinely on 16-mm microfilm when a large number of individual photographs, a complete set of photography, or complete magazines are requested.

UV Camera/Spectrograph

The UV camera/spectrograph experiment, which was not used on any previous Apollo mission, was intended to map deep space concentrations of hydrogen with photographic images and spectrographic data. Targets included the geocorona, the earth's atmosphere, solar wind, nebulae, star fields, clusters of galaxies, galactic objects, solar bow cloud, lunar atmosphere, and lunar volcanic gases. The experiment used a 75-mm (3-in.) electronographic Schmidt camera with a potassium bromide cathode and a 35-mm film magazine and transport. The apparatus was deployed in the shadow of the LM. The camera/spectrograph was fitted with lithium fluoride and calcium fluoride filters for detecting Hα(1216 A) radiation. Measurements ranged from 500 to 1500 A for spectroscopic data and from 1050 to 1550 A and 1250 to 1550 A for photographic energy. Hydrogen clouds should be detectable by a differential measurement of photoimagery.

The data from the UV camera/spectrograph are currently held by the principal investigator. Until these data are deposited in NSSDC, requests should be made to the principal investigator (see Appendix A).

RCA TV Camera

The Lunar Module carried an RCA TV camera that could be mounted on the LM modularized equipment storage assembly (MESA), set up on a tripod, or installed on the LRV. In addition to the crew's being able to aim and control the camera, personnel at the Mission Control Center could activate the camera "on" and "off," pan, tilt, zoom, iris open/close (f/2.2 to f/22), and peak or average light control functions.

The scanning rate for the RCA TV camera was the commercial 30 fps, 525 scan lines/frame. Scan conversion for black and white monitors was not required. The resolution of the camera was 200 TV lines/picture height (limited by S-band equipment) with an aspect ratio of 4:3 and a range of operation from 5 to 12,000 f-c. Color was achieved by using a rotating disk driven by a synchronous 600-rpm motor.

All of the TV coverage was recorded on 16-mm kinescope roll film. The parts of the film that involve surface activities and lunar liftoff are stored at NSSDC. These films total approximately 34,932 ft. Table 7 is a summary of the TV coverage available. All of this film or specified parts of it can be obtained on a 3-month loan basis. Special arrangements can be made for permanent retention.

ORDERING PROCEDURES

Investigators engaged in specific lunar studies will find the photographic indexes and catalogs very important for selecting photographs appropriate to their studies. As stated earlier, a catalog of all panoramic camera frames can be obtained on one reel of 35-mm microfilm whereas all usable mapping camera and Hasselblad camera photos can be obtained on 4- x 6-in. microfiche or 16-mm roll film. Corresponding indexes for these types of photos can be obtained on 16-mm microfilm or microfiche. It should be noted that the indexes for all photography are contained on a single roll of 16-mm microfilm. Microfiche cards include mapping and panoramic camera indexes as a set, and Hasselblad and Maurer camera indexes as a set; one microfiche card contains the Nikon photography index.

When ordering Apollo 16 data, please refer to the index maps that are included with this Data Users Note for the desired coverage and to the catalogs for the frame numbers of the desired photographs. Indicate the following in the request order:

- Apollo mission number.
- Complete frame number(s), e.g., AS16-116-18569 (AS = Apollo Spacecraft; 16 = mission number; 116 = magazine number; 18569 = frame number).
- Form and size of reproduction, e.g., 8- x 10-in. B/W print (glossy) or 4- x 5-in. color positive transparency.
- Other identifying information, e.g., crater or feature name or location of desired portion within a frame of the panoramic camera.

The Apollo 16 Lunar Photography Order Form enclosed with this Note is provided for the requester's convenience. The requester must complete all parts of the form to ensure satisfactory request fulfillment. All required photography should be identified in a single order to expedite the processing of the request.

Requesters should be aware of NSSDC policies concerning the dissemination of data. The purpose of the National Space Science Data Center is to provide data and information from space science experiments in support of additional studies beyond those performed by the principal investigators. Therefore, NSSDC will provide data and information upon request to any individual or organization resident in the United States. In addition, the same services are available to scientists outside the United States through the World Data Center A for Rockets and Satellites. Normally, a charge is made for the requested data to cover the cost of reproduction and the processing of the request. The requester will be notified of the cost, and payment must be received prior to processing the request. The Director of NSSDC may waive, as resources permit, the charge for modest amounts of data when they are to be used for scientific studies or for specific educational purposes and when they are requested by an individual affiliated with: (1) NASA installations, NASA contractors, or NASA grantees; (2) other U.S. Government agencies, their contractors, or their grantees; (3) universities and colleges; (4) state and local governments; or (5) nonprofit organizations.

When a user submits a request, he should indicate the intended scientific use of the ordered data. The Data Center would also appreciate receiving copies of all publications resulting from studies in which data supplied by NSSDC have been used. It is further requested that NSSDC be acknowledged as the source of the data in all publications resulting from use of the data provided.

Requesters may view the Apollo 16 photographs at NSSDC. Inquiries about or requests for photographs from U.S. scientists should be addressed to:

National Space Science Data Center
Code 601.4
Goddard Space Flight Center
Greenbelt, Maryland 20771
Telephone: (301) 982-6695

Requests from researchers outside the U.S.A. should be directed to:

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

Individuals or organizations that wish to obtain Apollo 16 photographic reproductions for purposes other than use in specific scientific research projects or college level space science courses should address their requests to:

Public Information Division
Code FP
National Aeronautics and Space Administration
Washington, D. C. 20546

The Public Information Division also has printed materials available to satisfy general information requests.

Representative sets of Apollo photographs suitable for framing can be obtained (at cost) as full-color lithographs from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D. C. 20402

Requests should specify NASA picture sets as follows:

- NASA Picture Set 1, "Apollo - In the Beginning" ($1.25)
- NASA Picture Set 2, "Men of Apollo" ($1.00)
- NASA Picture Set 3, "Eyewitness to Space" ($2.75)
- NASA Picture Set 4, "First Manned Lunar Landing" ($1.75)
- NASA Picture Set 5, "Man on the Moon" ($1.00)
- NASA Picture Set 6, "Pinpoint for Science" ($1.50)
- NASA Picture Set 7, "Apollo 15" ($1.50)

Inquiries or requests regarding pictures of the earth taken during the Apollo missions should be directed to:

Technology Application Center
University of New Mexico
Albuquerque, New Mexico 87106

ACKNOWLEDGMENTS

The Data Center wishes to thank the individuals and organizations responsible for the photographs and supporting data obtained during the Apollo 16 mission. This mission photography was accomplished by the Apollo 16 crew: Astronauts John W. Young, Thomas K. Mattingly, and Charles M. Duke.

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LIST OF ACRONYMS AND ABBREVIATIONS

AEI	Aerial Exposure Index
ALSEP	Apollo lunar surface experiments package
AS	Apollo spacecraft
AZ	azimuth
B/W	black and white (film)
CDR	commander
CEX	color exterior (film)
CIN	color interior (film)
CM	Command Module
CMP	Command Module pilot
CSM	Command and Service Modules
DAC	data acquisition camera
deg	degree
diag.	diagonal
DOI	descent orbit insertion
EDT	Eastern Daylight Time
Ekt.	Ektachrome
EO	earth oriented
EST	Eastern Standard Time
EVA	extravehicular activity
f	ratio of aperture to focal length
f-c	foot candle
FMC	forward motion compensation
FOV	field of view
fps	frames per second
FWD	forward
GCTA	ground controlled television assembly
GET	ground elapsed time
GMT	Greenwich Mean Time
HBW	high-speed black and white (film)
HCEX	high-speed color exterior (film)
HEC	Hasselblad electric camera
HEDC	Hasselblad electric data camera
hor.	horizontal
hr	hour
IVT	intravehicular traverse
LBW	low-speed black and white (film)
LM	Lunar Module
LOI	lunar orbit insertion
LRV	Lunar Roving Vehicle
mag.	magazine
MASCON	mass concentration
MCS	mapping camera system
MESA	modularized equipment storage assembly

MNVR	maneuver
mrad	milliradian
MSC	Manned Spacecraft Center
msec	millisecond
n.m.	nautical mile
nsec	nanosecond
NSSDC	National Space Science Data Center
NTB	Nuclear Track (Series) B (film)
pic	picture
PMT	photomultiplier tube
REV	orbital revolution number
rpm	revolutions per minute
Rx	receiving
S/C	spacecraft
sec	second
SIM	Scientific Instrument Module
SM	Service Module
SO	special order
STA	station
TEC	transearth coast
TEI	transearth injection
TLC	translunar coast
Tx	transmission
TYP.	typical
UT	universal time
UV	ultraviolet
vert.	vertical
V/H	velocity to height ratio
VHBW	very high-speed black and white (film)

BIBLIOGRAPHY

"Apollo 15 Photograph Evaluation (APE) Data Book," NASA-MSC, MSC-06886, Houston, Texas, June 1972.

"Apollo 16 Index of Mapping Camera and Panoramic Photographs," Lockheed Electronics Co., Inc., NASA-MSC, MSC-07251, Houston, Texas, August 1972.

"Apollo 16 Mission Report," Mission Evaluation Team NASA-MSC, MSC-07230, Houston, Texas, August 1972.

"Apollo 16 Preliminary Science Report," NASA SP-315, 1973.

Batson, R. M., K. B. Larson, V. S. Reed, and R. L. Tyner, "Preliminary Catalog of Pictures on the Lunar Surface during Apollo 16 Mission," U.S. Geological Service Inter-Agency Report, 50, March 19, 1972.

Bulban, E. J., "Problems Mar Apollo 16 Moon Flight," Aviation Week and Space Technology, 96, No. 17, 18-19, April 1972.

"CSM/LM Spacecraft Operational Data Book for J-Missions," North American Rockwell Corp., SNA-8-D-027, NASA-MSC, Houston, Texas, September 22, 1970.

Doyle, F. J., "Photographic Systems for Apollo," Photogrammetric Engineering, 25, October 1970.

Head, J. W., 3rd, and F. H. Goetz, "Descartes Region - Evidence for Copernican-Age Volcanism," J. Geophys. Res., 77, 1368-1374, March 1972.

Lankes, L. R., "The Role of Optics in the Apollo Program," Optical Spectra, 3, September-October 1969.

"Mission Director's Summary Report, Apollo 16," NASA HQ, Washington, D. C., April 27, 1972.

"Mission Science Planning Document," NASA-MSC, MSC-04143, Houston, Texas, March 15, 1972.

APPENDIX A

SUMMARY OF EXPERIMENTS CARRIED ON APOLLO 16

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SUMMARY OF EXPERIMENTS CARRIED ON APOLLO 16

EXPERIMENT	NO.	PRINCIPAL INVESTIGATOR	ADDRESS	OBJECTIVE
			COMMAND MODULE	
CM Photographic Tasks	--	Mr. Frederick J. Doyle*	Topographic Division U.S. Geological Survey 1340 Old Chain Bridge Rd. McLean, Virginia 22101 (202) 343-9445	Obtain photographs of lunar surface features of scientific interest from lunar orbit and during transearth coast, and obtain photographs of low brightness astronomical and terrestrial sources.
Apollo Window Meteoroid	S-176	Mr. B. G. Cour-Palais/TN61	Geology Branch Planetary and Earth Sciences Division NASA-Manned Spacecraft Center Houston, Texas 77058 (713) 483-4757	Acquire data pertaining to the meteoroid cratering flux for masses of 10^{-12} grams or larger.
UV Photography-Earth and Moon	S-177	Dr. Tobias C. Owen	Dept. of Earth and Space Sciences The State University of New York Stony Brook, L.I., New York 11790 (516) 246-5000	Obtain photographs of sun-lit areas of the earth and moon for study of planetary atmospheres and investigation of short wavelength fluorescence from the lunar surface.
Gegenschein from Lunar Orbit	S-178	Mr. Lawrence Dunkelman	Astronomy Systems Branch Code 673 NASA-Goddard Space Flight Center Greenbelt, Maryland 20771 (301) 982-4988	Make photographic observations to determine if, and to what extent, reflection from dust particles at the Moulton point contributes to gegenschein.
Visual Observations from Lunar Orbit	M-191	Dr. Farouk El-Baz	National Air and Space Museum Smithsonian Institution Washington, D.C. 20560 (202) 484-7636	Make and record observations of particular lunar surface features and processes to complement photographic and other remotely sensed data.

*Apollo Orbital Science Photographic Team Chairman

APPENDIX A (continued)

EXPERIMENT	NO.	PRINCIPAL INVESTIGATOR	ADDRESS	OBJECTIVE
			SERVICE MODULE	
SM Photographic Tasks		Mr. Frederick J. Doyle*	Topographic Division U.S. Geological Survey 1340 Old Chain Bridge Rd. McLean, Virginia 22101 (202) 343-9445	Obtain high-resolution panoramic and high-quality metric lunar surface photographs from lunar orbit and metric photos during TEC.
Gamma-Ray Spectrometer	S-160	Dr. James R. Arnold	Chemistry Department University of California at San Diego La Jolla, California 92037 (714) 453-2000 Ext. 1453	Acquire data relating to origin and evolution of the moon through study of chemical differentiation, and determine the composition of the lunar surface.
X-Ray Fluorescence	S-161	Dr. Isidore Adler	Theoretical Studies Branch Code 641 NASA-Goddard Space Flight Center Greenbelt, Maryland 20771 (301) 982-5759	Measure instantaneous fluorescent X-ray flux from the lunar surface; monitor both the direct solar X-ray flux and background galactic flux to obtain a gross analysis of the elemental surface composition of moon; measure X-ray flux of selected galactic objects.
Laser Altimeter	--	Mr. William M. Kaula	Institute of Geophysics and Planetary Physics University of California at Los Angeles Los Angeles, California 90024 (213) 825-4363	Obtain altimeter data from lunar orbit.
Alpha Particle Spectrometer	S-162	Dr. Paul Gorenstein	American Science and Engineering, Inc. 11 Carleton Street Cambridge, Massachusetts 02142 (617) 868-1600 Ext. 214	Acquire data on the gross rate of lunar surface radon evolution and on localized sources of enhanced radon emission for use in constructing a radiation map showing lunar surface inhomogeneities.

*Apollo Orbital Science Photographic Team Chairman

EXPERIMENT	NO.	PRINCIPAL INVESTIGATOR	ADDRESS	OBJECTIVE
Mass Spectrometer	S-165	Dr. John H. Hoffman	Atmospheric and Space Sciences University of Texas at Dallas P.O. Box 30365 Dallas, Texas 75230 (214) 231-1471 Ext. 322	Acquire data on the composition of the lunar ambient atmosphere, locate areas of volcanism, and determine amount of lunar atmospheric contamination due to rocket firing.
Bistatic Radar	S-170	Mr. H. Taylor Howard	Stanford Electronic Laboratory Stanford University Stanford, California 94305 (415) 321-2300 Ext. 3537	Obtain S-band and very high frequency (VHF) radar signals transmitted from the CSM and reflected from the lunar surface.
			LUNAR SURFACE	
Lunar Geology Investigation	S-059	Dr. William Muehlberger	Geology Department University of Texas at Austin Austin, Texas 78712 (512) 471-5172	Obtain better understanding of the Descartes highlands area and surface modification processes through the study of documented lunar geological features and returned lunar samples.
Solar Wind Composition	S-080	Dr. Johannes Geiss	University of Berne Berne, Switzerland	Determine elemental and isotopic composition of the noble gases and other selected elements in the solar wind.
Cosmic-Ray Detector	S-152	Dr. R. L. Fleischer PI Team Chairman	General Physics Laboratory General Electric Research & Development Center Schenectady, New York 12301 (518) 346-8771 Ext. 6469	Measure charge, mass, and energy spectrum of heavy cosmic-ray and solar wind particles in energy ranges from 0.02 to 200 Mev/nucleon and from 0.5 - 10 kev/nucleon and provide calibration data for glass detectors to measure thermal neutron flux at lunar surface and to assess argon-40 implantation.

EXPERIMENT	NO.	PRINCIPAL INVESTIGATOR	ADDRESS	OBJECTIVE
Portable Magnetometer	S-198	Dr. Palmer Dyal	Space Science Division, Electrodynamics Branch Code N204-4 NASA-Ames Research Center Moffett Field, California 94034 (415) 961-1111 Ext. 2706	Obtain data on intensity and direction of lunar magnetic field at the landing site and at widely separated points along the traverse.
Soil Mechanics	S-200	Dr. James K. Mitchell	Dept. of Civil Engineering 4400 Davis Hall University of California at Berkeley Berkeley, California 94726 (415) 642-1262	Obtain data on characteristics and mechanical behavior of lunar soil at surface and subsurface, and variation of these properties in a lateral direction.
Far UV Camera/ Spectrograph	S-201	Dr. George R. Carruthers	E. O. Hulbert Center for Space Research Code 7124.3 Naval Research Laboratory Washington, D.C. 20390 (202) 767-2764	Obtain photographic imagery and spectroscopic data from celestial objects in far UV region.
	--	Co-Investigator Dr. Thornton L. Page	Planetary and Earth Sciences Division NASA-Manned Spacecraft Center Houston, Texas 77058 (713) 483-3589	
			ALSEP	
Passive Seismic	S-031	Dr. Gary Latham	The Marine Biomedical Institute 200 University Boulevard Galveston, Texas 77550 (713) 765-2181	Measure seismic signals from all external and internal sources of seismic energy released on and within the moon.
Active Seismic	S-033	Dr. Robert Kovach	Department of Geophysics Stanford University Stanford, California 94305 (415) 321-2300 Ext. 4827	Acquire data to determine physical properties of lunar surface and subsurface materials.

APPENDIX A (continued)

EXPERIMENT	NO.	PRINCIPAL INVESTIGATOR	ADDRESS	OBJECTIVE
Lunar Surface Magnetometer	S-034	Dr. Palmer Dyal	Space Science Division Electrodynamics Branch Code N204-4 NASA-Ames Research Center Moffett Field, California 94034 (415) 961-1111 Ext. 2706	Measure lunar surface magnetic field vector and its temporal variations to determine magnetic and electrical properties of the moon.
Heat Flow Experiment	S-037	Dr. Marcus E. Langseth	Lamont-Doherty Geological Observatory Columbia University Palisades, New York 10964 (914) 359-2900 Ext. 335	Determine the rate of heat loss from the lunar interior.
			SUBSATELLITE	
S-Band Transponder	S-164	Mr. William L. Sjogren	Jet Propulsion Laboratory Mail Code 156-251 4800 Oak Grove Drive Pasadena, California 91103 (213) 354-4868	Acquire S-band Doppler resolver tracking data to determine distribution of mass along lunar surface ground track and location of mascons.
Particle Shadows/ Boundary Layer	S-173	Dr. Kinsey Anderson	Space Science Laboratory University of California at Berkeley Berkeley, California 94726 (415) 642-1313	Study the plasma flow and electric fields associated with the solar wind, magnetotail, and physics of solar wind.
Magnetometer	S-174	Dr. Paul J. Coleman, Jr.	Department of Planetary and Space Science University of California at Los Angeles Los Angeles, California 90024 (213) 825-1776	Obtain data on electrical and magnetic properties of the moon, interaction of solar wind plasma with the moon, and physical processes in solar wind plasma.

APPENDIX B

SAMPLES OF APOLLO 16 PHOTOGRAPHY

Samples of Apollo 16 Photography

The following pages contain sample photographs, as identified below, taken during the Apollo 16 mission.

B-1. Enlargement of 70-mm Hasselblad Frame AS16-124-19830, taken with the 250-mm focal length lens, showing the Descartes highlands with the landing area in shadow. Largest crater (lower right corner) is Kant. North is at the top.

B-2. Hasselblad (with the 60-mm lens) contact photograph (Frame AS16-116-18601), taken at Station 11 during EVA 2 on the lunar surface, showing part of the North Ray Crater.

B-3. Hasselblad (with the 500-mm lens) contact photograph (Frame AS16-112-18255), taken at Station 4 during EVA 2 on the lunar surface, showing part of the South Ray Crater.

B-4. Hasselblad (with the 60-mm lens) contact photograph (Frame AS16-113-18295), from the LM in orbit, showing the craters Theophilus and Madler (26°SE, 12.6°S).

B-5. Hasselblad (with the 80-mm lens) contact photograph (Frame AS16-122-19530), from orbit, showing the LM over the MacLaurin Crater (70°E, 0.2°N) approaching for rendezvous with the CM.

B-6. Mapping camera contact photograph (Frame AS16-2463), showing the craters Abulfeda, Almanon, their famous crater chain (top center), and the Descartes landing site between the two small ray craters (bottom center). South is at the top.

B-7. Panoramic camera reduced photograph (Frame AS16-4623), showing the lunar surface in the vicinity of the Descartes landing site, which is located between the two small ray craters at the center. North is at the top.

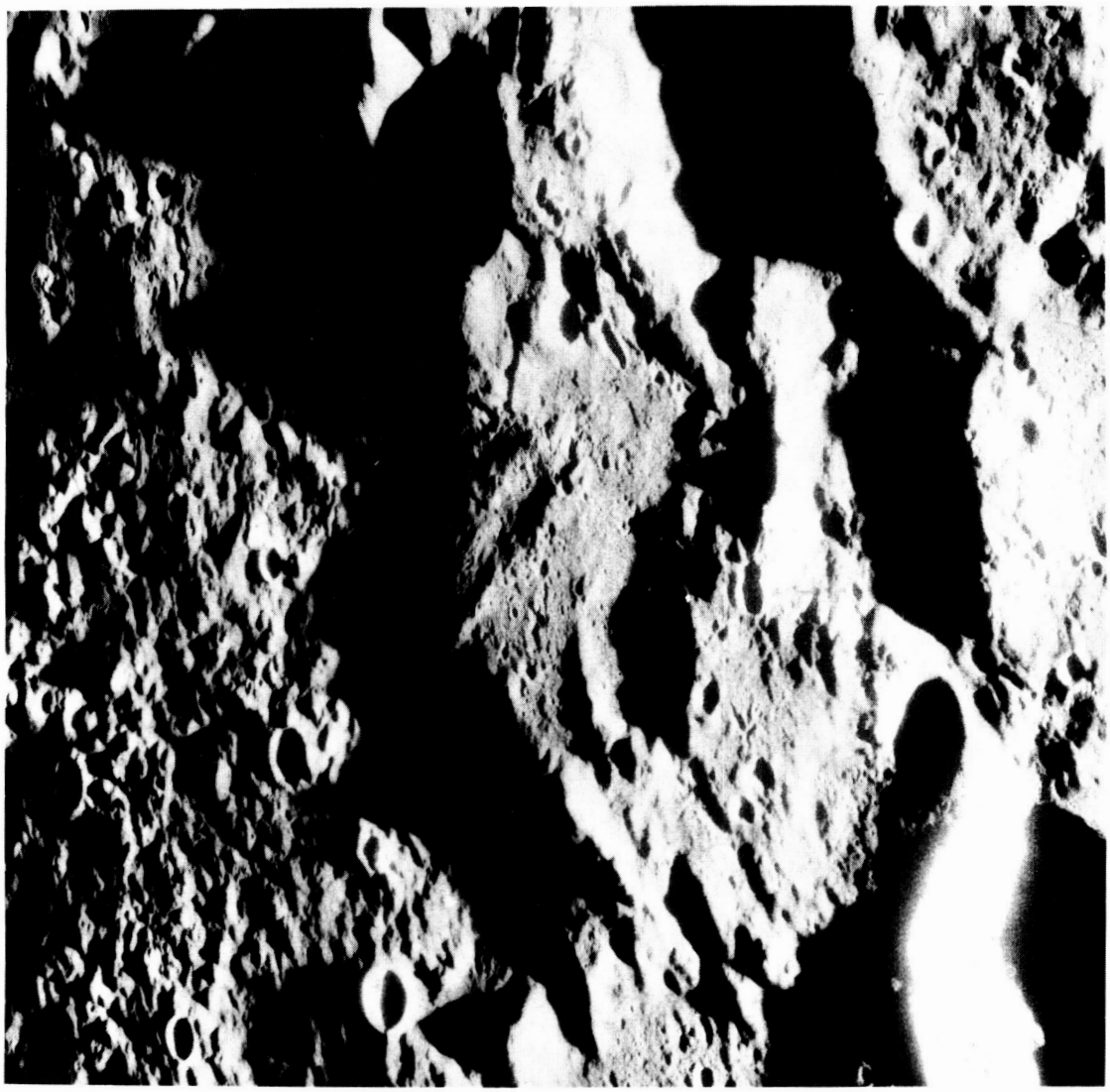


Figure B-1. 250-mm Hasselblad (Orbit)

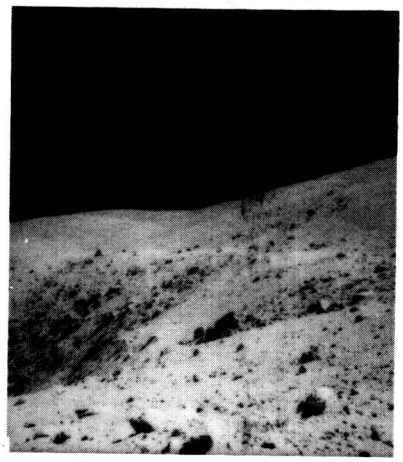


Figure B-2. 60-mm Hasselblad (Surface)

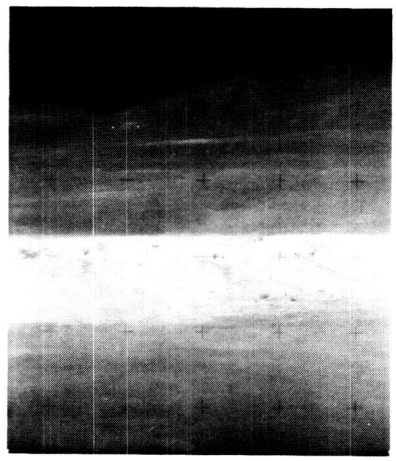


Figure B-3. 500-mm Hasselblad (Surface)

Figure B-4. 60-mm Hasselblad (Orbit)

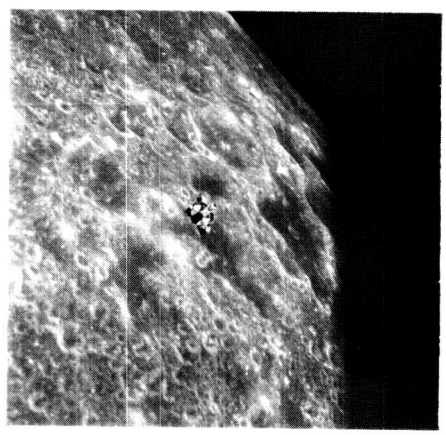


Figure B-5. 80-mm Hasselblad (Orbit)

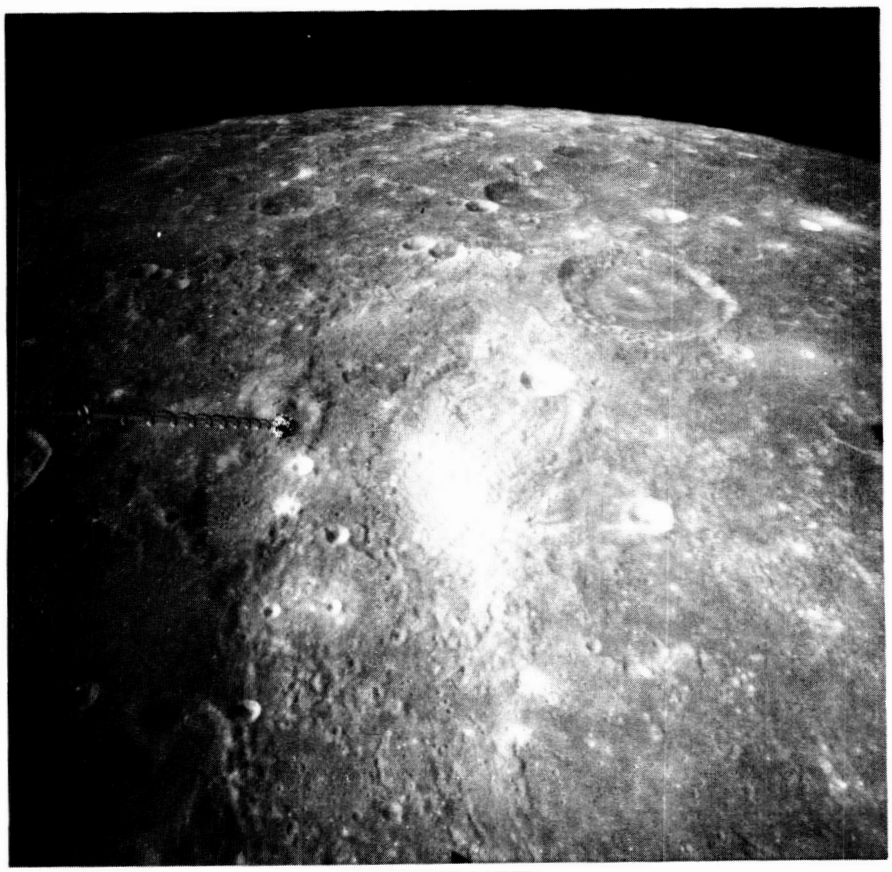
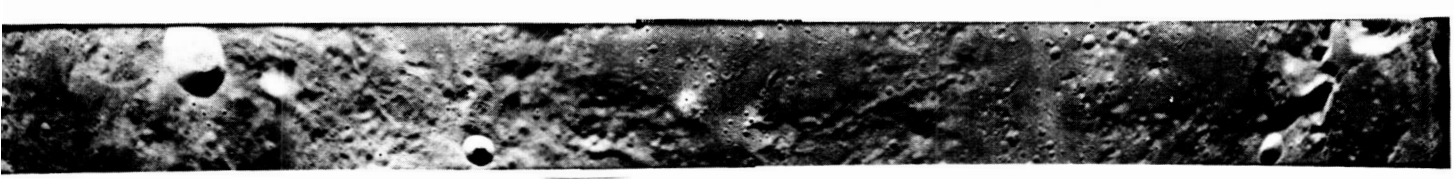


Figure B-6. Mapping Camera



AS16 PAN 4623

Figure B-7. Panoramic Camera (reduced from 5 x 48 in.)