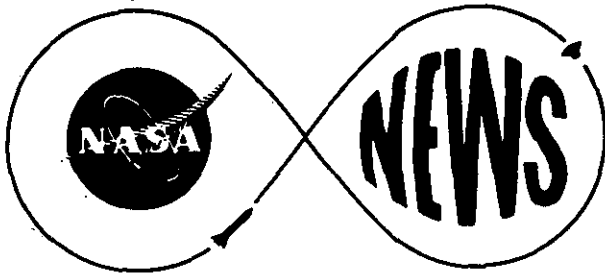


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**NATIONAL AERONAUTICS AND  
SPACE ADMINISTRATION**  
Washington, D. C. 20546  
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RELEASE NO: 72-64K

**FOR RELEASE:**  
THURSDAY A.M.  
April 6, 1972

**PROJECT:** APOLLO 16  
(To be launched no  
earlier than April 16)



**P  
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S**

**contents**

GENERAL RELEASE . . . . .	1-5
COUNTDOWN . . . . .	6-10
Launch Windows . . . . .	9
Ground Elapsed Time Update . . . . .	10
LAUNCH AND MISSION PROFILE . . . . .	11-39
Launch Events . . . . .	15-16
Mission Events . . . . .	19-24
EVA Mission Events . . . . .	29-39
APOLLO 16 MISSION OBJECTIVES . . . . .	40-41
SCIENTIFIC RESULTS OF APOLLO 11, 12, 14 AND 15 MISSIONS . . . . .	42-44
APOLLO 16 LANDING SITE . . . . .	45-47
LUNAR SURFACE SCIENCE . . . . .	48-85
Passive Seismic Experiment . . . . .	48-52
ALSEP to Impact Distance Table . . . . .	52-55
Lunar Surface Magnetometer . . . . .	55-58
Magnetic Lunar Sample Returned to the Moon . . . . .	59
Lunar Heat Flow Experiment . . . . .	60-65
ALSEP Central Station . . . . .	65
SNAP-27 -- Power Source for ALSEP . . . . .	66-67
Soil Mechanics . . . . .	68
Lunar Portable Magnetometer . . . . .	68-71
Far Ultraviolet Camera/Spectroscope . . . . .	71-73
Solar Wind Composition Experiment . . . . .	73
Cosmic Ray Detector . . . . .	74
Lunar Geology Investigation . . . . .	75-78
Apollo Lunar Geology Hand Tools . . . . .	79-85
LUNAR ORBITAL SCIENCE . . . . .	86-98
Gamma-Ray Spectrometer . . . . .	86
X-Ray Fluorescence Spectrometer . . . . .	86
Alpha-Particle Spectrometer . . . . .	86

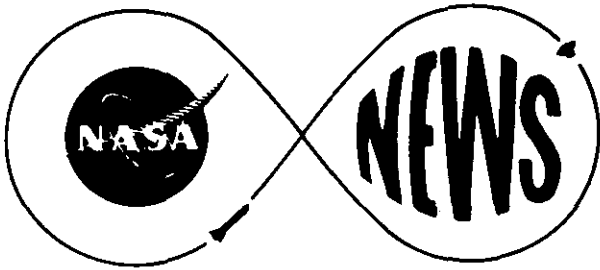
**K  
I  
T**

Laser Altimeter . . . . .	93
Subsatellite. . . . .	93-96
UV Photography-Earth and Moon . . . . .	96
Gegenschein from Lunar Orbit. . . . .	96
CSM/LM S-Band Transponder . . . . .	97
Bistatic Radar Experiment . . . . .	98
Apollo Window Meteoroid . . . . .	98
MEDICAL EXPERIMENTS AND TESTS . . . . .	99-101
Microbial Response in Space Environment . . . . .	99
Visual Light Flash Phenomenon . . . . .	99-100
Biostack. . . . .	100
Bone Mineral Measurement. . . . .	101
ENGINEERING/OPERATIONAL TESTS AND DEMONSTRATION . . . . .	102-104
Skylab Contamination Study. . . . .	102
Skylab Food Package . . . . .	102-103
Improved Gas/Water Separator. . . . .	103
Improved Fecal Collection Bag . . . . .	103
Electrophoretic Separation Demonstration. . . . .	103-104
LUNAR ROVING VEHICLE. . . . .	105-118
General Description . . . . .	105-109
Mobility System . . . . .	109-111
Crew Station. . . . .	111-114
Navigation System . . . . .	114-115
Power System. . . . .	115
Thermal Control . . . . .	115-116
Stowage and Deployment. . . . .	116
LUNAR COMMUNICATIONS RELAY UNIT (LCRU). . . . .	119-120
TELEVISION AND GROUND COMMANDED TELEVISION ASSEMBLY . . . . .	121-122
PHOTOGRAPHIC EQUIPMENT. . . . .	123-125
ASTRONAUT EQUIPMENT . . . . .	126-136
Space Suit. . . . .	126-129
Personal Hygiene. . . . .	130
Survival Kit. . . . .	130
Medical Kits. . . . .	131
Crew Food System. . . . .	132-136
APOLLO 16 FLAGS, LUNAR MODULE PLAQUE. . . . .	137
SATURN V LAUNCH VEHICLE . . . . .	138-140
APOLLO SPACECRAFT . . . . .	141-146
Launch Escape System. . . . .	141
Command Module. . . . .	141
Service Module. . . . .	143
Spacecraft-LM Adapter Structure . . . . .	143
Lunar Module. . . . .	144-146
CREW BIOGRAPHIES. . . . .	147-162
SPACEFLIGHT TRACKING AND DATA SUPPORT NETWORK . . . . .	163-166
NASA Communications Network (NASCOM). . . . .	163-165
ENVIRONMENTAL IMPACT OF APOLLO/SATURN V MISSION . . . . .	167-168
PROGRAM MANAGEMENT. . . . .	169-171
CONVERSION TABLE. . . . .	172

TABLES AND ILLUSTRATIONS

Apollo 16 Flight Profile . . . . .	12
Apollo 16 vs Apollo 15 Operational Differences . . . . .	13
Comparison of Apollo Missions. . . . .	14
Launch Events. . . . .	15-16
Apollo 16 In-Flight Activities . . . . .	17
Apollo 16. . . . .	18
Powered Descent Vehicle Positions. . . . .	21
Approach Phase . . . . .	22
First View of Descartes. . . . .	23
Film Retrieval From the Sim Bay. . . . .	25
Apollo 16 Recovery . . . . .	26
Apollo 16 Crew Post-Landing Activities . . . . .	27
Apollo 16 Alternate Missions . . . . .	28
Descartes LRV Traverses. . . . .	30
Apollo 16 Traverse Comparison with Apollo 15 . . . . .	31
Apollo 16 Lunar Surface Timeline . . . . .	32
Summary Time Line. . . . .	33
Near LM Lunar Surface Activity . . . . .	34
Apollo 16 Walking Traverse . . . . .	39
Apollo 16 Traverses - Geologic Sketch. . . . .	46
Apollo Landing Sites . . . . .	47
Lunar Surface Science Experiment Assignments . . . . .	49
Lunar Surface Experiment Scientific Discipline	
Contribution Correlation . . . . .	50
Apollo 16 ALSEP Deployment . . . . .	51
S-IVB/IU Impact. . . . .	53
Lunar Impact Target for Spent LM Ascent Stage. . . . .	54
Lunar Magnetic Environment . . . . .	57
Active Seismic Experiment. . . . .	63
Active Seismic Experiment Mortar Mode Concept. . . . .	64
Soil Mechanics Experiment Penetrometer . . . . .	69
Lunar Portable Magnetometer. . . . .	70
Tripod-Mounted Schmidt Electronographic UV Camera/Spectroscope	72
Lunar Geology Hand Tools . . . . .	83
Lunar Geology Sample Containers. . . . .	84
Extractor. . . . .	85
Lunar Orbital Science Experiment Assignments . . . . .	87
Apollo 16 Orbital Timeline . . . . .	88
Apollo 16 Potential Lunar Orbit Coverage . . . . .	89
Mission SIM Bay Science Equipment Installation . . . . .	90
Apollo Mapping Camera Systems. . . . .	92
Apollo Subsatellite. . . . .	94
SIM Bay Subsatellite Experiments Concepts. . . . .	95
LRV Without Stowed Payload . . . . .	106
LRV Components and Dimensions. . . . .	107
LRV Wheel. . . . .	110
LRV Crew Station Components - Control and Display Console. . . . .	112
Hand Controller. . . . .	113
LRV Deployment Sequence. . . . .	117
Lunar Field Geology Equipment Stowage on LRV . . . . .	118

Apollo 16 Television Events . . . . .	122
TV and Photographic Equipment . . . . .	125
Extravehicular Mobility Unit. . . . .	127
Apollo 16 Menu - Blue . . . . .	134
Apollo 16 - LM11 Menu . . . . .	135
Apollo 16 Pantry Stowage Items. . . . .	136
Saturn V Launch Vehicle . . . . .	139
Command Module. . . . .	142
Lunar Module. . . . .	145
Manned Space Flight Tracking Network. . . . .	166
Apollo/Saturn Officials . . . . .	170-171
Conversion Table. . . . .	172



**NATIONAL AERONAUTICS AND  
SPACE ADMINISTRATION**

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**FOR RELEASE:**

THURSDAY A.M.

April 6, 1972

Kenneth C. Atchison  
(Phone: 202/755-3114)

RELEASE NO: 72-64

APOLLO 16 LAUNCH APRIL 16

// Apollo 16 { scheduled for an April 16 launch } will devote its 12-day duration to gathering additional knowledge about the environment on and around the Moon and about our own planet Earth. //

During the three days two Apollo 16 crewmen spend on the lunar surface north of the crater Descartes, they will extend the exploration begun by Apollo 11 in the summer of 1969 and continued through the Apollo 12, 14, and 15 lunar landing missions. In addition to gathering samples of lunar surface material for analysis on Earth, the crew will emplace a fourth automatic scientific station.

- more -

March 22, 1972

An extensive array of scientific experiments in the orbiting command/service module will search out and record data on the physical properties of the Moon and near-lunar space and photographic images to further refine mapping technology. Additionally, the command module pilot will photograph astronomical phenomena in the distant reaches of space.

The Descartes landing site is a grooved, hilly region which appears to have undergone some modification by volcanic processes during formation. The Descartes region is in the southeast quadrant of the visible face of the Moon and will offer an opportunity to examine several young, bright-rayed craters created by impacts in the volcanic terrain.

John W. Young is Apollo 16 mission commander, with Thomas K. Mattingly flying as command module pilot and Charles M. Duke, Jr. as lunar module pilot. Young is a US Navy captain, Mattingly a Navy lieutenant commander, and Duke a US Air Force lieutenant colonel.

- more -

Young and Duke will climb down from the lunar module onto the lunar surface for three seven-hour periods of exploration and experimentation. A major part of the first EVA will be devoted to establishing the nuclear powered, automatic scientific station -- Apollo Lunar Surface Experiment Package (ALSEP) -- which will return scientific data to Earth for many months for correlation with data still being returned by the Apollo 12, 14 and 15 ALSEPs.

The second and third EVAs will be devoted primarily to geological exploration and sample gathering in selected areas in the vicinity of the landing site. As in past missions, the crew's observations and comments will be supplemented by panoramic, stereo, and motion picture photographic coverage and also by television coverage. Crew mobility again will be aided by the use of the lunar roving vehicle.

In lunar orbit, Mattingly will operate experiments in the scientific instrument module (SIM) bay for measuring such things as the lunar surface chemical composition, and the composition of the lunar atmosphere. A high-resolution camera and a mapping camera in the SIM bay will add to the imagery and photogrammetry gathered by similar cameras flown on Apollo 15. Mattingly will perform an inflight EVA during transearth coast to retrieve film cassettes from these cameras.

Using hand-held cameras, Mattingly will photograph such phenomena in deep space as the Gegenschein, and looking earthward, photograph the ultraviolet spectra around Earth.

A second subsatellite, similar to the one flown on Apollo 15, will be ejected into lunar orbit to measure the effect of the Earth's magnetosphere upon the Moon and to investigate the solar wind and the lunar gravity field.

Apollo 16 is scheduled for launch at 12:54 pm EST April 16 from the NASA Kennedy Space Center's Launch Complex 39, with lunar landing taking place on April 20. The landing crew will remain at Descartes for 73 hours before returning to lunar orbit and for rendezvous with the orbiting command module on April 23. Earth splashdown will occur on April 28 at 3:30 pm EST at 5 degrees north latitude and 158.7 degrees west longitude in the central Pacific just north of Christmas Island. The prime recovery vessel, USS Ticonderoga, an aircraft carrier, will be located near the splashdown point to recover the crew and spacecraft.



Communications call signs to be used during Apollo 16 are "Casper" for the command module and "Orion" for the lunar module. The United States flag will be erected on the lunar surface in the vicinity of the lunar module, and a stainless steel plaque engraved with the landing date and crew signatures will be affixed to the LM front landing gear.

Apollo 16 backup crewmen are civilian Fred W. Haise, Jr., commander; USAF LtCol Stuart A. Roosa, command module pilot; and USN Captain Edgar D. Mitchell, lunar module pilot.

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### COUNTDOWN

The Apollo 16 launch countdown will be conducted by a government-industry team working in two control centers at the Kennedy Space Center (KSC).

Overall space vehicle operations will be controlled from Firing Room No.1 in the Complex 39 Launch Control Center. The spacecraft countdown will be run from an Acceptance Checkout Equipment control room in the Manned Spacecraft Operations (MSO) Building.

Extensive checkout of the launch vehicle and spacecraft components are completed before the space vehicle is ready for the final countdown. The prime and backup crews participate in many of these tests, including mission simulations, altitude runs, a flight readiness test and a countdown demonstration test.

The Apollo 16 rollout -- the 5.5-kilometer (3.4-nautical-mile) trip from the Vehicle Assembly Building (VAB) to the launch pad -- took place Dec. 13, 1971. Due to a problem associated with the fuel tank system in the command module reaction control system, the space vehicle was returned to the VAB on Jan. 27. The spacecraft was taken to the MSO Building for changeout of the tanks. After re-mating the spacecraft with the launch vehicle, the KSC team again rolled Apollo 16 back to Pad A on Feb. 9, 1972.

Apollo 16 will be the tenth Saturn V launched from Pad A (eight manned). Apollo 10 was the only launch from Pad B, which will be used again in 1973 for the Skylab program.

The Apollo 16 precount activities will start at T-6 days. The early tasks include electrical connections and pyrotechnic installation in the space vehicle. Mechanical build-up of the spacecraft is completed, followed by servicing of the various gases and cryogenic propellants (liquid oxygen and liquid hydrogen) to the CSM and LM. Once this is accomplished, the fuel cells are activated.

The final countdown begins at T-28 hours when the flight batteries are installed in the three stages and instrument unit of the launch vehicle.

-more-

At the T-9 hour mark, a built-in hold of nine hours and 54 minutes is planned to meet contingencies and provide a rest period for the launch crew. A one hour built-in hold is scheduled at T-3 hours 30 minutes.

Following are some of the highlights of the latter part of the count:

T-10 hours, 15 minutes	Start mobile service structure move to park site.
T-9 hours	Built-in hold for nine hours and 54 minutes. At end of hold, pad is cleared for LV propellant loading.
T-8 hours, 05 minutes	Launch vehicle propellant loading - Three stages (LOX in first stage, LOX and LH <sub>2</sub> in second and third stages). Continues thru T-3 hours 38 minutes.
T-4 hours, 15 minutes	Flight crew alerted.
T-4 hours, 00 minutes	Crew medical examination.
T-3 hours, 30 minutes	Crew breakfast.
T-3 hours, 30 minutes	One-hour built-in hold.
T-3 hours, 06 minutes	Crew departs Manned Spacecraft Operations Building for LC-39 via transfer van.
T-2 hours, 48 minutes	Crew arrival at LC-39.
T-2 hours, 40 minutes	Start flight crew ingress.
T-1 hour, 51 minutes	Space Vehicle Emergency Detection System test (Young participates along with launch team).
T-43 minutes	Retract Apollo access arm to standby position (12 degrees).
T-42 minutes	Arm launch escape system. Launch vehicle power transfer test, LM switch to internal power.

-more-

T-37 minutes	Final launch vehicle range safety checks (to 35 minutes).
T-30 minutes	Launch vehicle power transfer test, LM switch over to internal power.
T-20 minutes to T-10 minutes	Shutdown LM operational instrumentation.
T-15 minutes	Spacecraft to full internal power.
T-6 minutes	Space vehicle final status checks.
T-5 minutes, 30 seconds	Arm destruct system.
T-5 minutes	Apollo access arm fully retracted.
T-3 minutes, 6 seconds	Firing command (automatic sequence).
T-50 seconds	Launch vehicle transfer to internal power.
T-8.9 seconds	Ignition start.
T-2 seconds	All engines running.
T-0	Liftoff.

NOTE: Some changes in the countdown are possible as a result of experience gained in the countdown test which occurs about two weeks before launch.

LAUNCH WINDOWS

The mission planning considerations for the launch phase of a lunar mission are, to a major extent, related to launch windows. Launch windows are defined for two different time periods: a "daily window" has a duration of a few hours during a given 24-hour period; a "monthly window" consists of a day or days which meet the mission operational constraints during a given month or lunar cycle.

Launch windows are based on flight azimuth limits of 72° to 100° (Earth-fixed heading east of north of the launch vehicle at end of the roll program), on booster and spacecraft performance, on insertion tracking, and on Sun elevation angle at the lunar landing site.

<u>LAUNCH DATE</u>	<u>Launch Windows*</u>		<u>SUN ELEVATION ANGLE</u>
	<u>OPEN</u>	<u>CLOSE</u>	
April 16, 1972	12:54 pm	4:43 pm	11.9°
May 14, 1972	12:17 pm	4:01 pm	6.8°
May 15, 1972	12:30 pm	4:09 pm	6.8°
May 16, 1972	12:38 pm	4:13 pm	18.6°
June 13, 1972**	10:50 am	2:23 pm	13.0°
June 14, 1972**	10:57 am	2:26 pm	13.0°
June 15, 1972**	( ----- To Be Determined ----- )		

\* April times are Eastern Standard Time; all others are Eastern Daylight Time.

\*\* Launch window times and Sun elevation angles for June will be refined. The June 15, 1972 launch opportunity is under review.

GROUND ELAPSED TIME UPDATE

It is planned to update, if necessary, the actual ground elapsed time (GET) during the mission to allow the major flight plan events to occur at the pre-planned GET regardless of either a late liftoff or trajectory dispersions that would otherwise have changed the event times.

For example, if the flight plan calls for descent orbit insertion (DOI) to occur at GET 82 hours, 40 minutes and the flight time to the Moon is two minutes longer than planned due to trajectory dispersions at translunar injection, the GET clock will be turned back two minutes during the translunar coast period so that DOI occurs at the pre-planned time rather than at 82 hours, 42 minutes. It follows that the other major mission events would then also be accomplished at the pre-planned times.

Updating the GET clock will accomplish in one adjustment what would otherwise require separate time adjustments for each event. By updating the GET clock, the astronauts and ground flight control personnel will be relieved of the burden of changing their checklists, flight plans, etc.

The planned times in the mission for updating GET will be kept to a minimum and will, generally, be limited to three updates. If required, they will occur at about 53, 97, and 150 hours into the mission. Both the actual GET and the update GET will be maintained in the MCC throughout the mission.

-more-

LAUNCH AND MISSION PROFILE

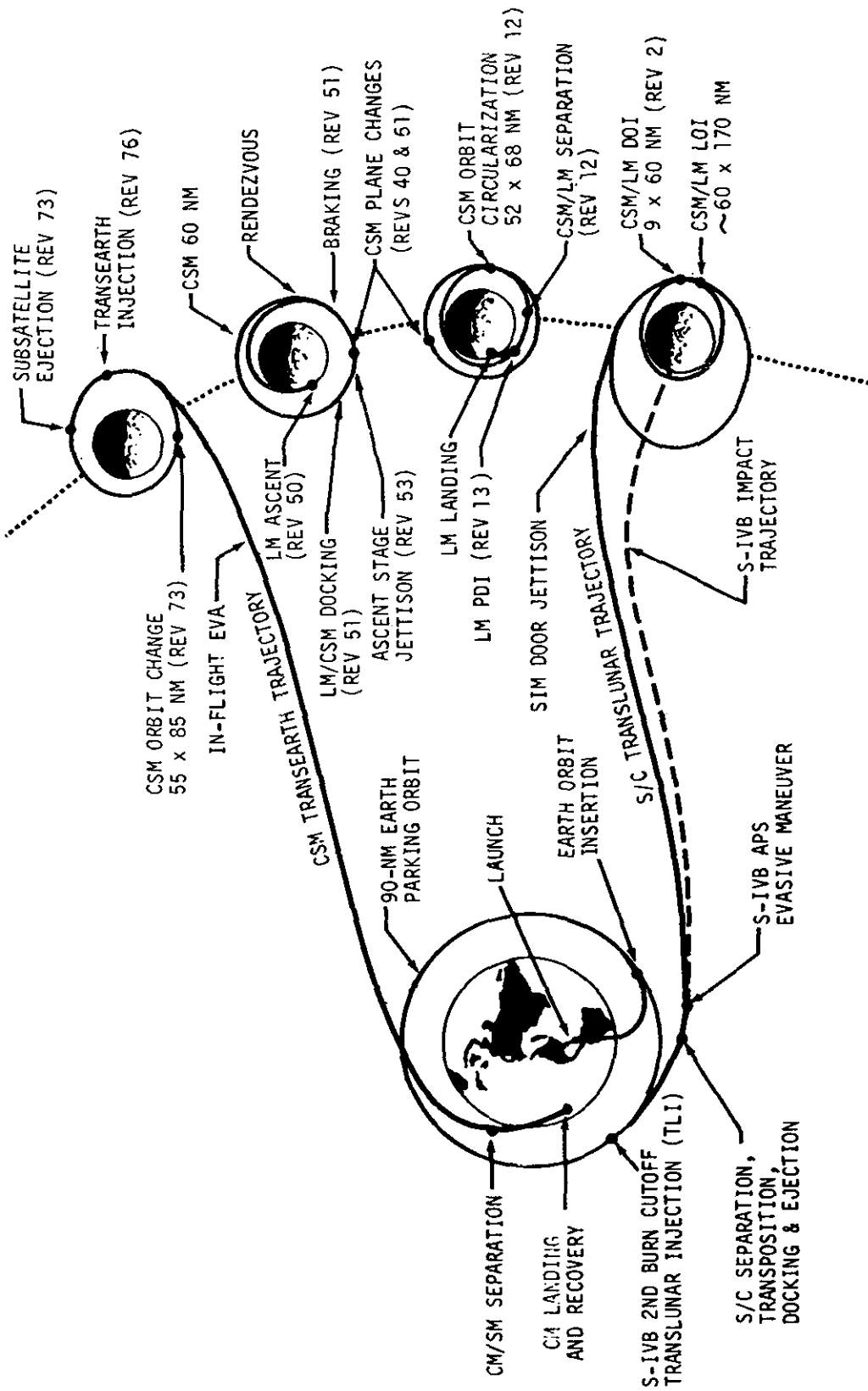
The Saturn V launch vehicle (SA-511) will boost the Apollo 16 spacecraft from Launch Complex 39A at the Kennedy Space Center, Fla., at 12:54 p.m. EST April 16, 1972, on an azimuth of 72 degrees.

The first stage (S-IC) will lift the vehicle 68.4 kilometers (37 nautical miles) above the Earth. After separation the booster stage will fall into the Atlantic Ocean about 668 km (361 nautical mi.) downrange from Cape Kennedy, approximately nine minutes, 14 seconds after liftoff.

The second stage (S-II) will push the vehicle to an altitude of about 173 km (93.6 nautical mi.). After separation the S-II stage will follow a ballistic trajectory which will plunge it into the Atlantic about 4,210 km (2,273 nautical mi.) downrange about 19 minutes, 51 seconds into the mission.

The single engine of the third stage (S-IVB) will insert the vehicle and spacecraft into a 173-km (93-nautical mi.) circular Earth parking orbit before it is cut off for a coast period. When reignited, the engine will inject the Apollo spacecraft into a trans-lunar trajectory.

# APOLLO 16 FLIGHT PROFILE





# APOLLO 16 vs APOLLO 15 OPERATIONAL DIFFERENCES

ITEM	APOLLO 16	APOLLO 15
LAUNCH AZIMUTH	72 - 100°	80 - 100°
INCLINATION	9°	26°
DOI TRIM MANEUVER	NOT PLANNED	ACCOMPLISHED
HIGH ALTITUDE LANDMARK TRACKING AND TV OF LANDING SITE	NO	YES
PDI	REV 13	REV 14
SURFACE STAY TIME	~73 HOURS	66.9 HOURS
SURFACE REST CYCLE	8 HOURS (REST BEFORE LIFTOFF)	7 - 7 1/2 HOURS (NO REST BEFORE LIFTOFF)
EVA's: DURATION (HRS) (PLANNED)	7 - 7 - 7	7 - 7 - 6
SEVA	NO	YES
TRAVERSE STATION TIMES	9:40 (PLANNED)	7:53 (PLANNED) 5:00 (ACTUAL)
SURFACE ACTIVITIES	ALSEP DEPLOYED FIRST	TRAVERSE FIRST
LUNAR ORBIT PLANE CHANGES	2	1
EARTH RETURN INCLINATION	62°	40°
LANDING	PLAN TO RECOVER PARA- CHUTES AND RETAIN RCS PROPELLANTS ON BOARD	NEITHER APOLLO 16 TYPE EVENTS WERE PLANNED

## COMPARISON OF APOLLO MISSIONS

	PAYLOAD DELIVERED TO LUNAR SURFACE KG (LBS)	EVA DURATION (HR:MIN)	SURFACE DISTANCE TRAVERSED (KM)	SAMPLES RETURNED KG (LBS)
APOLLO 11	104 (225)	2:24	.25	20.7 (46)
APOLLO 12	166 (365)	7:29	2.0	34.1 (75)
APOLLO 14	209 (460)	9:23	3.3	42.8 (94)
APOLLO 15	550 (1210)	18:33	27.9	76.6 (169)
APOLLO 16 (PLANNED)	558 (1228)	21:00	25.7	88.6 (195)

LAUNCH EVENTS

<u>Time</u>		<u>Event</u>	<u>Vehicle Wt</u> Kilograms (Pounds)*	<u>Altitude</u> Meters (Feet)*	<u>Velocity</u> Mtrs/Sec (Ft/Sec)*	<u>Range</u> Kilometers (Naut. Mi.)*
Hrs	Min Sec					
00	00 00	First Motion	2,920,956 (6,439,605)	60 (198)	0 (0)	0 (0)
00	01 20	Maximum Dynamic Pressure	1,853,350 (4,085,937)	12,646 (41,491)	481 (1,577)	5 (3)
00	02 18	S-IC Center Engine Cutoff	1,084,409 (2,390,712)	47,153 (154,703)	1,712 (5,618)	51 (27)
00	02 40	S-IC Outboard Engines Cutoff	843,020 (1,858,541)	67,371 (221,034)	2,369 (7,773)	91 (49)
00	02 42	S-IC/S-II Separation	676,542 (1,491,519)	69,094 (226,685)	2,375 (7,792)	95 (51)
00	02 44	S-II Ignition	676,542 (1,491,519)	70,645 (231,775)	2,369 (7,771)	98 (53)
00	03 12	S-II Aft Interstage Jettison	644,029 (1,419,840)	95,024 (311,758)	2,474 (8,117)	161 (87)
00	03 18	Launch Escape Tower Jettison	633,419 (1,396,451)	99,428 (326,207)	2,503 (8,213)	174 (94)
00	07 40	S-II Center Engine Cutoff	303,470 (669,037)	174,389 (572,142)	5,201 (17,065)	1,095 (591)
00	09 17	S-II Outboard Engines Cutoff	216,673 (477,682)	174,130 (571,291)	6,568 (21,550)	1,650 (891)

\* English measurements given in parentheses.

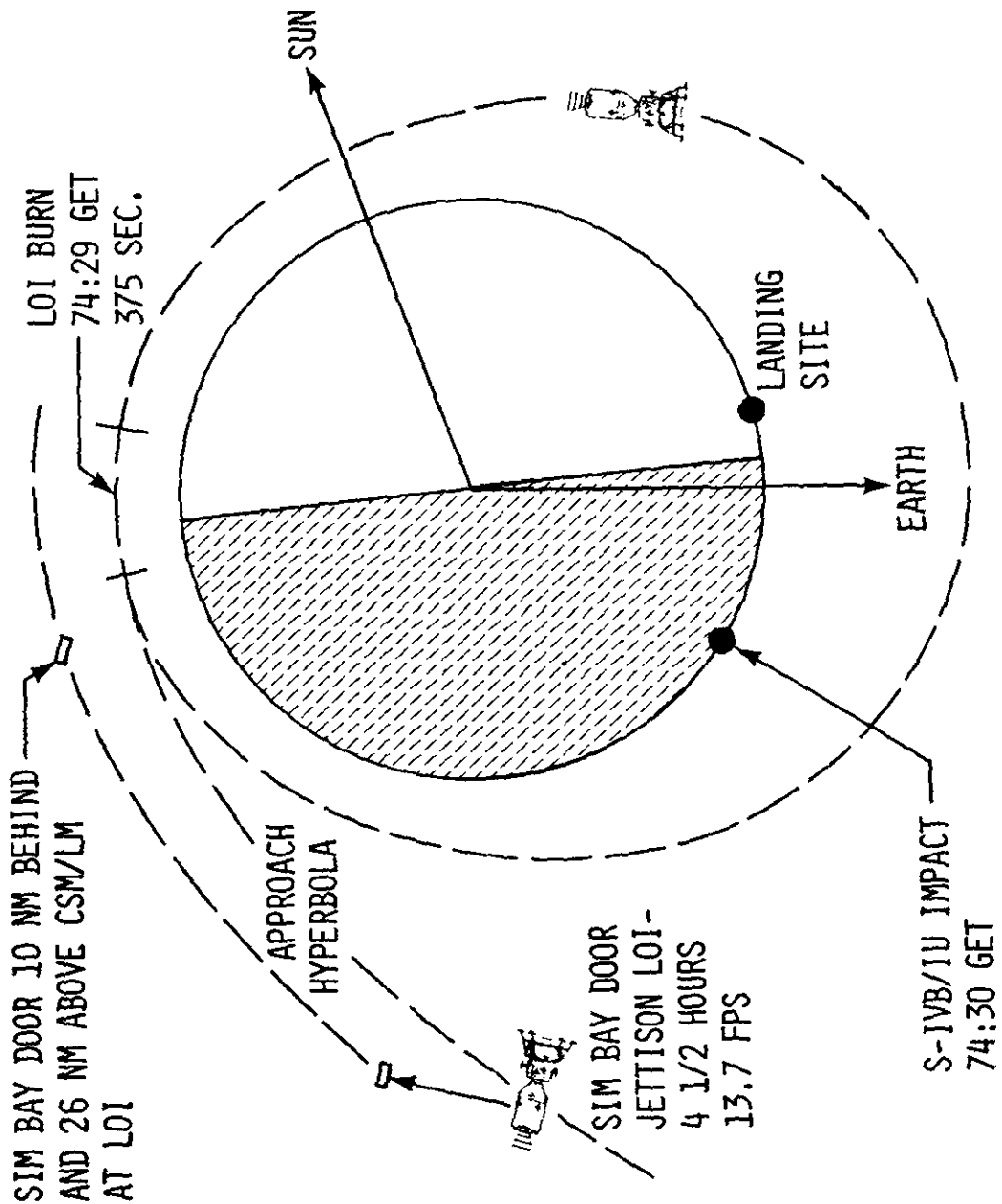
(continued)

<u>Time</u>		<u>Event</u>	<u>Vehicle Wt</u>		<u>Altitude</u>		<u>Velocity</u>		<u>Range</u>	
Hrs	Min Sec		Kilograms	(Pounds)*	Meters	(Feet)*	Mtrs/Sec	(Ft/Sec)*	Kilometers	(Naut Mi)*
00	09 18	S-II/S-IVB Separation	170,989	(376,967)	174,161	(571,395)	6,571	(21,558)	1,657	(895)
00	09 21	S-IVB First Ignition	170,947	(376,874)	174,235	(571,637)	6,571	(21,559)	1,677	(905)
00	11 44	S-IVB First Cutoff	140,103	(308,873)	172,908	(567,282)	7,400	(24,279)	2,643	(1,427)
00	11 54	Parking Orbit Insertion	140,039	(308,734)	172,914	(567,302)	7,402	(24,284)	2,715	(1,466)
02	33 35	S-IVB Second Ignition	139,052	(306,557)	175,919	(577,162)	7,404	(24,292)	16,203	(8,749)
02	39 19	S-IVB Second Cutoff	65,620	(144,666)	305,315	(1,001,688)	10,441	(34,256)	13,320	(7,192)
02	39 29	Trans-Lunar Injection	65,551	(144,514)	319,199	(1,047,241)	10,433	(34,230)	13,222	(7,139)

\* English measurements given in parentheses.

<u>ACTIVITY</u>	<u>TIME</u>	<u>PURPOSE</u>
<ul style="list-style-type: none"> <li>● VISUAL LIGHT FLASH PHENOMENON,</li> <li>● EYE SHIELDS</li> <li>● ALFMED</li> </ul>	TRANSLUNAR & TRANSEARTH TRANSLUNAR	TO STUDY THE ORIGIN OF VISUAL LIGHT FLASHES OBSERVED BY ASTRONAUTS ON PREVIOUS MISSIONS.
<ul style="list-style-type: none"> <li>● ELECTROPHORETIC SEPARATION</li> </ul>	TRANSLUNAR	TO STUDY A PROCESS OF MATERIALS PURIFICATION WHICH MAY PERMIT PRODUCTION SEPARATION OF MATERIALS OF HIGHER PURITY THAN CAN CURRENTLY BE PRODUCED ON EARTH.

# APOLLO 16



MISSION EVENTS

<u>Events</u>	<u>GET</u> <u>hrs:min</u>	<u>Date/EST</u>	<u>Velocity change</u> <u>m/sec (ft/sec)</u>	<u>Purpose and resultant orbit</u>
Translunar injection (S-IVB engine start)	2:33	16/3:27 pm	3053 (10,018)	Injection into translunar trajectory with 13 km (71 nm) pericyynthion
CSM separation, docking	3:04	16/3:58 pm	---	Mating of CSM and LM
Ejection from SLA	3:59	16/4:53 pm	.3 (1)	Separates CSM-LM from S-IVB/SLA
S-IVB evasive maneuver	4:23	16/5:17 pm	3 (9.8)	Provides separation prior to S-IVB propellant dump and thruster maneuver to cause lunar impact
S-IVB residual propellant dump	4:44	16/6:38 pm		
APS impact burn	5:30	16/7:24 pm		
APS correction burn	9:30	16/11:24 pm		
Midcourse correction 1	TLI+9 hr	17/00:33 am	0*	*These midcourse corrections have a nominal velocity change of 0 m/sec, but will be calculated in real time to correct TLI dispersions;
Midcourse correction 2	TLI+28 hr	17/7:33 pm	0*	Trajectory remains within capability of a
Midcourse correction 3	LOI-22 hr	18/5:23 pm	0*	docked-DPS TEI burn should SPS fail to ignite.
Midcourse correction 4	LOI-5 hr	19/10:23 am	0*	
SIM door jettison	LOI-4.5 hr	19/10:53 am	4.2 (13.7)	
Lunar Orbit insertion	74:29	19/3:23 pm	-855.6 (-2807)	Inserts Apollo 16 into 108x316 km (58x170 nm) elliptical lunar orbit.
S-IVB impacts lunar surface	74:30	19/3:24 pm		Seismic event for Apollo 12, 14 and 15 passive seismometers. Target: 2.2 degrees south latitude by 21.4 degrees west longitude.
Descent orbit insertion	78:36	19/7:30 pm	-62.8 (206)	SPS burn places CSM/LM into 20x109 km (11x59 nm) lunar orbit.

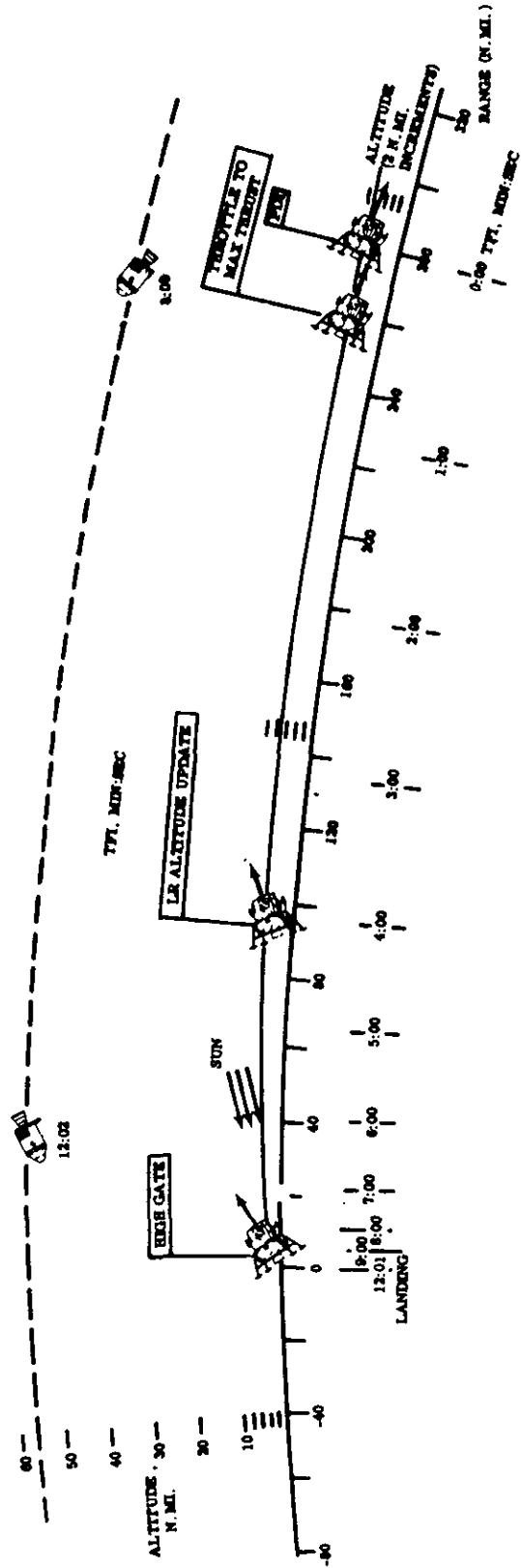
- more -

<u>Events</u>	<u>GFT</u> hrs:min	<u>Date/EST</u>	<u>Velocity change</u> m/sec (ft/sec)	<u>Purpose and resultant orbit</u>
CSM/LM undocking	96:14	20/01:08 pm	---	
CSM circularization burn	97:42	20/2:36 pm	30.3 (99.6)	Inserts CSM into 96x111 km (52x60 nm) orbit (SPS burn)
LM powered descent	98:35	20/3:29 pm	-2041 (6696)	Three-phase DPS burn to brake LM out of transfer orbit, vertical descent and lunar surface touchdown.
LM lunar surface touchdown	98:46	20/3:41 pm	---	Lunar exploration, deploy ALSEP, collect geological samples, photography.
EVA-1 begins	102:25	20/7:19 pm	---	See separate EVA timelines
EVA-2 begins	124:50	21/5:44 pm	---	See separate EVA timelines
EVA-3 begins	148:25	22/5:19 pm	---	See separate EVA timelines
CSM plane change 1	152:29	22/9:23 pm	48 (159)	Changes CSM orbital plane by 1.7 degree to coincide with LM orbital plane at time of LM ascent from surface
LM ascent	171:45	23/4:39 pm	1,843 (6048)	Boosts ascent stage into 16.6x84 km (9x45.4 nm) lunar orbit for rendezvous with CSM
Lunar orbit insertion	171:52	23/4:46 pm		
Terminal phase initiate (TPI) LM RPS	172:39	23/5:33 pm	15	Boosts ascent stage into 81.4x114.5 km (44x61.9 nm) catch-up orbit; LM trails CSM by 59.2 km (32 nm) and 27.7 km (15 nm) below at TPI burn time
Braking: 4 LM RCS burns	173:20	23/6:14 pm	10	Line-of-sight terminal phase braking to place LM in 110.7x109.8 km (59.8x59.3 nm) orbit for final approach, docking.
Docking	173:40	23/6:34 pm	---	CDR and LMP transfer back to CSM
LM jettison, separation	177:31	23/10:25 pm	---	Prevents recontact of CSM with LM ascent stage for remainder of mission

-- more --



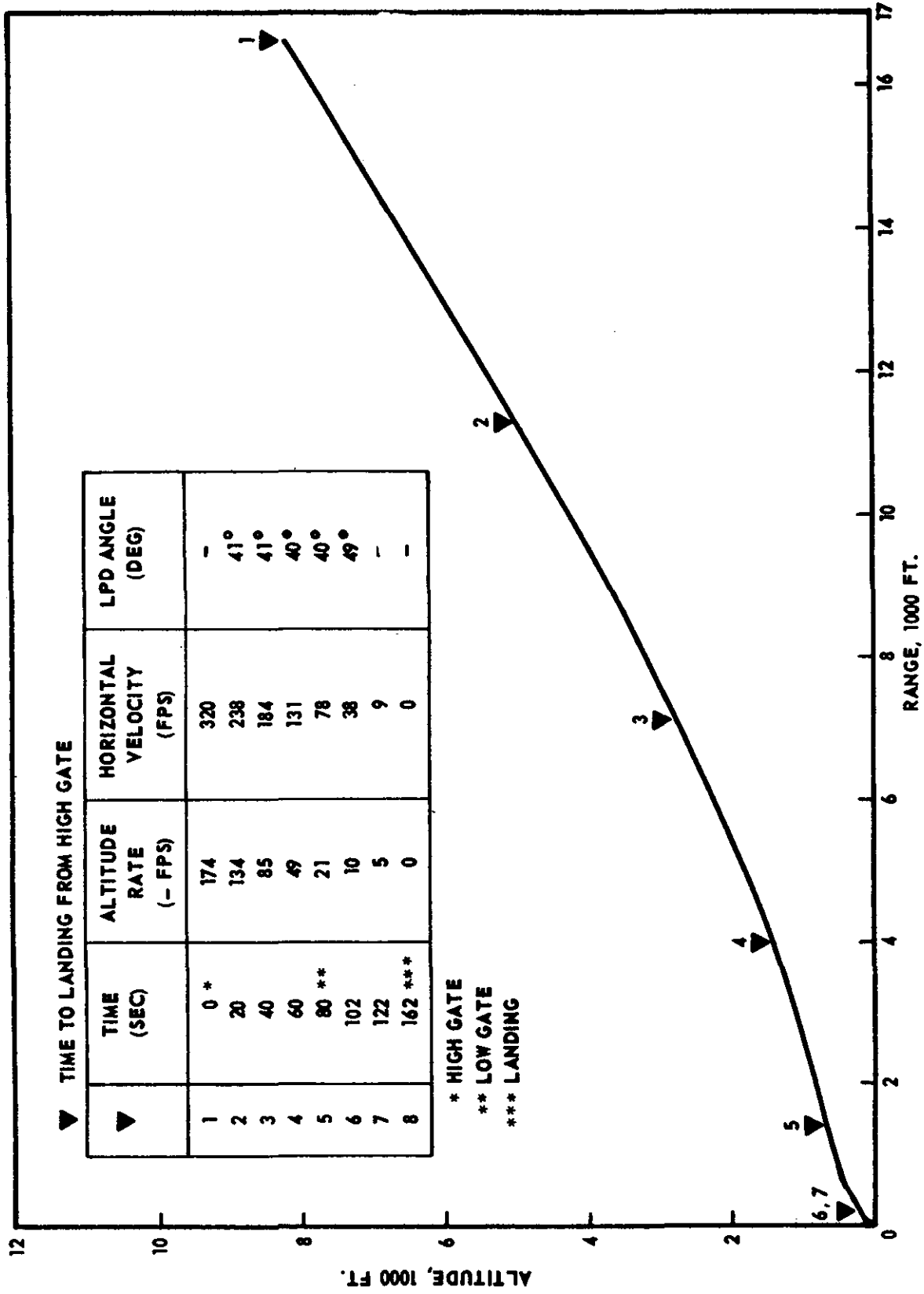
# POWERED DESCENT VEHICLE POSITIONS



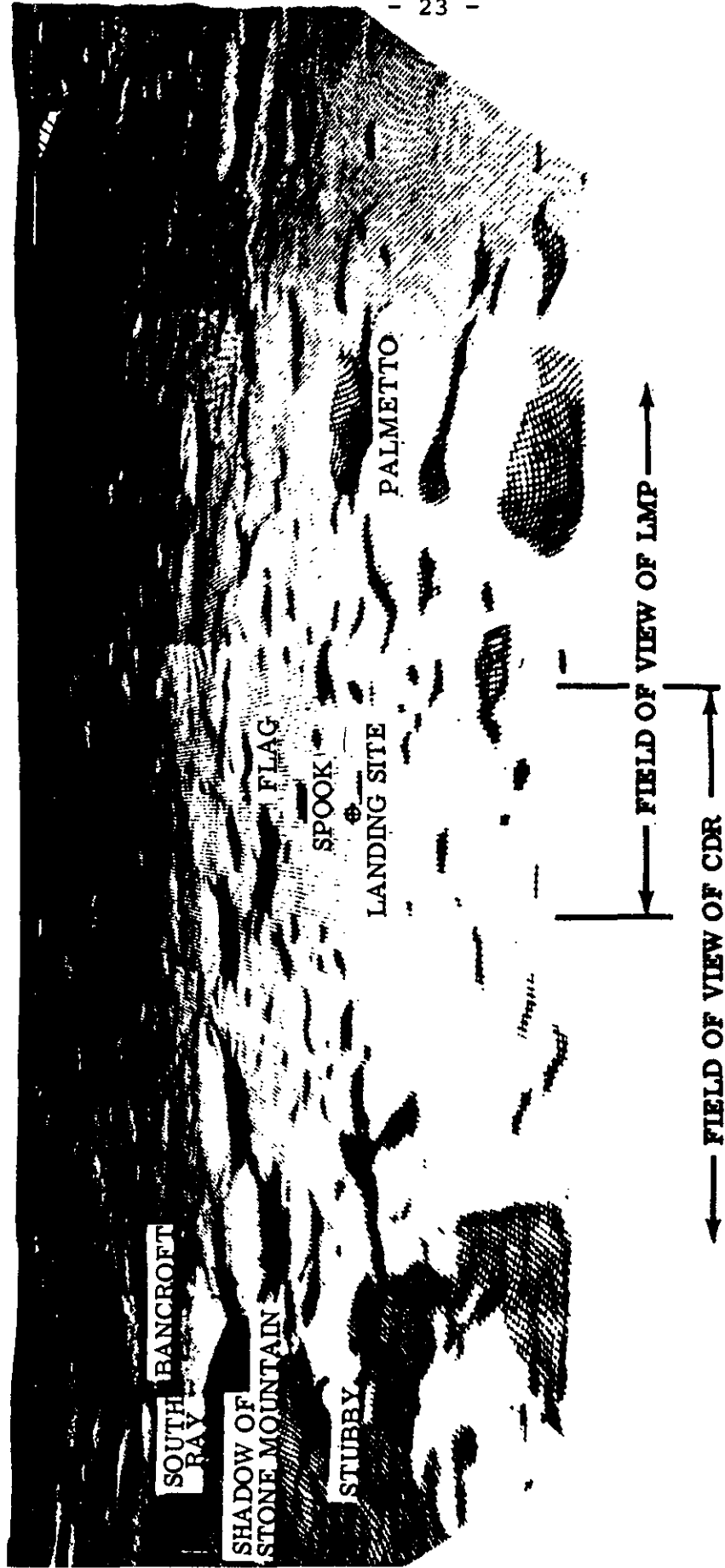
SUMMARY

EVENT	TFI MIN:SEC	V <sub>1</sub> ,FPS	Ḣ FPS	H FT	ΔV FPS
POWERED DESCENT INITIATION	0:00	5555	-5	52700	0
THRUSTLE TO MAXIMUM THRUST	0:26	5527	-4	52600	28
YAW TO VERTICAL	3:00	4096	-56	46840	1476
THRUSTLE RECOVERY	7:20	1188	-91	24740	4559
HIGH GATE	9:20	342	-174	7970	5602
LOW GATE	10:42	76	-21	583	6246
LANDING	12:01.5	0	-5	0	6697

# APPROACH PHASE



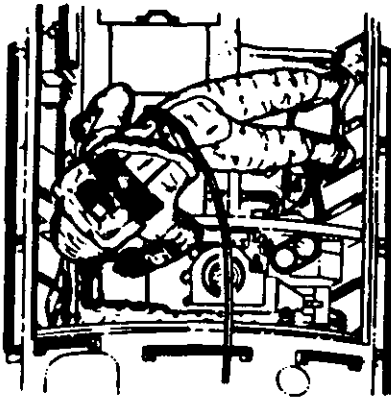
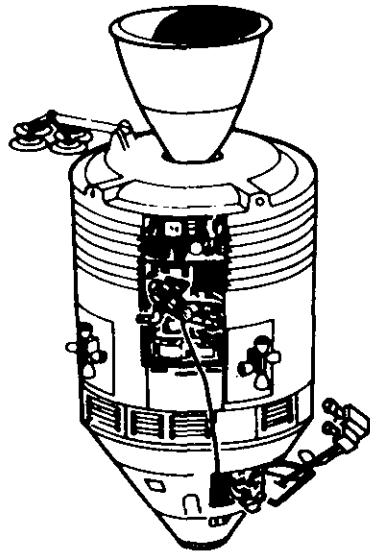
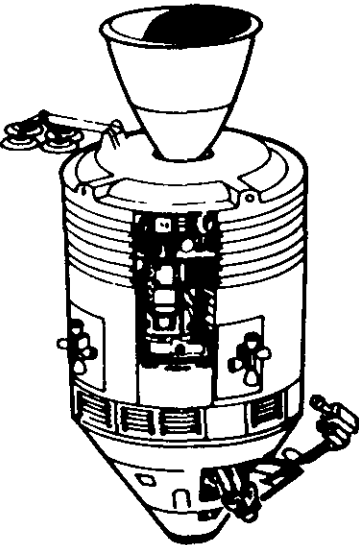
# FIRST VIEW OF DESCARTES (HIGH GATE + 8 SECONDS)



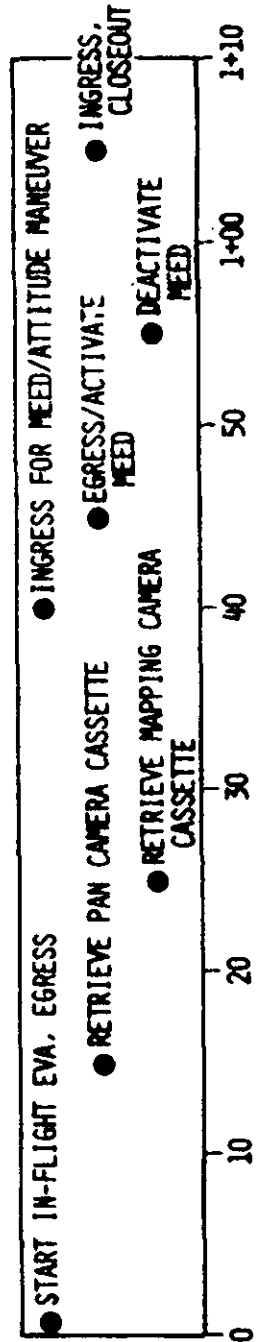
<u>Events</u>	<u>GET</u> <u>hrs:min</u>	<u>Date/EST</u>	<u>Velocity change</u> <u>m/sec (ft./sec)</u>	<u>Purpose and resultant orbit</u>
LM ascent stage deorbit (RCS burn)	179:16	24/00:10 am	-70 (-229)	ALSEP seismometers at Apollo 16, 15, 14 and 12 landing sites record impact.
LM impact	179:39	24/00:33 am	---	Impact at about 1691 m/sec (5550 fps) at -3.2 degree angle. 23 km (12 nm) west of Apollo 16 ALSEP.
CSM plane change 2	193:14	24/2:08 pm	86 (282)	Increase lunar surface photo coverage, changes plane 3 degrees.
CSM shaping burn	216:49	25/1:43 pm	11 (38)	Adjusts CSM orbit for later subsatellite jettison orbit: 102x147 km (55x85 nm).
Subsatellite jettison	218:02	25/2:56 pm	---	Lunar orbit science experiments
Transearth injection (TEI)	222:21	25/7:15 pm	979 (3212)	Inject CSM into transearth trajectory
Midcourse correction 5	239:21	26/12:17 pm	0	Transearth midcourse corrections will be computed in real time for entry corridor control and recovery area weather avoidance.
Transearth EVA	241:57	26/2:51 pm	---	Retrieve SM SIM bay film canisters.
Midcourse correction 6	EI-22 hrs	27/5:17 pm	0	
Midcourse correction 7	EI-3 hrs	28/12:17 pm	0	
CM/SM separation	290:08	28/3:02 pm	---	Command module oriented for Earth atmosphere entry
Entry interface (121,9 km, 400,000 ft)	290:23	28/3:17 pm		Command module enters Earth's atmosphere at 11,026 m/s (36,175 fps).
Splashdown	290:36	28/3:30 pm		Landing 2111 km (1140 nm) downrange from entry; splash at 5 degrees north latitude by 158 degrees west longitude.

- more -

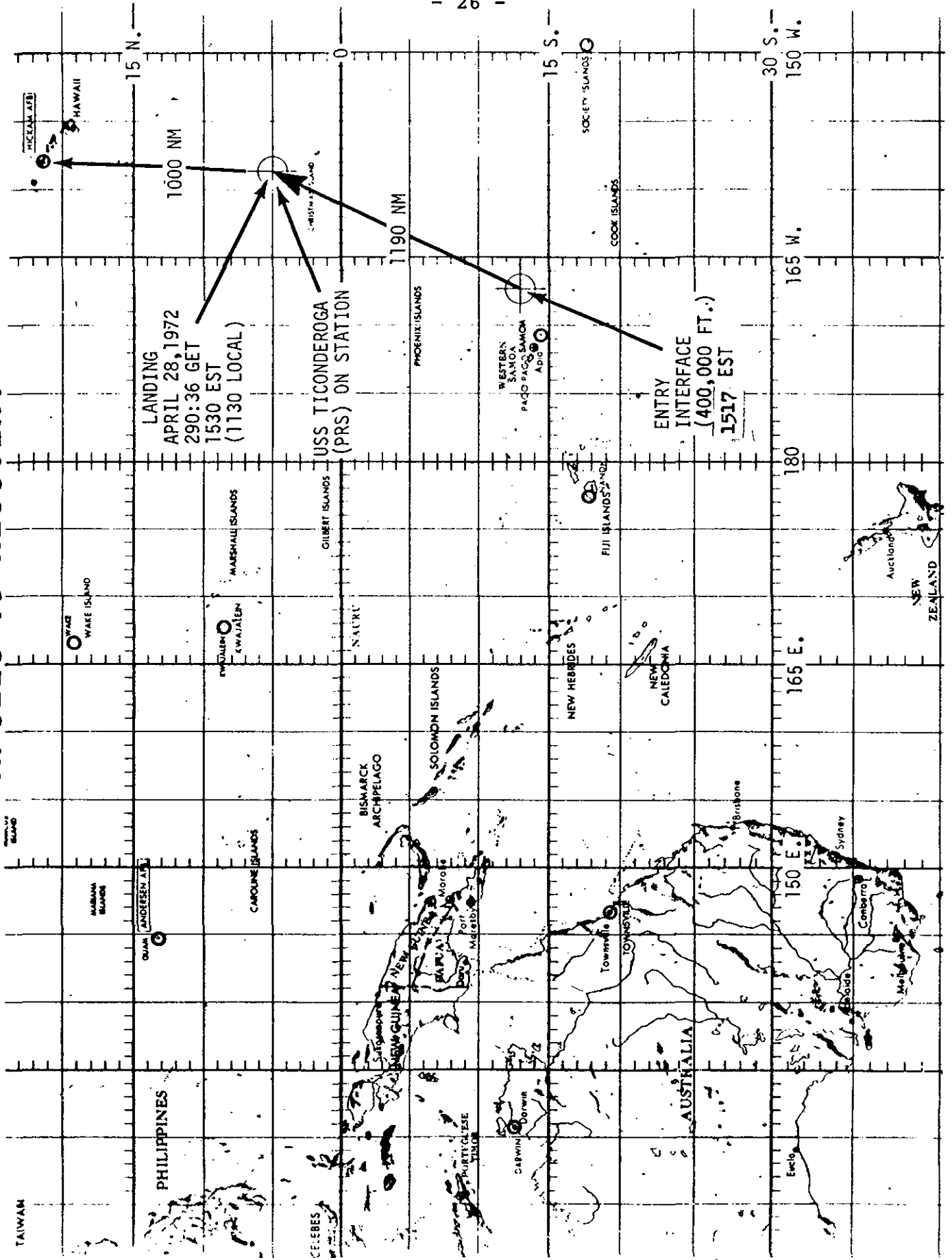
# FILM RETRIEVAL FROM THE SIM BAY



## EVA TIME LINE



# APOLLO 16 RECOVERY



**APOLLO 16**

**CREW POST-LANDING ACTIVITIES**

<u>DAYS FROM RECOVERY</u>	<u>DATE</u>	<u>ACTIVITY</u>
SPLASHDOWN	APRIL 28	
R + 1	APRIL 29	DEPART SHIP, ARRIVE HAWAII
R + 2	APRIL 30	DEPART HAWAII, ARRIVE HOUSTON
R + 3 THRU R + 15	MAY 1-12	CREW DEBRIEFING PERIOD

## APOLLO 16 ALTERNATE MISSIONS

- EARTH ORBIT MISSION (NO TLI)
- PHOTOGRAPHIC MISSION OVER U.S. OF ABOUT 6 DAYS DURATION, X-RAY AND GAMMA RAY SPECTROMETERS WILL ALSO BE OPERATED, CMP EVA TO RETRIEVE FILM CASSETTES.
- LUNAR ORBIT MISSIONS
  - APPROXIMATELY 6 DAYS IN LUNAR ORBIT
  - USE OF SIM BAY EXPERIMENTS
  - SUBSATELLITE JETTISON REQUIRED

### TYPES OF CONTINGENCIES

- CSM ALONE
- CSM/LM (OPERABLE AND INOPERABLE DPS CASES)
- FROM LM ABORTS

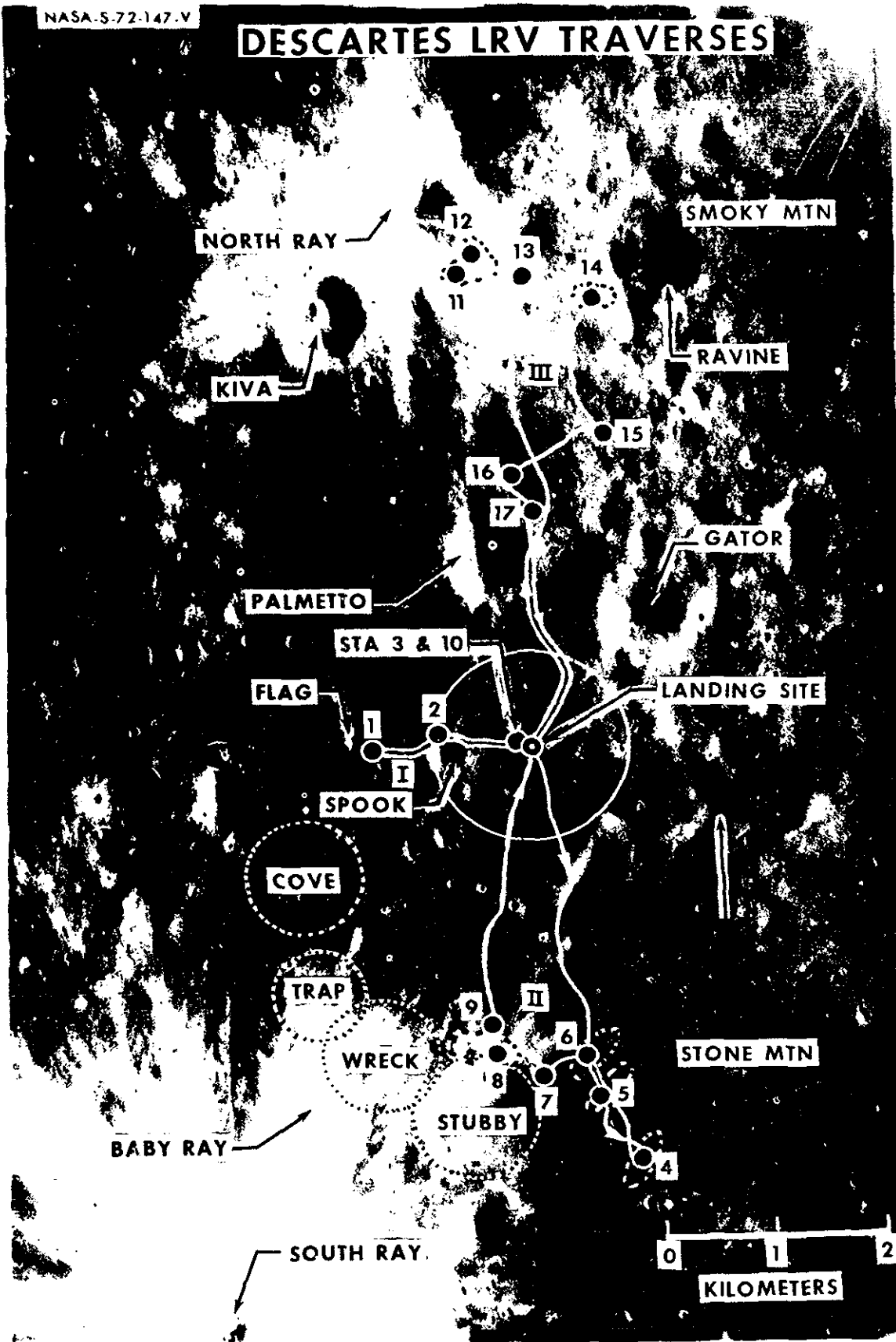


EVA MISSION EVENTS

Events	GET hrs:min	Date/EST
<u>Depressurize LM for EVA 1</u>	102:25	Apr 20/7:19 pm
CDR steps onto surface	102:40	20/7:34 pm
LMP steps onto surface	102:45	20/7:39 pm
Crew offloads LRV	102:53	20/7:47 pm
CDR test drives LRV	103:13	20/8:07 pm
LRV parked near MESA	103:15	20/8:09 pm
CDR offloads, deploys far-UV camera/ spectroscope	103:24	20/8:18 pm
LMP mounts LCRU, TV on LRV	103:25	20/8:19 pm
Crew loads geology equipment on LRV	103:37	20/8:31 pm
CDR deploys United States flag	103:50	20/8:44 pm
LMP carries ALSEP "barbell" to deployment site	104:02	20/8:56 pm
CDR drives LRV to ALSEP site	104:12	20/9:06 pm
Crew begins ALSEP deploy	104:20	20/9:14 pm
ALSEP deploy complete	106:22	20/11:16 pm
Crew drives to station 1 (Flag Crater)	106:27	20/11:21 pm
Crew arrives at station 1 for rake/ soil sample, crater sample	106:39	20/11:33 pm
Crew drives to station 2 (Spook crater)	107:22	21/00:06 am
Crew arrives at station 2 for crater area sampling, magnetometer site measurement	107:27	21/00:21 am
Crew returns to LM/ALSEP area Station 3	108:23	Apr 21/1:17 am

NASA-S-72-147-V

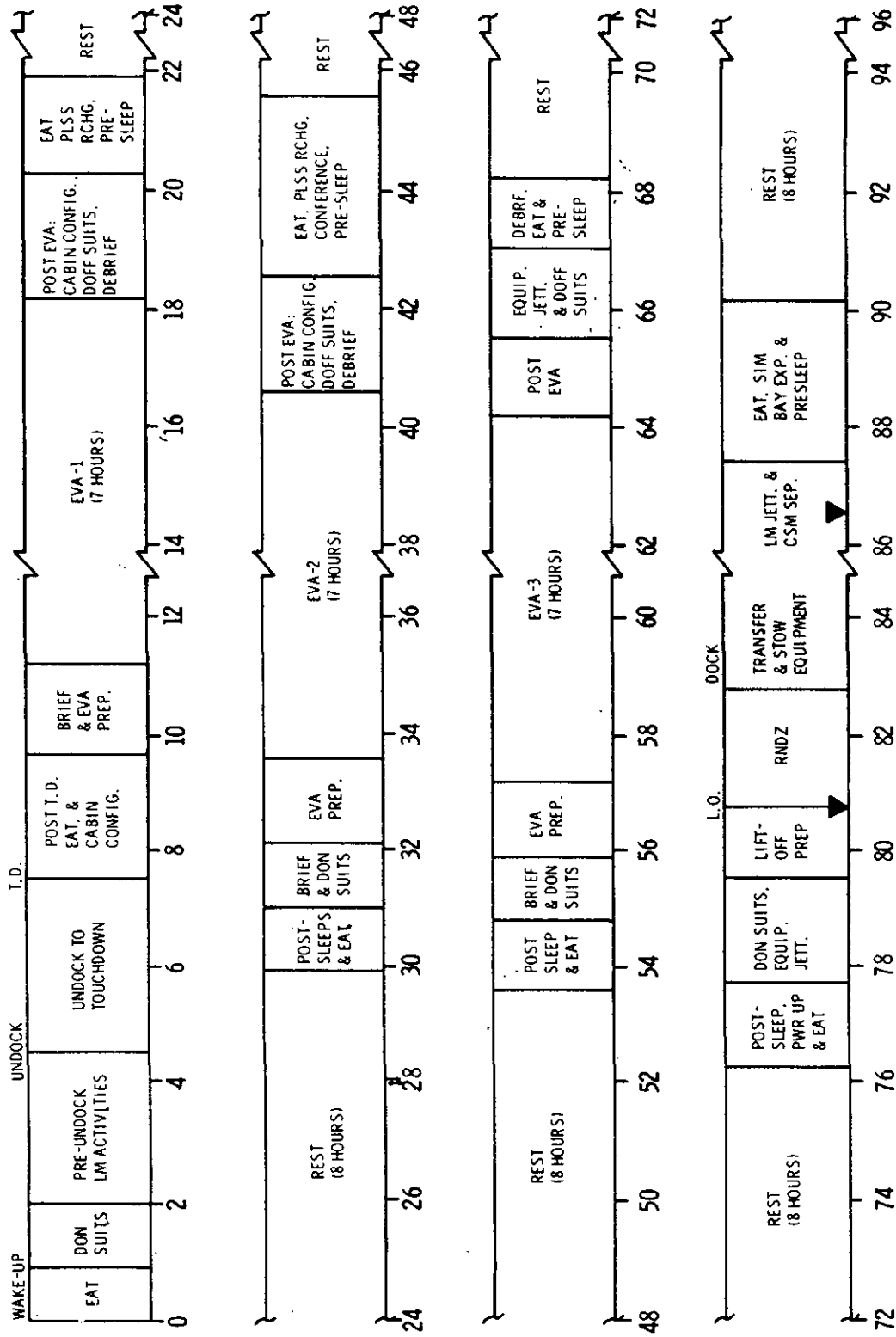
# DESCARTES LRV TRAVERSES



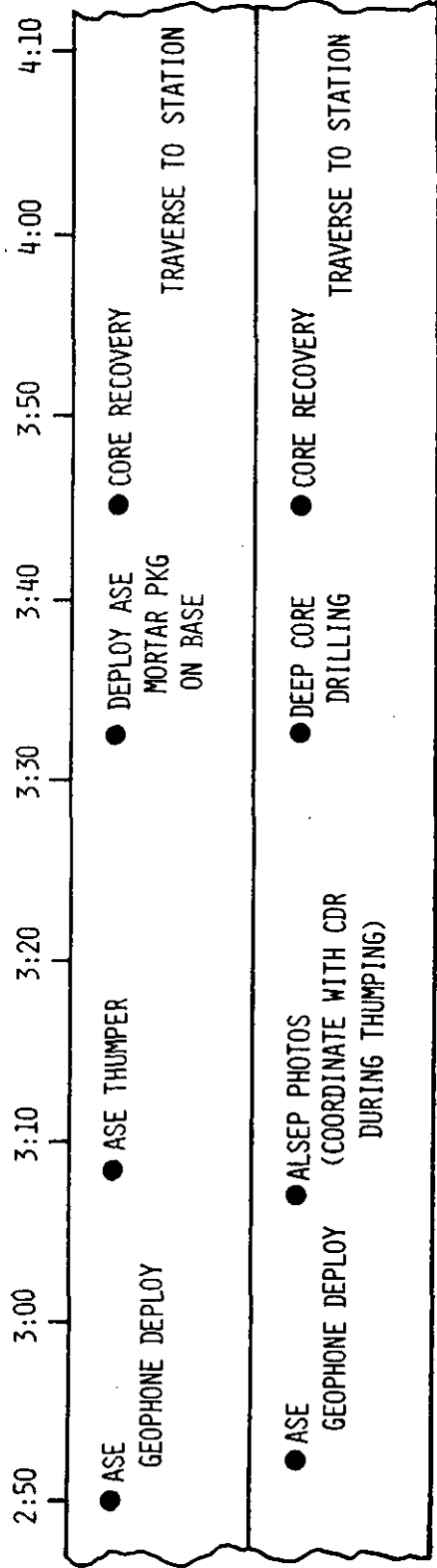
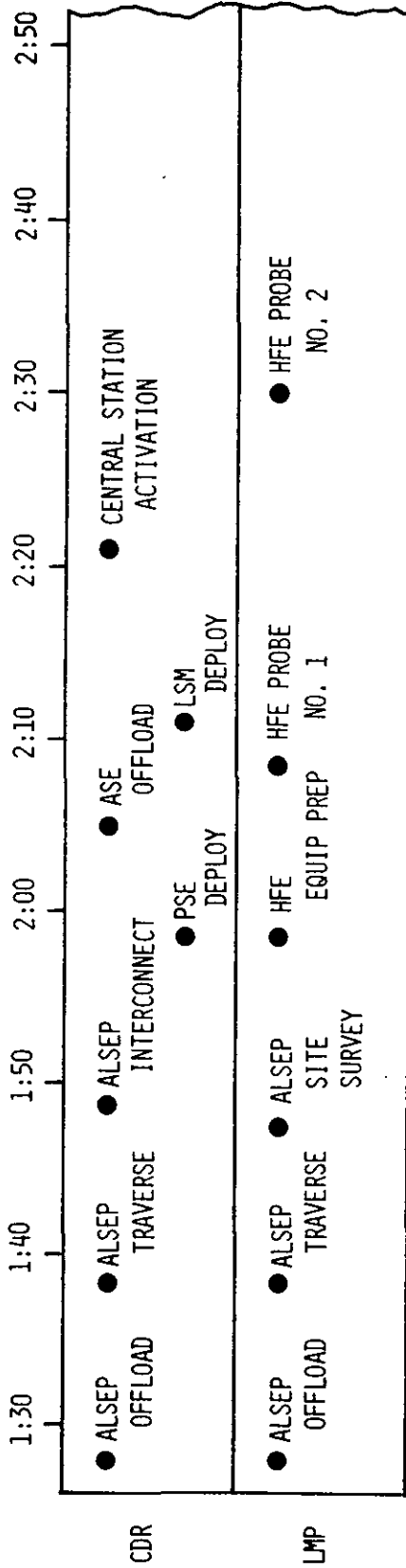
# APOLLO 16 TRAVERSE COMPARISON WITH APOLLO 15

	DURATION (HR:MIN)		TRAVERSE STATION TIME (HR:MIN)		LM/ALSEP AREA TIME (HR:MIN)		LRV DRIVING TIME (HR:MIN)		TRAVERSE DISTANCE (KM)	
	PLAN	ACTUAL	PLAN	ACTUAL	PLAN	ACTUAL	PLAN	ACTUAL	PLAN	ACTUAL
EVA I										
APOLLO 15	7:00	6:32	1:16	1:10	4:35	4:14	1:08	1:08	8.2	10.3
APOLLO 16	7:00	-	1:53	-	4:41	-	:26	-	3.2	-
EVA II										
APOLLO 15	7:00	7:12	3:32	2:37	1:29	3:11	1:59	1:24	14.3	12.5
APOLLO 16	7:00	-	4:11	-	1:30	-	1:19	-	9.5	-
EVA III										
APOLLO 15	6:00	4:49	3:05	1:23	1:27	2:50	1:28	:36	10.5	5.1
APOLLO 16	7:00	-	3:36	-	1:40	-	1:44	-	12.6	-
TOTALS										
APOLLO 15	20:00	18:33	7:53	5:00	7:31	10:15	4:35	3:08	33.0	27.9
APOLLO 16	21:00	-	9:40	-	7:51	-	3:29	-	25.2	-

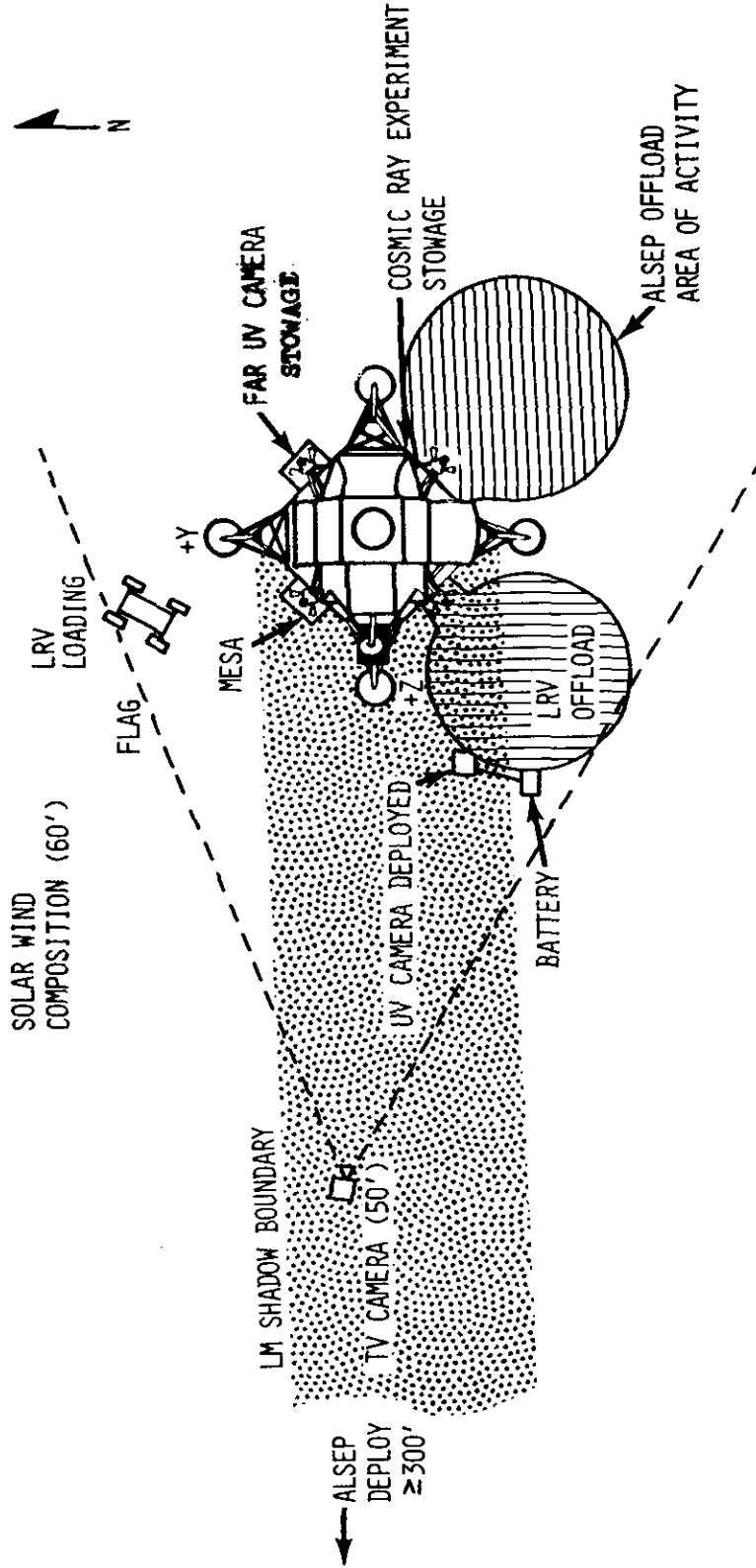
# APOLLO 16 LUNAR SURFACE TIMELINE



# SUMMARY TIME LINE FROM ALSEP OFFLOAD THROUGH ALSEP DEPLOYMENT



# NEAR LM LUNAR SURFACE ACTIVITY



Events	GET hrs:min	Date/EST
Crew arrives at station 3 to retrieve deep core. Comprehensive sampling, arm mortar package, perform LRV "Gran Prix".	108:30	21/1:24 am
Crew returns to LM	108:44	21/1:38 am
Crew arrives at LM	108:45	21/1:39 am
LMP deploys solar wind composition experiment	109:02	21/1:56 am
CDR offloads geology equipment, film mags	109:05	21/1:59 am
LMP ingresses LM	109:15	21/2:09 am
CDR ingresses LM	109:22	21/2:16 am
Repressurize LM, end EVA 1	109:25	21/2:19 am
<u>Depressurize LM for EVA 2</u>	124:50	Apr 21/5:44 pm
CDR steps onto surface	125:10	21/5:59 pm
LMP steps onto surface	125:10	21/6:04 pm
Crew completes loading LRV for geology traverse	125:30	21/6:24 pm
Crewmen load geological gear on each other's PLSS	125:32	21/6:26 pm
Crew drives to station 4 (upper slope of Stone Mountain)	125:40	21/6:34 pm
Crew arrives at station 4 for rake soil, documented } and double core samples, photo panorama, penetrometer reading	126:15	21/7:09 pm
Crew drives to station 5 (on slope of Stone Mountain)	127:13	21/8:07 pm
Crew arrives at station 5 for documented samples, photo panorama	127:19	21/8:13 pm

Events	GET hrs:min	Date/EST
Crew drives to station 6 (at base of Stone Mountain)	127:59	Apr 21/8:53 pm
Crew arrives at station 6 for documented samples, photo panorama	128:02	21/8:56 pm
Crew drives to station 7 (Stubby Crater, base of Stone Mountain)	128:22	21/9:16 pm
Crew arrives at station 7 for documented samples, photo panorama	128:26	21/9:20 pm
Crew drives to station 8 (rays from South Ray Crater)	128:41	21/9:35 pm
Crew arrives at station 8 for rake soil, documented double core samples, photo panorama	128:46	21/9:40 pm
Crew drives to station 9 (Cayley Plains)	129:45	21/10:39 pm
Crew arrives at Station 9 for surface and core samples, photo panorama	129:50	21/10:44 pm
Crew drives to station 10 (LM/ALSEP area)	130:15	21/11:09 pm
Crew arrives at station 10 for soil mechanics investigation, double core, radial sample, photo panorama	130:36	21/11:30 pm
Crew drives back to LM	131:09	22/00:03 am
Crew arrives at LM	131:10	22/00:04 am
Crew unloads LRV, packs sample containers, clean-up	131:20	22/00:14 am
LMP ingresses LM	131:37	22/00:31 am
CDR ingresses LM	131:48	22/00:42 am
Repressurize LM, end EVA 2	131:50	22/00:44 am

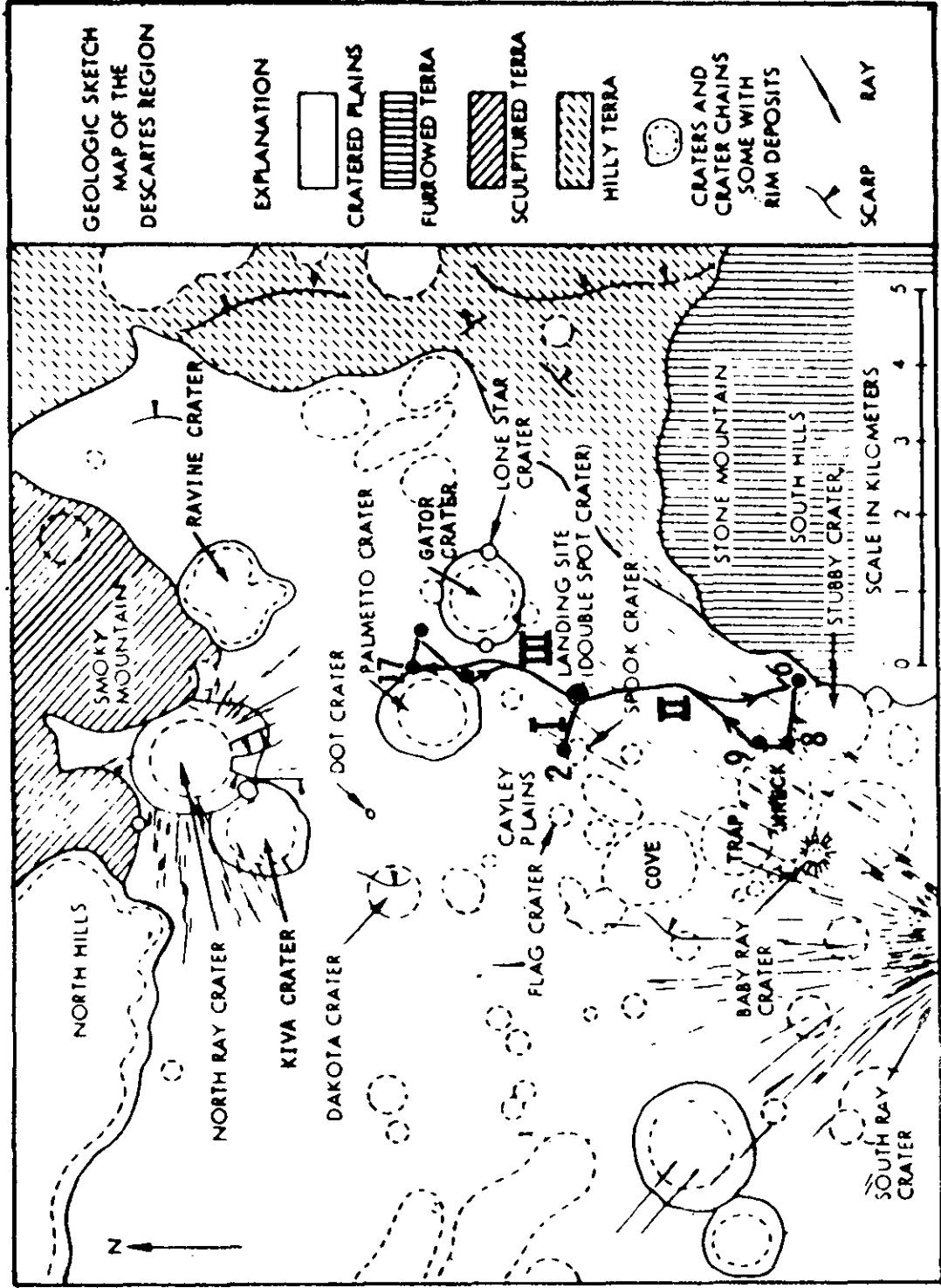


Events	GET hrs:min	Date/EST
<u>Depressurize LM for EVA 3</u>	148:25	Apr 22/5:19 pm
CDR steps onto surface	148:40	22/5:34 pm
LMP steps onto surface	148:46	22/5:40 pm
Crew completes loading LRV, PLSSs for geology traverse	149:02	22/5:56 pm
Crew drives to station 11 (South rim, North Ray Crater)	149:10	22/6:04 pm
Crew arrives at station 11 for polarimetric photos, documented samples, photo panorama	149:54	22/6:48 pm
Crew drives to station 12 (North Ray, Crater, southeast rim, large block area)	150:49	22/7:43 pm
Crew arrives at station 12 for rake/soil and documented samples, photo panorama	150:52	22/7:46 pm
Crew drives to station 13 (outer ejecta blanket, North Ray Crater)	151:47	22/8:41 pm
Crew arrives at station 13 for rock/soil samples, photo panorama	151:52	22/8:46 pm
Crew drives to station 14 (Smoky Mountain)	152:02	22/8:56 pm
Crew arrives at station 14 for rake/soil, double core, documented samples, photo panorama	152:09	22/9:03 pm
Crew drives to station 15 (Cayley Plains)	152:49	22/9:43 pm
Crew arrives at station 15 for magnetometer measurements, rock/soil sample, photo panorama	153:00	22/9:49 pm
Crew drives to station 16 (Dot Crater)	153:10	22/10:04 pm
Crew arrives at station 16 for magnetometer measurement, rock/soil samples, photo panorama	153:19	22/10:13 pm

Events	GET hrs:min	Date/EST
Crew drives to station 17 (NE rim, Palmetto Crater)	153:29	Apr 22/10:23 pm
Crew arrives at station 17 for rake/soil and documented samples, magnetometer readings, photo panorama	153:34	22/10:28 pm
Crew drives back to LM	154:12	22/11:06 pm
Crew arrives at LM	154:30	22/11:24 pm
Crew transfers samples, film packs, etc. stowage in LM; close-out final EVA	154:36	22/11:30 pm
LMP ingresses LM	155:19	23/00:13 am
CDR ingresses LM	155:23	23/00:17 am
Repressurize LM, end EVA 3	155:25	23/00:19 am

- more -

# APOLLO 16 WALKING TRAVERSE (CONTINGENCY)



## APOLLO 16 MISSION OBJECTIVES

Apollo 16 astronauts will explore the Descartes region, man's first opportunity to explore the lunar highlands. The site is some 2,250 meters (7,400 feet) higher than the Apollo 11 site and is representative of over three-fourths of the lunar surface. Preliminary geological analysis of the highlands indicates that the Moon's crust underwent modification early in its history. By studying these modification processes, we hope to achieve a better understanding of the development of this portion of the Moon's surface as well as the development of the Earth's crust, its continents, and ocean basins.

The three basic objectives are to explore and sample the materials and surface features, to set up and activate experiments on the lunar surface which will continue to relay data back to Earth after the crew has returned, and to conduct inflight experiments and photographic tasks.

The lunar roving vehicle, used for the first time on Apollo 15, will extend the range of the exploration and geological investigations that Young and Duke will make during their three seven-hour EVAs. The Apollo lunar surface package (ALSEP) which the crew will set up and place into operation will, with the Apollo 12, 14 and 15 ALSEPs, become the fourth in a network of lunar surface scientific stations.

The scientific instrument module (SIM) bay in the service module is the heart of the inflight experiment effort on Apollo 16. Quite similar to the SIM bay flown on Apollo 15, the bay contains high-resolution and mapping cameras and scientific sensors for photographing and measuring properties of the lunar surface and the environment around the Moon.

While in lunar orbit, command module pilot Mattingly will have the responsibility for operating the inflight experiments during the time his crewmates are on the lunar surface. During the homeward coast after transearth injection, Mattingly will exit through the command module crew hatch and maneuver hand-over-hand to the SIM bay where he will retrieve film cassettes, pass them back into the cabin for return to Earth and emplace a medical experiment for exposure to the solar-space environment. Mattingly also will take photographs aimed at gathering knowledge of astronomical phenomena such as Gegenschein from lunar orbit and ultraviolet photography of both the Earth and the Moon.

Engineering and operational tasks the Apollo 16 crew will carry out include further evaluation of the lunar roving vehicle and Skylab crew equipment, and use of the SIM bay subsatellite as a navigation tracking aid. Other medical experiments include biostack, ALFMED, and the passive bone mineral measurement.

- more -

SCIENTIFIC RESULTS OF APOLLO 11, 12, 14 and 15 MISSIONS

The Apollo 14 and Apollo 15 missions have clearly demonstrated that the major scientific returns from the Apollo program are to be expected from the later Apollo missions. The scientific results from the Apollo 15 mission have advanced the science of understanding the Moon from the stage characterized by interesting and stimulating speculations to one characterized by scientific hypotheses. The hypotheses which lead to specific experiments that, in turn, give answers that rapidly reduce the uncertainty regarding many basic questions concerning the origin and evolution of the Moon. The extended stay times and extended mobility available on the lunar surface and the wide-array of instrumentation carried in the SIM bay of the command and service module have already provided a rich harvest of scientific information from the first J mission.

Samples from the first two lunar landings showed us that most of the surface of the Moon dates back to a time when the terrestrial geologic record is just barely decipherable. They show that the lunar maria that covers about 1/3 of the side of the Moon viewed from Earth largely consists of an iron-rich volcanic rock produced from a partially molten shell 100-200 miles beneath the surface of the Moon. The soil samples from these two sites also included a variety of intriguing fragments clearly distinguishable from the mare basalts. These soil samples became the basis of widespread speculation on the composition and origin of the lunar highlands that make up most of the backside and approximately 2/3 of the front side of the Moon. Both the samples and the results of experiments flown in the Apollo 15 CSM have shown that these intriguing bits of rock are indeed representative of the large areas of the Moon that contain the bulk of the early history of the planet.

The measurement of gamma rays, produced by minute amounts of radioactive substances in the lunar soil, and characteristic x-rays, induced by the high energy solar radiation impinging on the sunlit side of the Moon has shown that much of the northwestern quadrant of the Earth side of the Moon is probably underlain by a very old (probably first formed 4.4-4.5 billion years ago) uranium- and thorium-rich volcanic rock and that most of the backside of the Moon, along with the eastern highland regions on the front side, appears to be made up of an aluminum- and calcium-rich rock (anorthosite) that was first observed in the Apollo 11 soil samples.

The widespread occurrence of both of these rock types tells us a great deal about the early history of the Moon. The aluminum-rich rocks suggest that the primitive Moon had a liquid outer shell that may have been 50-80 miles thick that gave rise to a lunar crust almost simultaneously with the formation of the Moon itself. The old uranium-rich volcanic rocks both limit the thickness of this early liquid layer and tell us something about the composition of the solid interior very early during lunar history. In particular, they suggest that the Moon was formed from material that condensed at temperatures much higher than previously thought out of the primitive dust cloud that surrounded the early Sun.

In addition to the chemical study of the lunar surface, the Apollo 15 mission returned excellent photographs of more than 10 percent of the surface of the Moon which reveal geological features as small as the size of the LM. Like the rock samples returned from this and previous missions, these photographs will provide a source of data for scientists for generations to come.

A subsatellite left behind by the Apollo 15 mission has measured the present magnetic field over a large percentage of the Moon's surface. These magnetic field measurements, along with studies of the magnetization of lunar rocks, indicate that the Moon's magnetic field 3 billion years ago must have been 100 to 1,000 times stronger than it is today. The subsatellite and altimeter have also shown that the mascons discovered by Lunar Orbiter spacecraft consist of circular plates of very dense rocks which fill the deep circular basins produced by collisions of asteroid-size objects with the Moon.

Most of the experiments deployed on the lunar surface during the Apollo 12, 14, and 15 missions continue to function well, but more important -- they have provided information regarding geological processes that are still going on today and have shown us that the interior of the Moon can be investigated with present instrumentation. The impact of the Apollo 15 SIVB was recorded by both the Apollo 14 and Apollo 12 seismometers. Sound waves from this impact penetrated about 80 kilometers (50 miles) into the lunar interior. The relatively high sound velocity found at these depths was a complete surprise to seismologists and lunar scientists. The sound velocity profile in the upper 80 kilometers (50 miles) indicates that the concept of the lunar crust derived from mineralogy and chemistry of rocks was well-founded. Ultrasensitive thermometers implaced in two holes on the lunar surface showed that the amount of heat escaping from the lunar interior exceeds even the highest estimates made by scientists who speculated on the content of radioactive elements found in the Moon.

During the week of January 10, approximately 700 scientists, 15 from foreign countries including three scientists from the Soviet Union, gathered at the Manned Spacecraft Center to present and summarize results obtained by the Apollo 14, Apollo 15, and Luna 16 missions. In addition to the conclusions and ideas already mentioned here, studies of Apollo 14 samples have shown that the largest collision with an asteroidal object recorded on the surface of the Moon took place about 4 billion years ago. This was much later than had been anticipated from various theories dealing with the formation of large planetary objects. It raises the possibility that major collisions of asteroid-sized objects and the Earth continued more than 1 billion years after the planet was formed.

The relatively small Luna 16 samples provided a surprising number of extremely interesting results that indicate that unmanned sampling of the Moon is, indeed, a useful augmentation of the manned program.

As we enter into the homestretch of the Apollo program, it is clear that a successful Apollo 16 and 17 added to the missions already flown will produce a chapter in the history of science that will be a permanent and living testimony to this undertaking.



APOLLO 16 LANDING SITE

A hilly region north of the Descartes crater in a highlands area of the southeastern quadrant of the visible face of the Moon is the landing site chosen for Apollo 16.

The Descartes site appears to have structural characteristics similar to vulcanism sites on Earth, and has two separate volcanic features -- Cayley Plains and the Descartes mountains -- which will be extensively explored and sampled by the Apollo 16 crew.

The Cayley Plains segment of the landing site is characterized by terrain ranging from smooth to undulating,-- possibly as a result of fluid volcanic rock flow. The Descartes Mountains, part of the Kant Plateau are characterized by hilly, furrowed highland plateau material that is thought to have come from a more viscous volcanic flow. Additionally, the Descartes landing site provides an opportunity to study the evolution of young, bright-rayed craters and to extend age-dating to similar craters in other regions of the Moon.

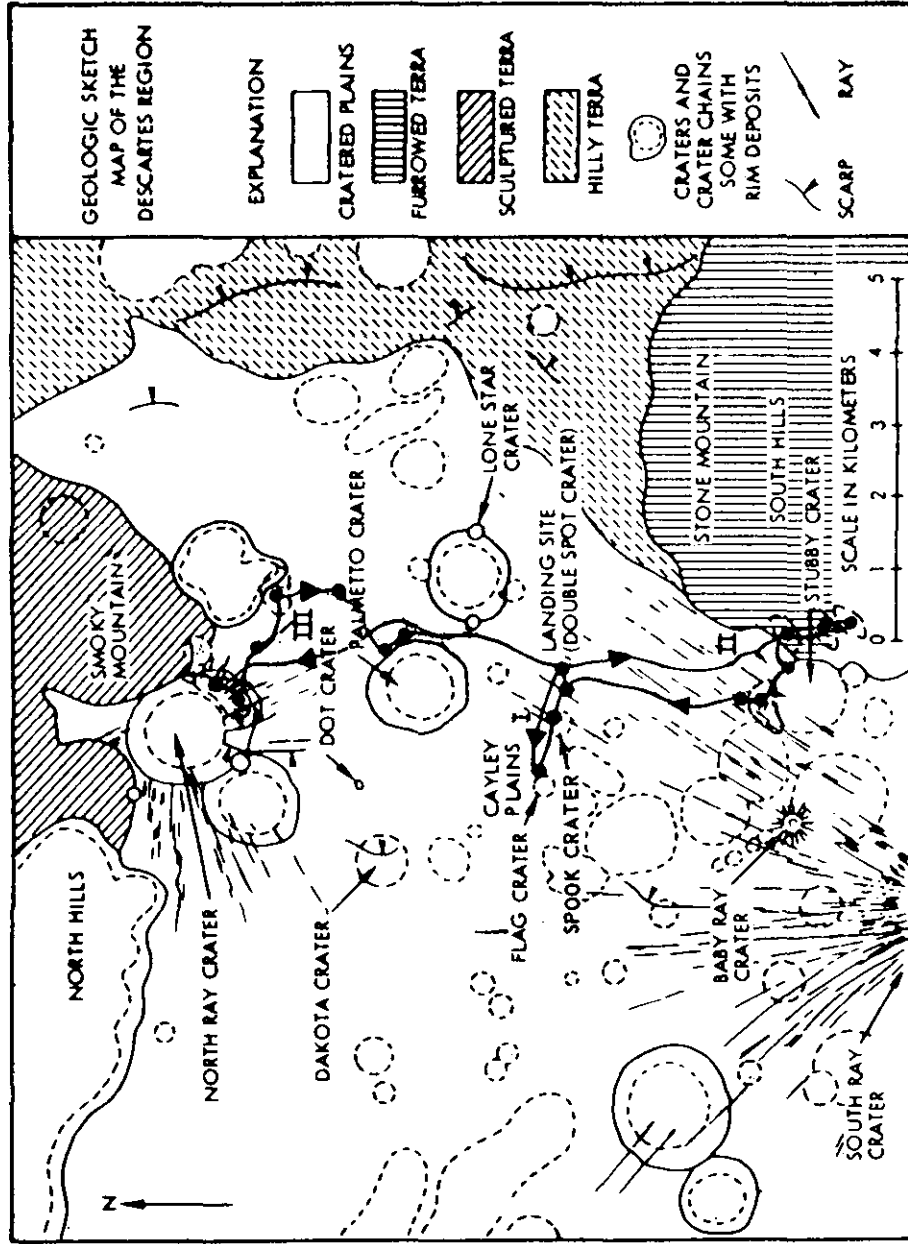
The landing site has two basic areas which will be explored and sampled: Cayley Plains, including North Ray and South Ray craters; Stone Mountain and Smoky Mountain of the South and North Descartes Mountains.

The low crater density in the Cayley Plains suggests an Imbrian age for the rolling, ridged portion of Cayley in the Apollo 16 traverse area. Stone and Smoky mountains, on the other hand, appear to have shapes typical of volcanic formations on Earth -- shapes that might be formed by movement of rather viscous material.

North and South Ray craters appear to penetrate deeply into the Cayley formation and reveal the sequence of layering, perhaps through an overlap of both the Cayley and Descartes formations.

Smaller, subdued craters in the landing site seem to have a characteristic concave bottom, which suggests that the substrata underlying the crater impact were more resistant than in other crater fields on the Moon.

# APOLLO 16 TRAVERSES - GEOLOGIC SKETCH



SITE	LAT.	LONG.	TERRAIN FEATURES	SCIENTIFIC INTEREST
APOLLO 11 (SEA OF TRANQUILITY)	0°41'N.	23°26'E.	MARE: LARGE SUBDUED CRATERS (200-600 METERS DIAMETER), INTERMEDIATE CRATERS (50-200 METERS DIAMETER).	MARE MATERIAL AGE AND COMPOSITION, GEOPHYSICAL DATA.
APOLLO 12 (OCEAN OF STORMS)	3°12'S.	23°24'W	MARE: SAME AS APOLLO 11.	MATERIAL AGE AND COMPOSITION FOR COMPARISON WITH APOLLO 11, SURVEYOR DATA.
FRA MAURO (APOLLO 14)	3°40'S.	17°28'W	UPLAND: DEEP-SEATED EJECTA BLANKET.	EJECTA AGE, COMPOSITION AND STRUCTURE, GEOPHYSICAL DATA.
HADLEY-APENNINES (APOLLO 15)	26°04'N.	3°39'E	MARE/HIGHLAND: V-SHAPED SINUOUS RILLE, RILLE FLOOR BLOCKS; APENNINE HIGHLANDS.	BASIN AND RILLE ORIGIN AND AGE; HIGHLANDS COMPOSITION, GEOPHYSICAL DATA
DESCARTES	10°00'S.	16°00'E	HIGHLAND/HIGHLAND BASIN FILL	VOLCANICS AND PLAINS STRUCTURE, HIGHLAND AGE AND COMPOSITION, VOLCANISM TIME SPAN AND COMPOSITIONAL TRENDS, GEOPHYSICAL DATA.

APOLLO LANDING SITES

### Lunar Surface Science

The ALSEP array carried on Apollo 16 has four experiments: heat flow, lunar surface magnetometer, passive seismic and active seismic.

Six additional experiments will be conducted on the Descartes landing area: far ultraviolet camera/spectroscope, portable magnetometer, cosmic ray detector (sheets), solar wind composition, lunar geology investigation, and soil mechanics.

Passive Seismic Experiment (PSE): The PSE measures seismic activity of the Moon and gathers and relays to Earth information relating to the physical properties of the lunar crust and interior. The PSE reports seismic data on man-made impacts (LM ascent stage), natural impacts of meteorites, and moon-quakes. Dr. Gary Latham of the Lamont-Doherty Geological Observatory (Columbia University) is responsible for PSE design and experiment data analysis.

Three similar PSEs, deployed as a part of the Apollo 12, 14 and 15 ALSEPs, have transmitted to Earth data on lunar surface seismic events since deployment. The Apollo 12, 14, 15 and 16 seismometers differ from the seismometer left at Tranquillity Base in July 1969 by the Apollo 11 crew in that the later PSEs are continuously powered by SNAP-27 radio-isotope thermoelectric generators. The Apollo 11 seismometer, powered by solar cells, transmitted data only during the lunar day and is no longer functioning.

After Apollo 16 trans-lunar injection, the Saturn V's spent S-IVB stage and instrument unit will be aimed to impact the Moon. This will stimulate the passive seismometers left on the lunar surface during previous Apollo missions.

The S-IVB/IU will be commanded to hit the Moon 250 kilometers (135 nautical miles) west of the Apollo 12 ALSEP site, at a target point 2.2 degrees south latitude by 31.4 degrees west longitude, near Lansberg Craters F and D in the Ocean of Storms.

After the spacecraft is ejected from the launch vehicle, a launch vehicle auxiliary propulsion system (APS) ullage motor will be fired to separate the vehicle a safe distance from the spacecraft. Residual liquid oxygen in the almost spent S-IVB/IU will then be dumped through the engine with the vehicle positioned so the dump will slow it into an impact trajectory. Mid-course corrections will be made with the stage's APS ullage motors if necessary.

	APOLLO MISSIONS						
	11	12	14	15	16	17	
<u>ALSEP EXPERIMENTS</u>							
S-031 LUNAR PASSIVE SEISMOLOGY	X	X	X	X	X		
S-033 LUNAR ACTIVE SEISMOLOGY			X		X		
S-034 LUNAR TRI-AXIS MAGNETOMETER		X		X	X		
S-035 SOLAR WIND SPECTROMETER		X		X			
S-036 SUPRATHERMAL ION DETECTOR		X	X	X			
S-037 LUNAR HEAT FLOW				X	X		X
S-038 CHARGED PARTICLE LUNAR ENVIRONMENT			X				
S-058 COLD CATHODE GAUGE		X	X	X			
S-202 LUNAR EJECTA AND METEORITES							X
S-203 LUNAR SEISMIC PROFILING							X
S-205 LUNAR ATMOSPHERIC COMPOSITION							X
S-207 LUNAR SURFACE GRAVIMETER							X
M-515 LUNAR DUST DETECTOR	X	X	X	X			
<u>OTHER EXPERIMENTS</u>							
S-059 LUNAR GEOLOGY INVESTIGATION	X	X	X	X	X		X
S-078 LASER RANGING RETRO-REFLECTOR	X	X	X	X			
S-080 SOLAR WIND COMPOSITION	X	X	X	X			
S-151 COSMIC RAY DETECTOR (HELMET)	X						
S-152 COSMIC RAY DETECTOR (SHEETS)	X						
S-184 LUNAR SURFACE CLOSE-UP CAMERA		X	F		X		
S-198 PORTABLE MAGNETOMETER			X		X		
S-199 LUNAR GRAVITY TRAVERSE							X
S-200 SOIL MECHANICS			X	X	X		X
S-201 FAR UV CAMERA/SPECTROSCOPE					X		X
S-204 SURFACE ELECTRICAL PROPERTIES							X

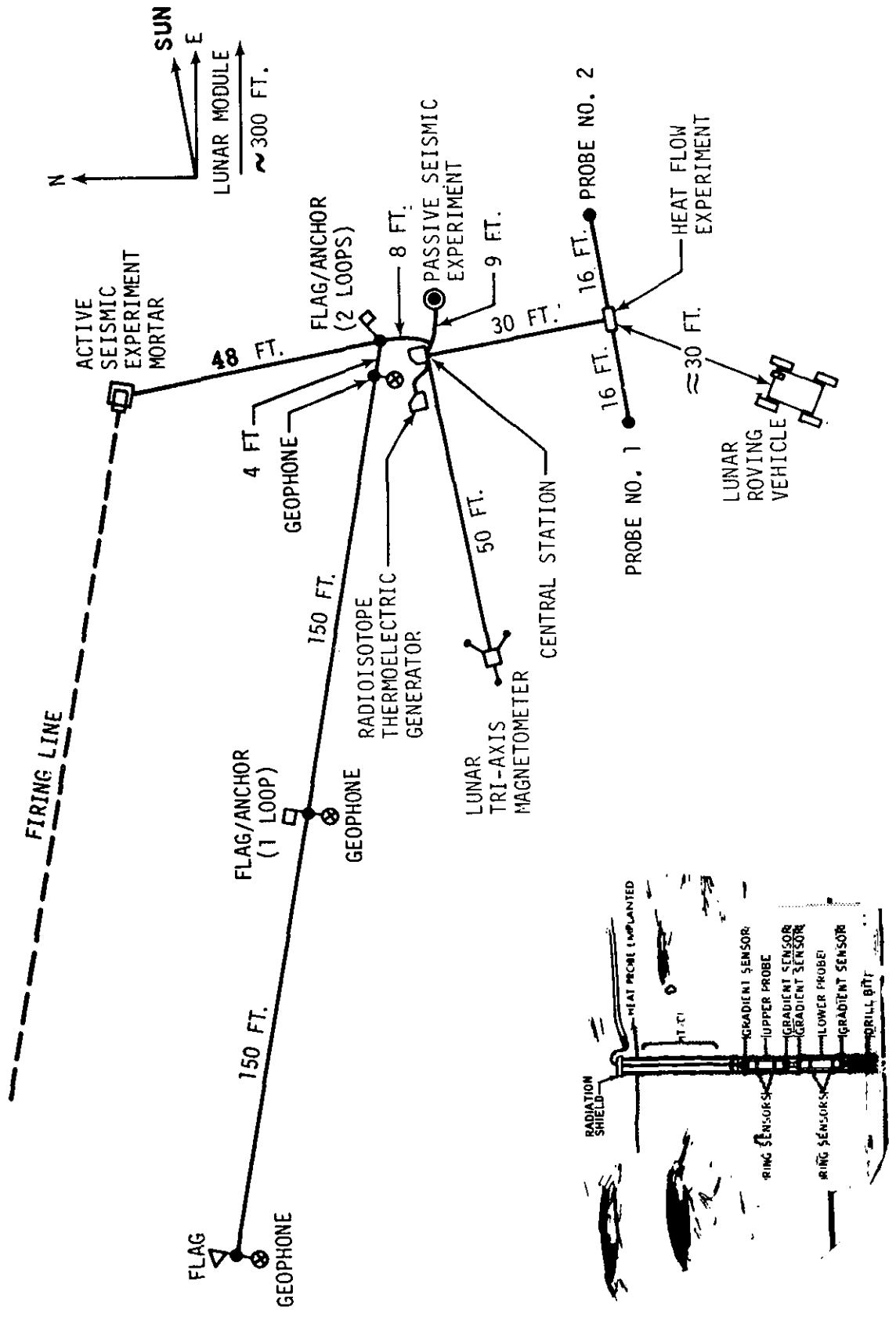
F - FACILITY EQUIPMENT

LUNAR SURFACE SCIENCE EXPERIMENT ASSIGNMENTS

Lunar Surface Experiment Scientific Discipline  
Contribution Correlation

SCIENTIFIC DISCIPLINE EXPERIMENT	GEOLOGY	GEOPHYSICS	GEOCHEMISTRY	BIOSCIENCES	LUNAR ATMOSPHERE	PARTICLES AND FIELDS	ASTRONOMY
CONTINGENCY SAMPLE COLLECTION	AID IN DETERMINING LUNAR HISTORY BY AGING OF LUNAR SAMPLES		DETERMINE COMPOSITION OF LUNAR SURFACE BY CHEMICAL ANALYSIS OF LUNAR SAMPLES	AID IN DETERMINING POSSIBI- LITY OF BIOLOGICAL FORMS ON LUNAR SURFACE		MONOPOLE SEARCH	
ALSEP PASSIVE SEISMIC (5-031)	AID IN DETERMINING INTERIOR STRUCTURE, TECTONISM AND VOLCANISM	AID IN DETERMINING FREE OSCILLATIONS, TIDES, SEICULAR STRAINS, TILT, VELOCITY, ATTENUATION AND DIRECTION OF SEISMIC WAVES					MEASURE METEOROID IMPACTS
ACTIVE SEISMIC 5-033	AID IN DETERMINING THE TYPE AND CHARACTER AS WELL AS HARDNESS AND BEARING STRENGTH OF LUNAR MATERIALS	AID IN DETERMINING FREE OSCILLATIONS, TIDES, SEICULAR STRAINS, TILT, VELOCITY, ATTENUATION AND DIRECTION OF SEISMIC WAVES					MEASURE METEOROID IMPACTS
LUNAR SURFACE MAGNETOMETER 5-034	AID IN DETERMINING MAGNET- IC ANOMALIES, SUBSURFACE FEATURES AND LUNAR HISTORY	AID IN DETERMINING THERMAL STATE OF THE LUNAR INTERIOR				ESTABLISH GROSS ELECTRICAL DIFFRACTION; MEASURE MAG- NETIC FIELD OF THE MOON	DETERMINE LUNAR RESPONSE TO FLUCTUATIONS IN THE INTER- PLANETARY MAGNETIC FIELD
HEAT FLOW 5-037	AID IN DETERMINING LUNAR EVOLUTION	MEASURE VERTICAL TEMPERA- TURE GRADIENTS, ABSOLUTE TEMPERATURE OF THE SURFACE TO ESTABLISH VERTICAL THERMAL CONDUCTIVITY	HEAT COMPOSITION AND CHEMICAL SORTING MAY BE INFERRED FROM DATA				DETERMINE THERMAL ENVIRON- MENT
PORTABLE MAGNETOMETER 5-196	AID IN DETERMINING LOCAL LUNAR MAGNETIC ANOMALIES, PRESENCE OF MASCONS AND OTHER LOCAL MAGNETIC FIELD SOURCES	AID IN MEASURING DISTORTION OF EARTH MAGNETIC FIELD BY SOLAR WIND, SHOCK FRONT, CORONA SHEETS, MAGNETOSPHERE				MEASURE LOCAL MAGNETIC FIELD OF MOON AND MAG- NETIC FIELD/SOLAR PLASMA INTERACTION	DETERMINE LUNAR FIELD FLUCTUATIONS DUE TO DIF- FRACTION OF INTERPLANETARY MAGNETIC FIELD
FAR UV CAMERA/ SPECTROSCOPE		PROVIDE INFORMATION ON THE COMPOSITION OF GASES AND COMPOSITION OF GLO- CORONA, SOLAR WIND, AND INTERSTELLAR MEDIUM			DETECT THE POSSIBLE PRESENCE OF GASES OR GAS VEILING FROM THE LUNAR SURFACE		PROVIDE OPPORTUNITY TO Determine THE COMPOSITION FROM INTERGALACTIC HYDROGEN AND OBTAIN AN ACCURATE SURVEY OF FAINT STARLIGHT AND COSMIC ULTRAVIOLET LIGHT
COSMIC RAY DETECTOR (BHEETS) 5-152		AID IN DETERMINING THE ORIGIN OF FETITES IN LUNAR SOILS OF PROBABLY METEORITIC ORIGIN	DETERMINE COMPOSITION OF SOLAR WIND PLASMA		AID IN DETERMINING HISTORY OF PLANETARY ATMOSPHERE	MEASURE NEUTRON FLUX ON LUNAR SURFACE, PROVIDE EVIDENCE OF INTERGALACTIC PARTICLES, BOTH SOLAR AND GALACTIC	
LUNAR GEOLOGY INVESTIGATION 5-069	AID IN DETERMINING LUNAR GEOLOGICAL STRUCTURE AND HISTORY		DETERMINE CHEMICAL COMPO- SITION OF LUNAR SAMPLES	LUNAR SAMPLES MAY BE TESTED FOR ABILITY TO SUPPORT LIFE POSSIBILITY OF BIOLOGICAL LIFE FORMS ON THE LUNAR SURFACE		MONOPOLE SEARCH	
SOIL MECHANICS 5-286	AID IN DETERMINING LUNAR HISTORY, ENABLE DETERMINA- TION OF COMPOSITIONAL, TER- MINAL, AND MECHANICAL PROPERTIES OF LUNAR SOIL		ENABLE DETERMINATION OF COMPOSITION OF LUNAR SOIL				
SOLAR WIND COMPOSITION * 5-066			DETERMINE COMPOSITION OF SOLAR WIND PLASMA		AID IN DETERMINING HISTORY OF PLANETARY ATMOSPHERE	PROVIDE INFORMATION ON THE COMPOSITION OF NOBLE GASES AND OTHER ELEMENTS IN THE SOLAR WIND	

# APOLLO 16 ALSEP DEPLOYMENT



The S-IVB/IU will weigh 13,973 kilograms (30,805 pounds) and will be traveling 9,223 kilometers an hour (4,980 nautical mph) at lunar impact. It will provide an energy source at impact equivalent to about 11 tons of TNT.

After Young and Duke have completed their lunar surface operations and rendezvoused with the command module in lunar orbit, the lunar module ascent stage will be jettisoned and later ground-commanded to impact on the lunar surface west of the Apollo 16 landing site at Descartes. The stage will impact the surface at 1.692 m/s (5,550 fps) at a -3.2° angle.

Impacts of these objects of known masses and velocities will assist in calibrating the Apollo 16 PSE readouts as well as in providing comparative readings between the Apollo 12, 14, 15 and 16 seismometers.

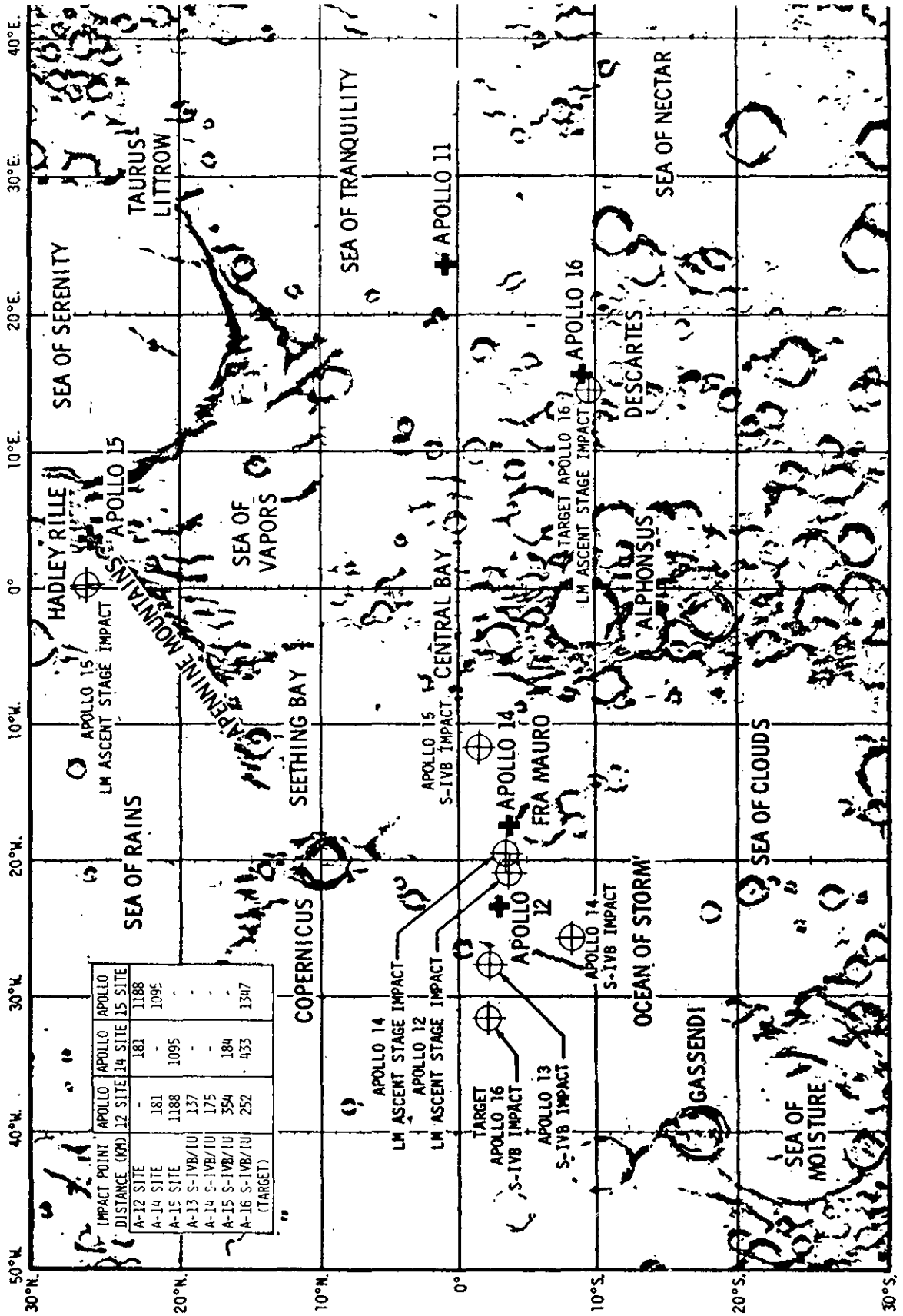
ALSEP to Impact Distance Table

	<u>Approximate Distance</u>	
	<u>Kilometers</u>	<u>Nautical miles</u>
Apollo 12 ALSEP (3.03°S, 23.4°W) to:		
Apollo 12 LM A/S Impact	72	39
Apollo 13 S-IVB Impact	137	74
Apollo 14 S-IVB Impact	175	95
Apollo 14 LM A/S Impact	114	62
Apollo 15 S-IVB Impact	354	191
Apollo 15 LM A/S Impact	1130	610
Apollo 16 S-IVB Impact	252	136
Apollo 16 LM A/S Impact	1173	633
Apollo 14 ALSEP (3.67°S, 17.45°W) to:		
Apollo 14 LM A/S Impact	68	37
Apollo 15 S-IVB Impact	184	99
Apollo 15 LM A/S Impact	1048	565
Apollo 16 S-IVB Impact	433	234
Apollo 16 LM A/S Impact	992	536
Apollo 15 ALSEP (26.10°N, 3.65°E) to:		
Apollo 15 LM A/S Impact	92	50
Apollo 16 S-IVB Impact	1347	727
Apollo 16 LM A/S Impact	1129	609

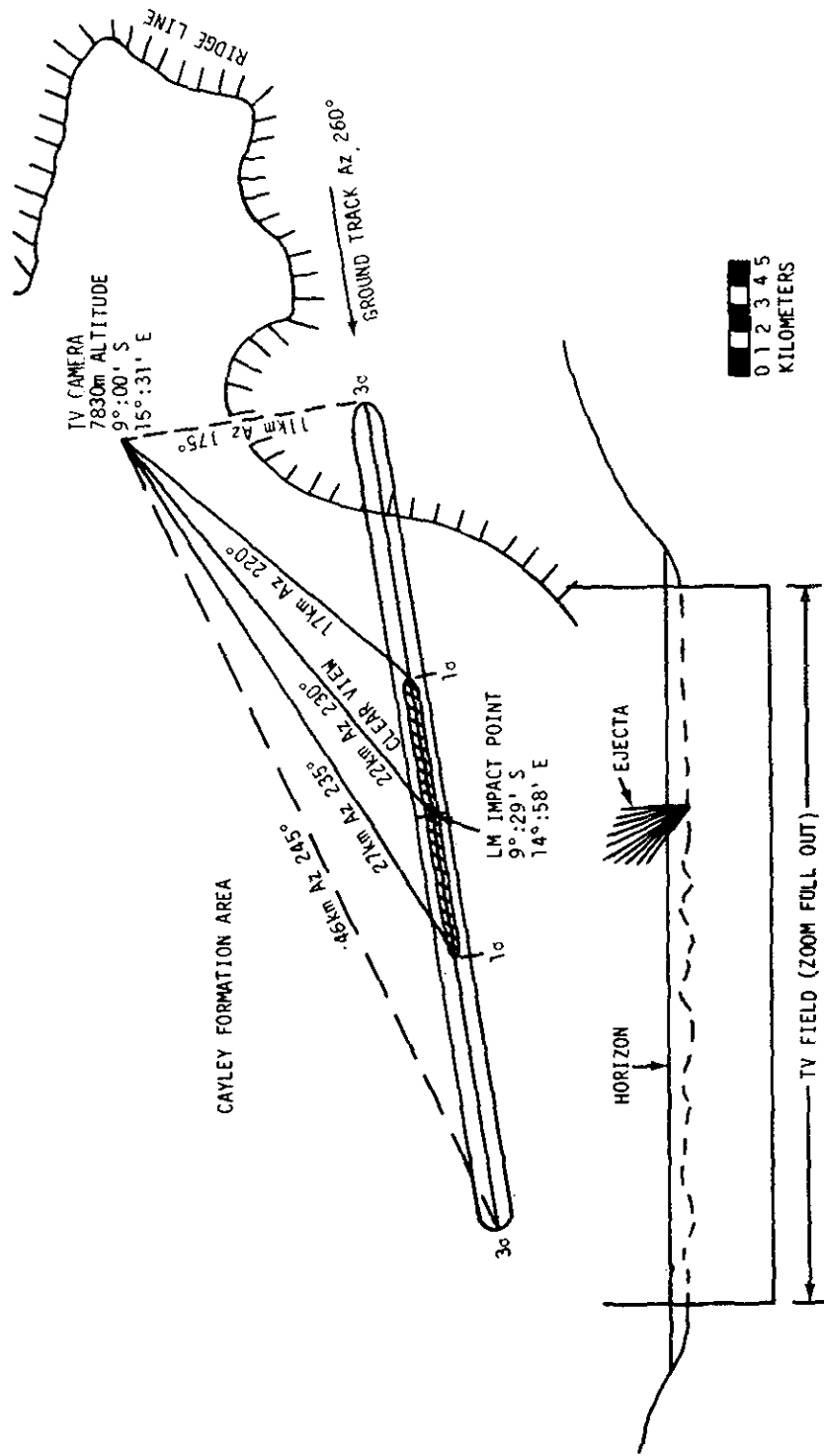
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# S-IVB/IU IMPACT



# LUNAR IMPACT TARGET FOR SPENT LM ASCENT STAGE



Approximate Distance

	<u>Kilometers</u>	<u>Nautical Miles</u>
Apollo 16 ALSEP (9.0°S, 15.52°E) to:		
Apollo 16 LM A/S Impact	23	12
Apollo 16 S-IVB Impact 2.3°S, 31°W		
Apollo 16 LM A/S Impact 9.48°S, 14.97°E		

There are three major physical components of the PSE:

1. The sensor assembly is comprised of 3 long period (LP) and a short period (SP) seismometer, an electrical power and a data subsystem, and a thermal control system. In the LP seismometer, low frequency (approximately 250 to 0.3 second periods) motion of the lunar surface caused by seismic activity is detected by tri-axial, orthogonal displacement amplitude type sensors. In the SP seismometer, the higher frequency (approximately 5 to 0.04 second periods) vertical motion of the lunar surface is detected by a displacement velocity sensor.
2. The external leveling stool allows manual leveling of the sensor assembly by the crewman to within +5 degrees. Final internal leveling to within +3 arc seconds is accomplished by control motors.
3. The five-foot diameter hat-shaped thermal shroud covers and helps stabilize the temperature of the sensor assembly. The instrument uses thermostatically controlled heaters to protect it from the extreme cold of the lunar night.

The Lunar Surface Magnetometer (LSM): The scientific objective of the magnetometer experiment is to measure the magnetic field at the lunar surface. Charged particles and the magnetic field of the solar wind impact directly on the lunar surface. Some of the solar wind particles are absorbed by the surface layer of the Moon. Others may be deflected around the Moon. The electrical properties of the material making up the Moon determine what happens to the magnetic field when it hits the Moon. If the Moon is a perfect insulator the magnetic field will pass through the Moon undisturbed. If there is material present which acts as a conductor, electric currents will flow in the Moon. A small magnetic field of approximately 35 gammas, one thousandth the size of the Earth's field was recorded at the Apollo 12 site.

Fields recorded by the portable magnetometer on Apollo 14 were about 43 gammas and 103 gammas in two different locations. (Gamma is a unit of intensity of a magnetic field. The Earth's magnetic field at the Equator, for example, is 35,000 gamma. The interplanetary magnetic field from the Sun has been recorded at 5 to 10 gamma.)

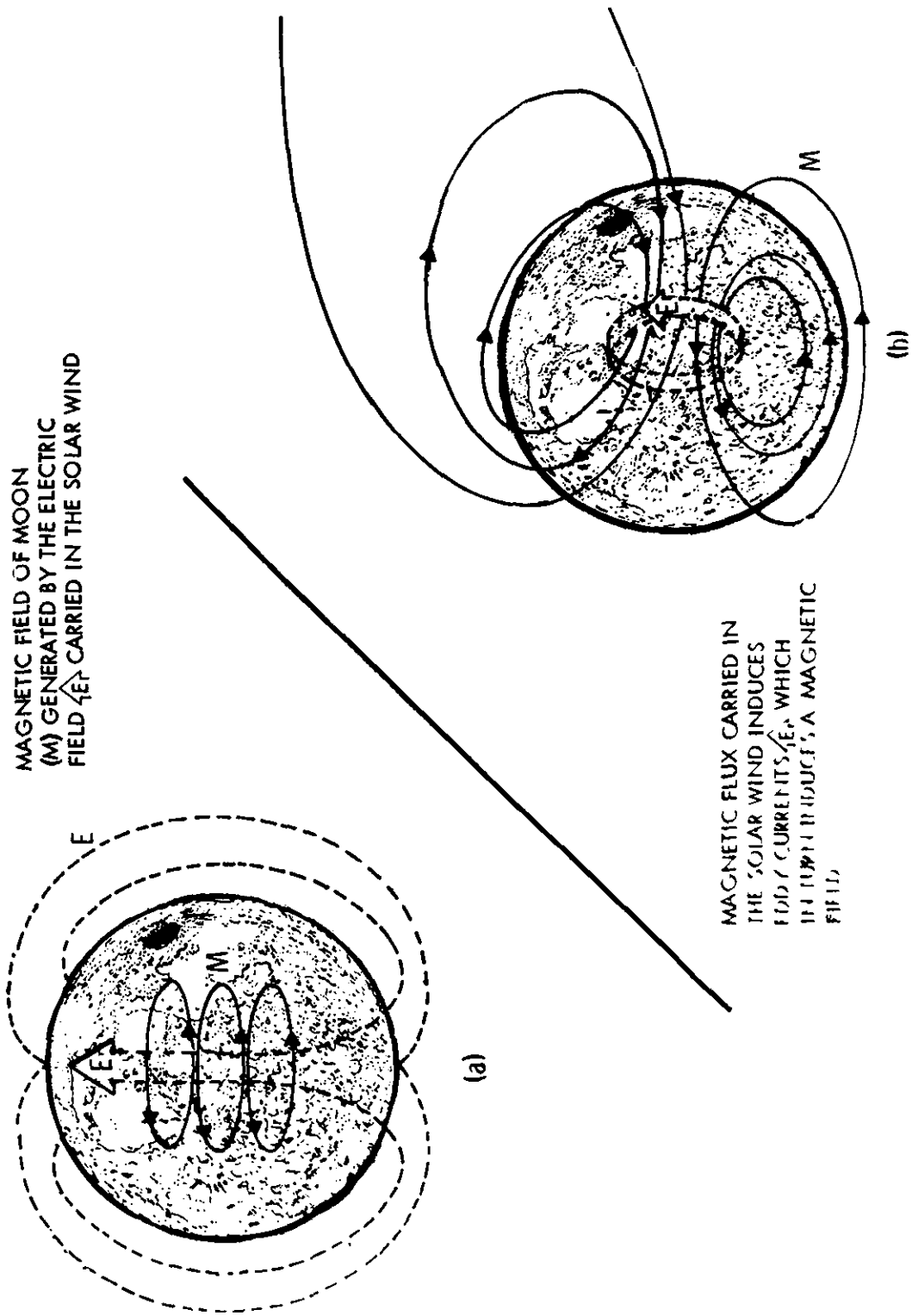
Two possible models are shown in the next drawing. The electric current carried by the solar wind goes through the Moon and "closes" in the space surrounding the Moon (figure a). This current (E) generates a magnetic field (M) as shown. The magnetic field carried in the solar wind will set up a system of electric currents in the Moon or along the surface. These currents will generate another magnetic field which tries to counteract the solar wind field (figure b). This results in a change in the total magnetic field measured at the lunar surface.

The magnitude of this difference can be determined by independently measuring the magnetic field in the undisturbed solar wind nearby, yet away from the Moon's surface. The value of the magnetic field change at the Moon's surface can be used to deduce information on the electrical properties of the Moon. This, in turn, can be used to better understand the internal temperature of the Moon and contribute to better understanding of the origin and history of the Moon.

The principal investigator for this experiment is Dr. Palmer Dyal, NASA Ames Research Center, Mountain View, California.

The magnetometer consists of three magnetic sensors aligned in three orthogonal sensing axes, each located at the end of a fiberglass support arm extending from a central structure. This structure houses both the experiment electronics and the electro-mechanical gimbal/flip unit which allows the sensor to be pointed in any direction for site survey and calibration modes. The astronaut aligns the magnetometer experiment to within  $\pm 3$  degrees east-west using a shadowgraph on the central structure, and to within  $\pm 3$  degrees of the vertical using a bubble level mounted on the  $\bar{Y}$  sensor boom arm

# LUNAR MAGNETIC ENVIRONMENT



MAGNETIC FIELD OF MOON  
(M) GENERATED BY THE ELECTRIC  
FIELD  $E$  CARRIED IN THE SOLAR WIND

MAGNETIC FLUX CARRIED IN  
THE SOLAR WIND INDUCES  
FIELD CURRENTS  $E \times v$ , WHICH  
IN TURN INDUCE, A MAGNETIC  
FIELD.

(a)

(b)

Size, weight and power are as follows:

Size deployed	102 cm (40 inches) high with 152 cm (60 inches) between sensor heads
Weight (pounds)	8 kilograms (17.5 lbs)
<u>Peak Power Requirements (watts)</u>	
Site Survey Mode	11.5
Scientific Mode	6.2 12.3 (night)
Calibration Mode	10.8

The magnetometer experiment operates in three modes:

Site Survey Mode -- An initial site survey is performed in each of the three sensing modes for the purpose of locating and identifying any magnetic influences permanently inherent in the deployment site so that they will not affect the interpretation of the LSM sensing of magnetic flux at the lunar surface.

Scientific Mode -- This is the normal operating mode wherein the strength and direction of the lunar magnetic field are measured continuously. The three magnetic sensors provide signal outputs proportional to the incidence of magnetic field components parallel to their respective axes. Each sensor will record the intensity three times per second which is faster than the magnetic field is expected to change. All sensors have the capability to sense over any one of three dynamic ranges with a resolution of 0.2 gamma.

-100 to +100 gamma

-200 to +200 gamma

-400 to +400 gamma

Calibration Mode -- This is performed automatically at 18-hour intervals to determine the absolute accuracy of the magnetometer sensors and to correct any drift from their laboratory calibration.

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### Magnetic Lunar Sample Returned to the Moon

In the study of returned lunar samples it has been found that there are commonly two components of remanent magnetization. The first of these is quite soft and can be removed by cleaning in alternating fields of about 50 to 100 oersteds. The second component is quite stable and is hardly affected by alternating fields up to 500 oersteds. It is this stable component which is most likely to represent ancient lunar magnetic fields and on which most attention has been focused. It can be simulated in the laboratory by allowing the sample to cool in the presence of a weak field from above its Curie point -- about 780 degrees Centigrade (1,400 degrees Fahrenheit) in the case of lunar samples.

The soft component can also be simulated in the laboratory by exposing lunar samples to steady magnetic fields of about 10 to 50 oersteds. The field required to do this is much greater than the Earth's field which is only about 0.5 oersteds. One possibility, therefore, is that this magnetization was acquired on the return journey to Earth either in the spacecraft or in Earth laboratories. Another possibility is that this magnetization is truly of lunar origin, perhaps related to thermal fluctuations in the presence of a weak, solar wind field. It is important to establish the origin of this soft component and two steps are being taken to do this.

At the last lunar portable magnetometer (LPM) station a documented sample (preferably igneous) will be picked up and placed on the LPM after the first reading is taken. It will be documented in place on the magnetometer and the LPM reading retaken. If the intensity of magnetization of the soft component is like that seen in the returned samples it should be measurable at the level of several gammas. On return to Earth this same sample will be placed on the back-up flight model LPM in the shielded room in the LRL and the same procedure repeated. This will tell if additional magnetization has been acquired on the return journey.

The second step consists of taking a lunar sample back to the Moon. The sample chosen is Apollo 12 sample 12002,78. Weight is 4 grams (0.14 ounces). This sample has been thoroughly tested magnetically and has a very clear stable component of magnetization. When first received in the laboratory it also had a soft component of magnetization which has been removed. Upon return to Earth it will be tested once again to see if it has reacquired the soft component. If it has, the soft remanence is not of lunar origin. The sample will be placed in a bag, sewn inside an interim stowage assembly bag and returned to Earth stowed as on Apollo 12.

Lunar Heat Flow Experiment (HFE): The scientific objective of the heat flow experiment is to measure the steady-state heat flow from the lunar interior. Two predicted sources of heat are: (1) original heat at the time of the Moon's formation and (2) radioactivity. Scientists believe that heat could have been generated by the infalling of material and its subsequent compaction as the Moon was formed. Moreover, varying amounts of the radioactive elements uranium, thorium and potassium were found in the Apollo 11, 12, 14, and 15 lunar samples which if present at depth, would supply significant amounts of heat. No simple way has been devised for relating the contribution of each of these sources to the present rate of heat flow. In addition to temperature, the experiment is capable of measuring the thermal conductivity of the lunar rock material.

The combined measurement of temperature and thermal conductivity gives the net heat flux from the lunar interior through the lunar surface. Similar measurements on Earth have contributed basic information to our understanding of volcanoes, earthquakes and mountain building processes. In conjunction with the seismic and magnetic data obtained on other lunar experiments the values derived from the heat flow measurements will help scientists to build more exact models of the Moon and thereby give us a better understanding of its origin and history.

The heat flow experiment consists of instrument probes, electronics and emplacement tool and the lunar surface drill. Each of two probes is connected by a cable to an electronics box which rests on the lunar surface. The electronics, which provide control, monitoring and data processing for the experiment, are connected to the ALSEP central station.

Each probe consists of two identical 51 cm (20 in.) long sections each of which contains a "gradient" sensor bridge, a "ring" sensor bridge and two heaters. Each bridge consists of four platinum resistors mounted in a thin-walled fiberglass cylindrical shell. Adjacent areas of the bridge are located in sensors at opposite ends of the 51 cm (20 in.) fiberglass probe sheath. Gradient bridges consequently measure the temperature difference between two sensor locations.

In thermal conductivity measurements at very low values a heater surrounding the gradient sensor is energized with 0.002 watts and the gradient sensor values monitored. The

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rise in temperature of the gradient sensor is a function of thermal conductivity of the surrounding lunar material. For higher range of values, the heater is energized at 0.5 watts of heat and monitored by a ring sensor. The rate of temperature rise, monitored by the ring sensor is a function of the thermal conductivity of the surrounding lunar material. The ring sensor, approximately 10 cm (4 in.) from the heater, is also a platinum resistor. A total of eight thermal conductivity measurements can be made. The thermal conductivity mode of the experiment will be implemented about 20 days (500 hours) after deployment. This is to allow sufficient time for the perturbing effects of drilling and emplacing the probe in the borehole to decay; i.e., for the probe and casings to come to equilibrium with the lunar subsurface.

A 9.1 meter (30-ft.) cable connects each probe to the electronics box. The cable contains four evenly spaced thermocouples: at the top of the probe; at 66 cm (26 in.), 114 cm (45 in.) and 168 cm (66 in.). The thermocouples will measure temperature transients propagating downward from the lunar surface. The reference junction temperature for each thermocouple is located in the electronics box. In fact, the feasibility of making a heat flow measurement depends to a large degree on the low thermal conductivity of the lunar surface layer, the regolith. Measurement of lunar surface temperature variations by Earth-based telescopes as well as the Surveyor and Apollo missions show a remarkably rapid rate of cooling. The wide fluctuations in temperature of the lunar surface are to influence only the upper one meter (three ft.) and not the bottom one meter (three ft.) of the borehole.

The astronauts will use the Apollo lunar surface drill (ALSD) to make a lined borehole in the lunar surface for the probes. The drilling energy will be provided by a battery-powered rotary percussive power head. The drill borestem rod consists of fiberglass tubular sections reinforced with boron filaments, one section 137 cm (54 in) long and two sections each 71 cm (28 in) long. A closed drill bit, placed on the first drill rod, is capable of penetrating the variety of rock including 95 cm (3 ft.) of vesicular basalt (40 percent porosity). As lunar surface penetration progresses, additional drill rod sections will be connected to the drill string. The drill string is left in place to serve as a hole casing

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An emplacement tool is used by the astronaut to insert the probe to full depth. Alignment springs position the probe within the casing and assure a well-defined radiative coupling between the probe and the borehole. Radiation shields on the hole prevent direct sunlight from reaching the bottom of the hole.

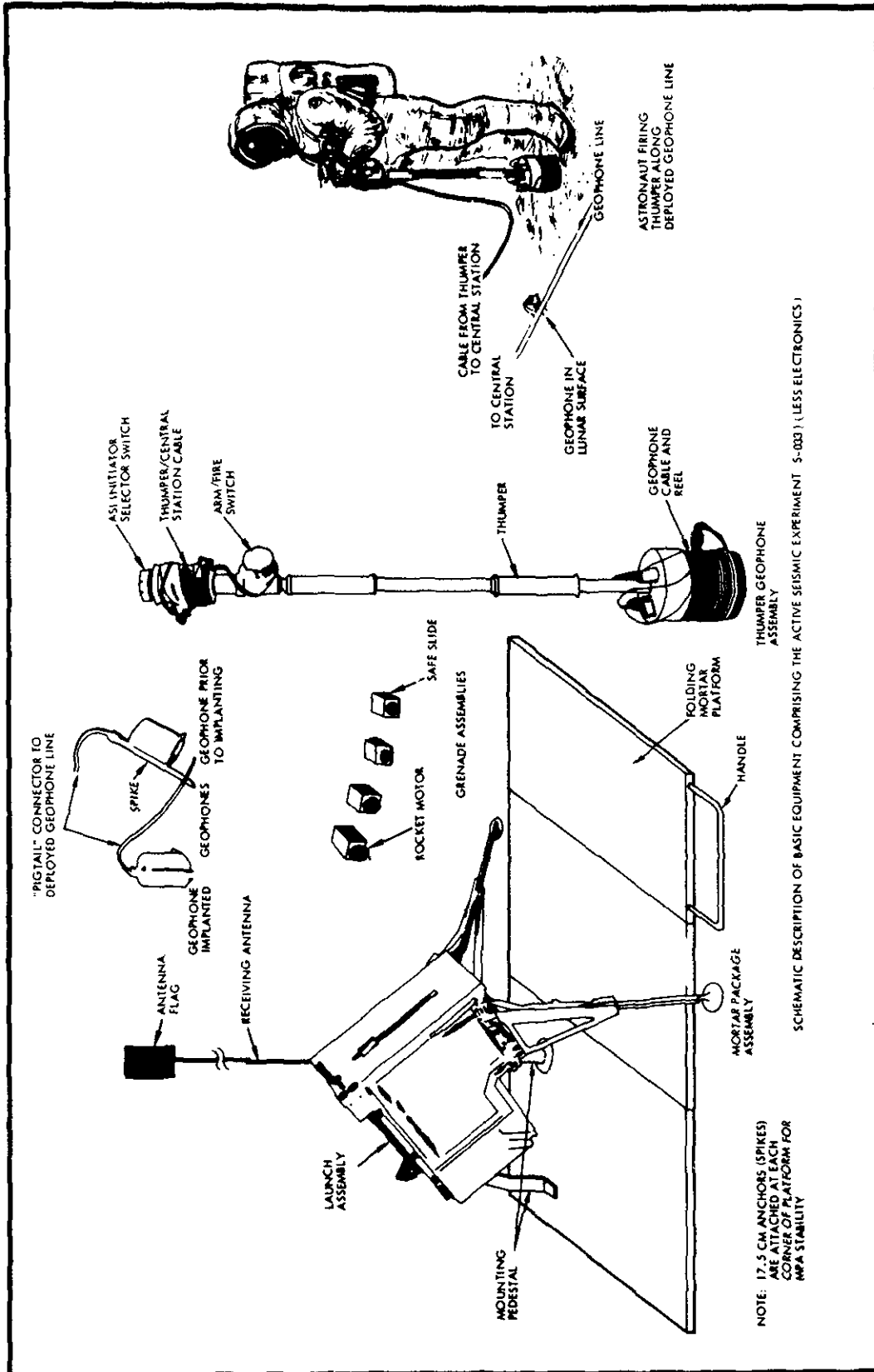
As a part of the field geology experiment, the astronaut will drill a third hole near the HFE, using corestem drill sections and a coring bit, and obtain cores of lunar material for subsequent analysis of thermal properties and composition. Total available core length is 2.5 m (100 in.).

The heat flow experiment, design, and data analysis are the responsibility of Dr. Marcus Langseth of the Lamont-Doherty Geological Observatory.

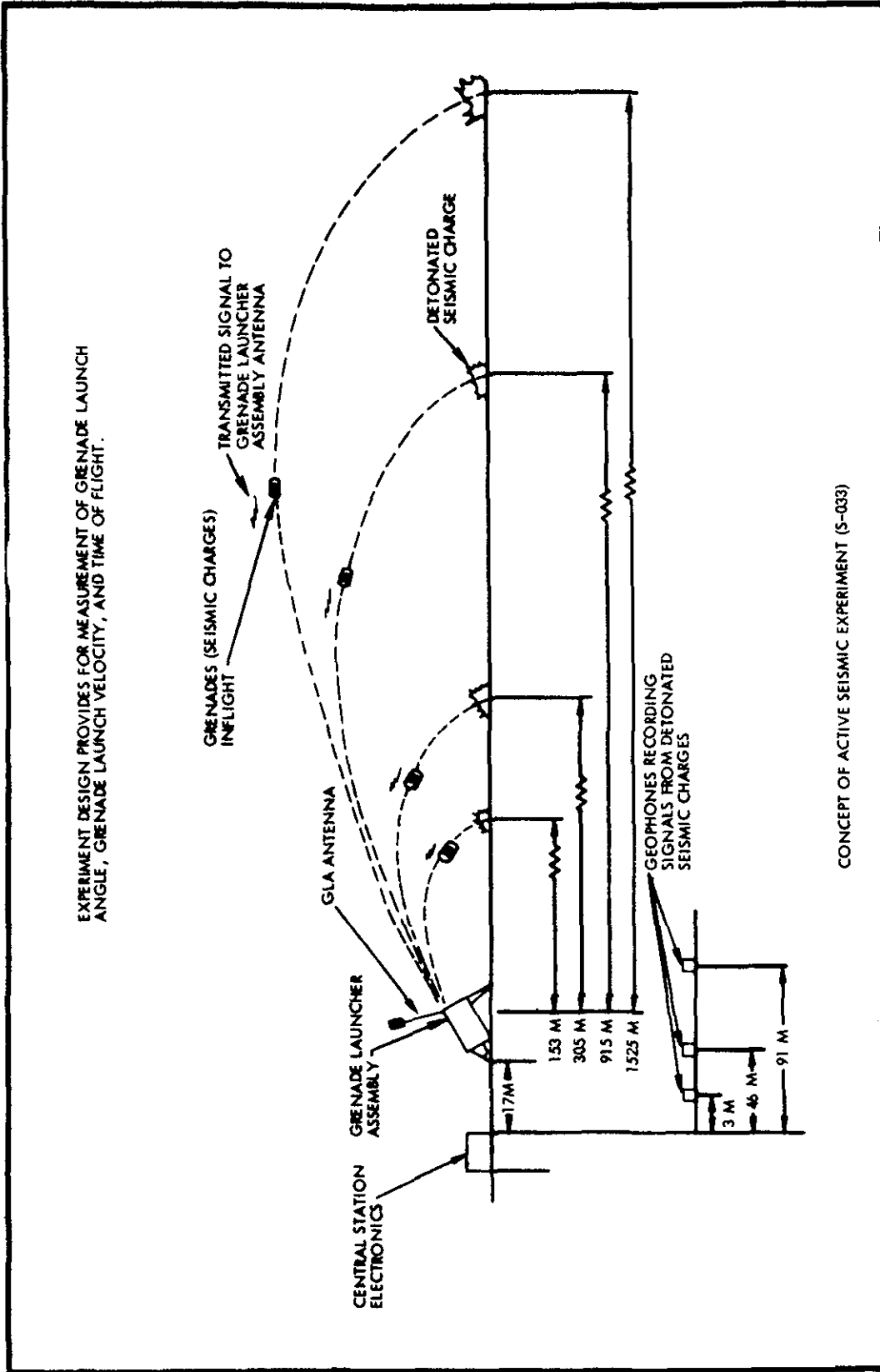
Active Seismic Experiment: The ASE will produce data on the physical structure and bearing strength of the lunar surface by measuring seismic waves. Two types of man-made seismic sources will be used with the ASE: a crew-actuated pyrotechnic "thumper" and a mortar-like device from which four rocket propelled projectiles can be launched by command from Earth. Naturally produced seismic events will be detected passively by the ASE (the ASE geophones will be turned on remotely for short listening periods). The seismic waves are detected by geophones deployed by the crew. Data on wave penetration, frequency spectra, and velocity to lunar depths of 152 meters (500 ft.) will be obtained and passed to the ALSEP central station for transmittal to the Earth. Dr. Robert Kovach of Stanford University is the Principal Investigator.

The mortar like device will be deployed, aligned and activated about 15 meters (48 ft.) north of the ALSEP central station. The four grenade-like projectiles will be launched sometime after the crew returns and at a time specified by the principal investigator, but no sooner than the third lunation.

The crew will deploy three geophones at 3.5, 45.7 and 91.4 meters (10, 150, 300 ft.) from the ALSEP central station. Enroute back to the central station, the crewman will fire 19 "thumper" charges at 4.5 meters (15 ft.) intervals along the geophone line. The thumper serves as a storage and transport rack for the geophones and their connecting cable.



Active Seismic Experiment



Active Seismic Experiment Mortar Mode Concept

The two major components of the ASE are:

1. The thumper-geophone assembly measuring 1.13 m (44.5 in.) when deployed and weighing 3.2 kg. (7 lbs.) including three geophones and cable. Each geophone is 12.2 cm (4.8 in.) high, 4.1 cm (1.6 in.) in diameter and weighs less than 0.4 kg. (1 lb.).

2. The package projectile launch assembly weighs 6.8 kg. (15 lbs.) (including four projectiles) and is 24 cm (9.5 in.) high, 10.2 cm (4 in.) wide and 38 cm (15.6 in.) long. The mortar-like launching device is made of fiberglass and magnesium, and contains firing circuitry and a receiver antenna. The projectile launch assembly is enclosed in a box and consists of four fiberglass launch tubes and four projectiles. The projectiles vary in length and weight according to the propellant and explosive charges. Radio transmitters in each projectile furnish start-and-stop flight time data for telemetry back to Earth. Thus, with the launch angle known, range can be calculated. The geophones provide information on seismic wave travel time. Correlation of this time with range will establish wave velocity through the lunar surface.

ALSEP Central Station: The central station serves as a power-distribution and data-handling point for experiments carried on the ALSEP. Central station components are the data subsystem, helical antenna, experiment electronics, and power conditioning unit. The central station is deployed after other experiment instruments are unstowed from the pallet.

The central station data subsystem receives and decodes uplink commands, times and controls experiments, collects and transmits scientific and engineering data downlink, and controls the electrical power subsystem through the power distribution and signal conditioner.

The modified axial-helix S-band antenna receives and transmits a right-hand circularly-polarized signal. The antenna is manually aimed with a two-gimbal azimuth/elevation aiming mechanism.

The ALSEP electrical power subsystem draws electrical power from a SNAP-27 (Systems for Nuclear Auxiliary Power) radioisotope thermoelectric generator.

SNAP-27--Power Source for ALSEP

A SNAP-27 unit, similar to three others deployed on the Moon, will provide power for the ALSEP package. SNAP-27 is one of a series of radioisotope thermoelectric generators, or atomic batteries, developed by the Atomic Energy Commission under its space SNAP program. The SNAP (Systems for Nuclear Auxiliary Power) program is directed at development of generators and reactors for use in space, on land, and in the sea.

SNAP-27 on Apollo 12 marked the first use of a nuclear power system on the Moon. The nuclear generators are required to provide power for periods of at least one year. Thus far, the SNAP-27 unit on Apollo 12 has operated over two years; and the SNAP-27 unit on Apollo 14 has operated a little over a year.

The basic SNAP-27 unit is designed to produce at least 68 watts of electrical power. The SNAP-27 unit is a cylindrical generator, fueled with the radioisotope plutonium-238. It is about 46 cm (18 inches) high and 41 cm (16 inches) in diameter, including the heat radiating fins. The generator, making maximum use of the lightweight material beryllium, weighs about 12.7 kilograms (28 pounds) without fuel.

The fuel capsule, made of a superalloy material, is 42 cm (16.5 inches) long and 6.4 cm (2.5 inches) in diameter. It weighs about 7 km (15.5 pounds), of which 3.8 km (8.36 pounds) represent fuel. The plutonium-238 fuel is fully oxidized and is chemically and biologically inert.

The rugged fuel capsule is stowed within a graphite fuel cask from launch through lunar landing. The cask is designed to provide reentry heating protection and containment for the fuel capsule in the event of an aborted mission. The cylindrical cask with hemispherical ends includes a primary graphite heat shield, a secondary beryllium thermal shield, and a fuel capsule support structure. The cask is 58.4 cm (23 inches) long and 20 cm (eight inches) in diameter and weighs about 11 km (24.5 pounds). With the fuel capsule installed, it weighs about 18 km (40 pounds). It is mounted on the lunar module descent stage.

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Once the lunar module is on the Moon, an Apollo astronaut will remove the fuel capsule from the cask and insert it into the SNAP-27 generator which will have been placed on the lunar surface near the module.

The spontaneous radioactive decay of the plutonium-238 within the fuel capsule generates heat which is converted directly into electrical energy--at least 68 watts. Units now on the lunar surface are producing 72 to 74 watts. There are no moving parts.

The unique properties of plutonium-238, make it an excellent isotope for use in space nuclear generators. At the end of almost 90 years, plutonium-238 is still supplying half of its original heat. In the decay process, plutonium-238 emits mainly the nuclei of helium (alpha radiation), a very mild type of radiation with a short emission range.

Before the use of the SNAP-27 system was authorized for the Apollo program a thorough review was conducted to assure the health and safety of personnel involved in the launch and of the general public. Extensive safety analyses and tests were conducted which demonstrated that the fuel would be safely contained under almost all credible accident conditions.

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Soil Mechanics: Mechanical properties of the lunar soil, surface, and subsurface will be investigated through trenching at various locations and through use of the self-recording penetrometer. The self-recording penetrometer measures the characteristics and mechanical properties of the lunar surface material. The penetrometer consists of a 76 cm (30-in) penetration shaft and recording drum. Three interchangeable penetration cones 1.3, 3.2 and 6.4 cm<sup>2</sup> (0.2, 0.5 and 1.0 in)<sup>2</sup> cross sections and a 2.5 x 12.7 cm (1 x 5-in.) pressure plate may be attached to the shaft. The crewman forces the penetrometer into the surface and a stylus scribes a force vs. depth plot on the recording drum. The drum can record up to 24 force-depth plots. The upper housing containing the recording drum is detached at the conclusion of the experiment for return to Earth and analysis by the principal investigator. This experiment will be documented with the electric Hasselblad and the 16mm data acquisition cameras.

Soil behavior characteristics are also determined from interactions of LRV wheels, LM footpads, and footprints with the lunar soil.

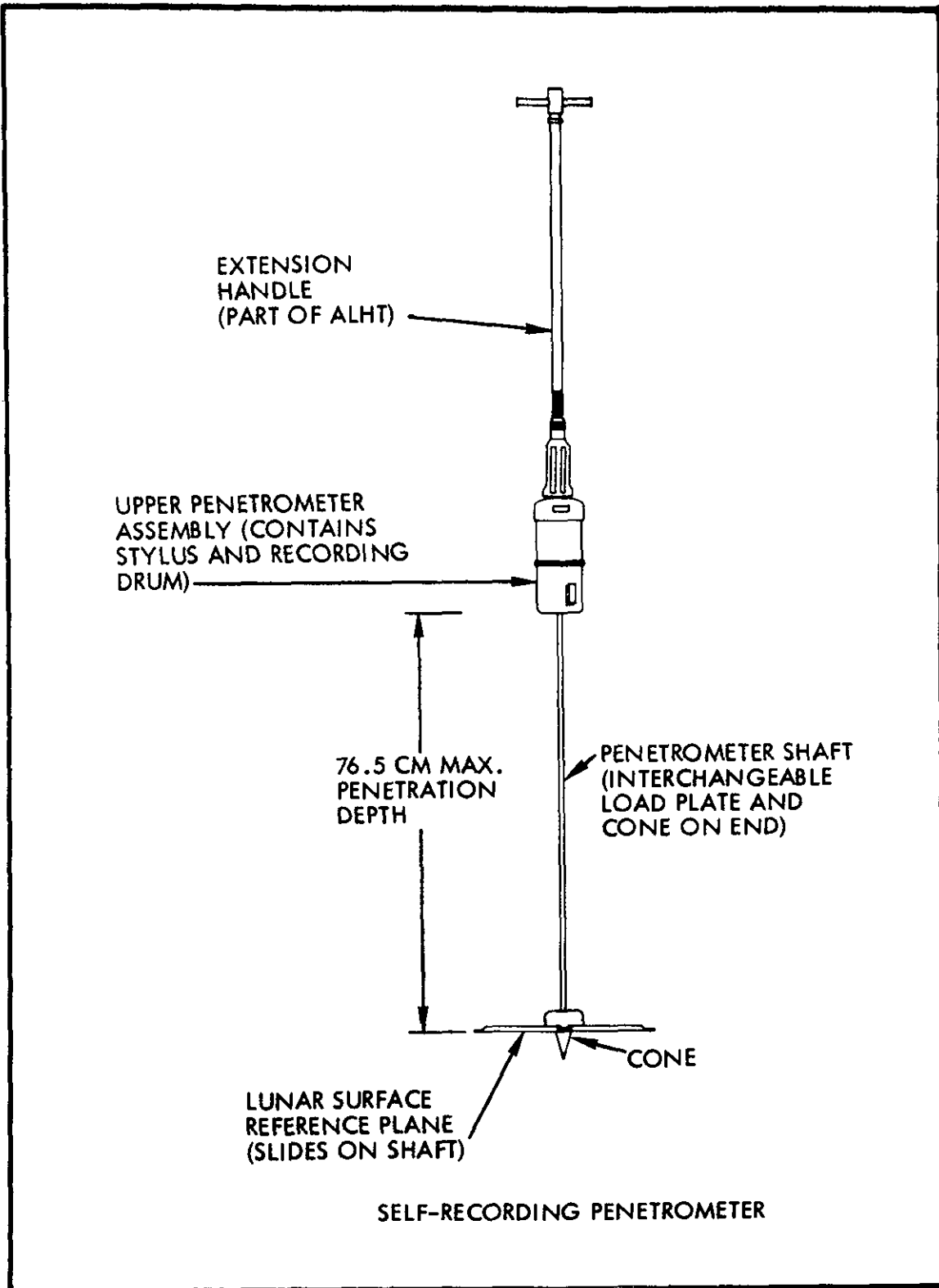
Lunar Portable Magnetometer (LPM): The Apollo 16 crew will use the LPM during EVAs 1 and 3 for measuring variations in the lunar magnetic field at several points during the geology traverses. Data gathered will be used to determine the location, strength, and dimensions of the magnetic field, as well as knowledge of the local selenological structure. The LPM experiment was also flown on Apollo 14.

The LPM will be carried on the LRV aft pallet and consists of a flux-gate magnetometer sensor head mounted on a tripod and an electronics data package. The sensor head is connected to the data package by a 15.2-meter (50 ft.) flat cable, and after the crewman aligns the sensor head at least 14 meters (46 ft.) from the data package, he returns to the LRV and relays readouts to Earth by voice.

The sensor head is sensitive to magnetic interference from the crew's portable life support systems, the geology tool, and the LRV, hence the need for emplacing and aligning the sensor well away from them. The mercury-cell powered electronics package has a range of +256 gamma. Readings are displayed in three digital meters---one for each axis (orthogonal X, Y and Z). At each traverse location for LPM measurements, the crew will call out the meter readings on each axis.

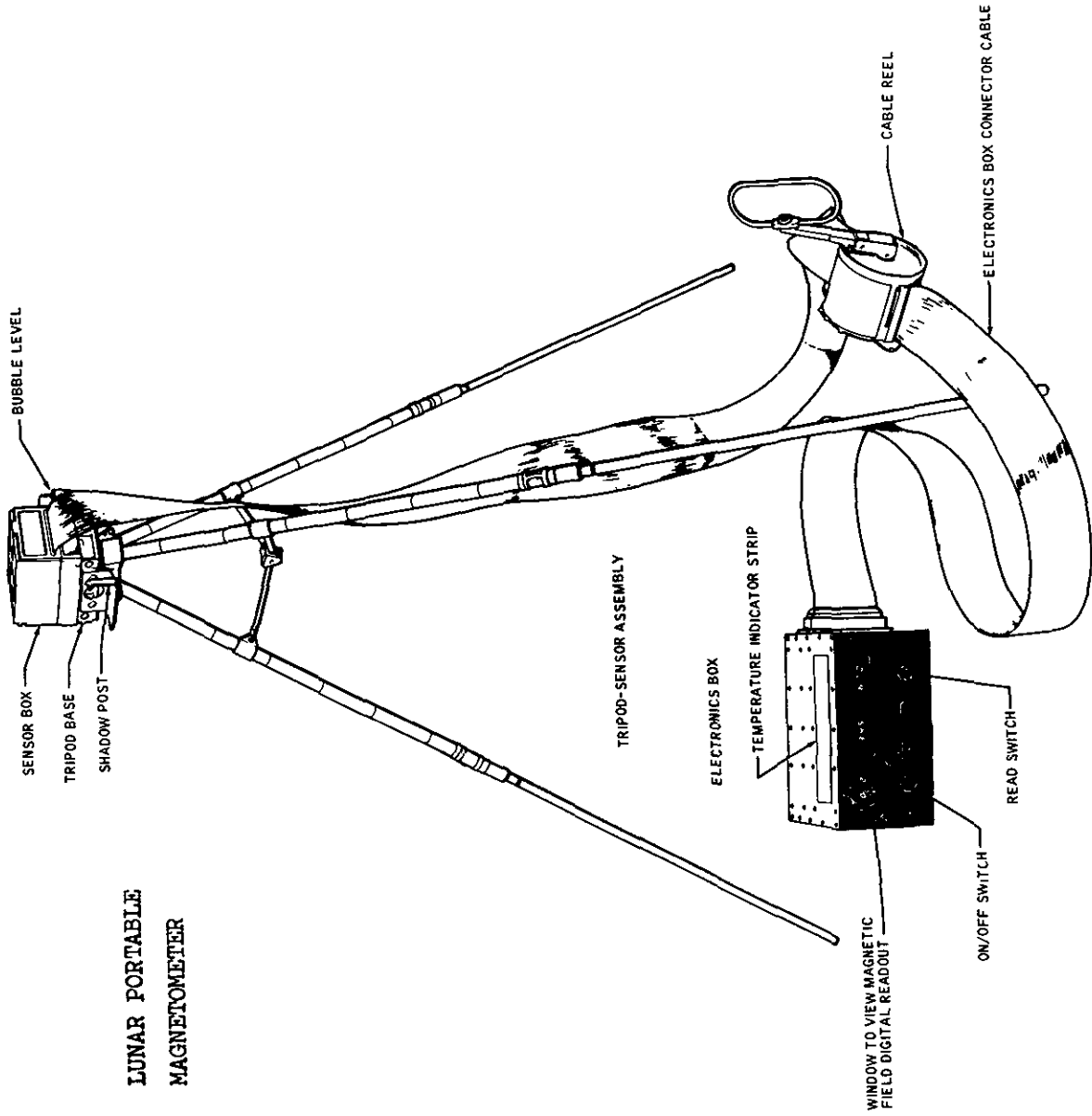
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Soil Mechanics Experiment Penetrometer

# LUNAR PORTABLE MAGNETOMETER



Dimensions of the LPM components are 10.2 x 19 x 12.7 cm (4 x 7 1/2 x 5 inches) for the data package and 8.6 x 14.4 x 6.7 cm (3 3/8 x 5 11/16 x 2 5/8 inches) for the sensor head. The sensor head tripod is 45.7 cm (18 inches) long when retracted and extends to 78.7 cm (31 inches). The principal investigator is Dr. Palmer Dyal, NASA Ames Research Center, Mountain View, Calif.

Far Ultraviolet Camera/Spectroscope: Deep-space concentrations of hydrogen in interplanetary, interstellar and intergalactic regions will be mapped by this experiment using an instrument which gathers both photographic images and spectroscopic data in the far ultraviolet spectrum. The experiment will be the first such astronomical observation emplaced on the lunar surface.

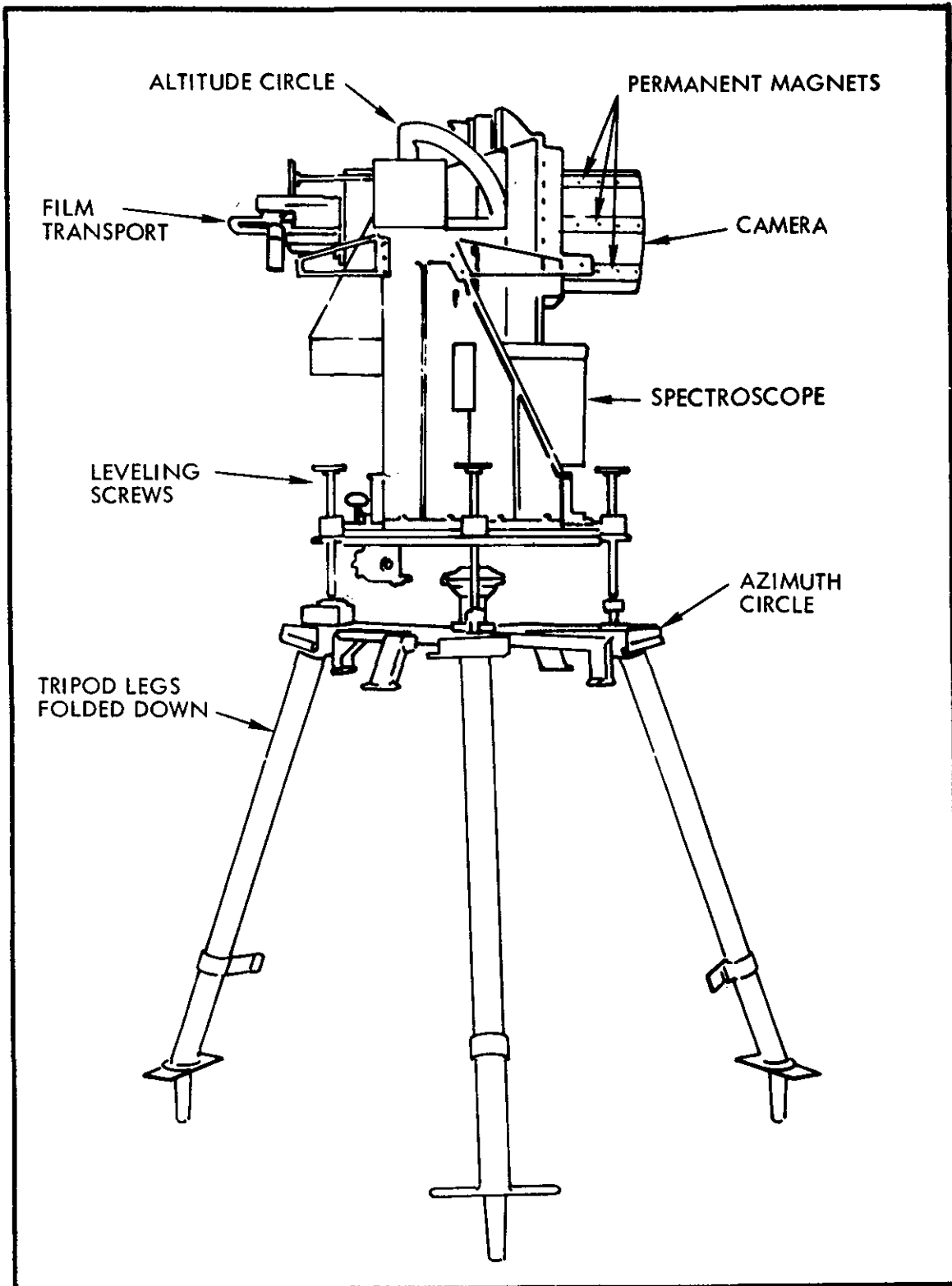
Earlier spectrographic searches for hydrogen sources in space from Earth-orbiting astronomical satellites were impaired by the "masking" effect of the Earth's corona. The instrument will be pointed toward such targets as star clouds, nebulae, galaxy clusters and other galactic objects, intergalactic hydrogen, the solar bow cloud and solar wind, lunar atmosphere and any possible lunar volcanic gases, and the Earth's atmosphere and corona. Several astrophysicists have speculated that extremely hot hydrogen exists in intergalactic space and that hydrogen clusters may be detected between galaxies by an instrument such as the far UV camera spectroscope.

The experiment includes a 75mm (3-in) electronographic Schmidt camera with a potassium bromide cathode and 35mm film magazine and transport. Emplaced on a tripod in the LM shadow, the instrument is provided with a battery pack which is placed in the Sun at the end of its connecting cable. The spectroscope is fitted with lithium fluoride and calcium fluoride filters for detecting hydrogen Lyman-alpha radiation in the 1216 Å (angstrom) wavelength.

Measurements will range from 500 to 1550 Å for spectroscopic data and from 1050 to 1550 Å and 1230 to 1550 Å in photographic imagery. Hydrogen gas clouds will be detected through differential measurements of the photoimagery.

Using the elevation/azimuth adjustments on the instrument mount, the crew will align the camera/spectroscope toward specific targets periodically during the three EVAs. Near the end of EVA 3, the camera film cassette will be retrieved for return to Earth.

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Tripod-Mounted Schmidt Electronographic UV Camera/Spectroscope

Experiment principal investigator is Dr. George R. Carruthers of the E.O. Hurlburt Center for Space Research, Naval Research Laboratory, Washington, D.C.

Solar Wind Composition Experiment (SWC): The scientific objective of the solar wind composition experiment is to determine the elemental and isotopic composition of the noble gases in the solar wind.

As in Apollos 11, 12, 14 and 15, the SWC detector will be deployed on the lunar surface and brought back to Earth by the crew. The detector will be exposed to the solar wind flux for 46 hours compared to 41 hours on Apollo 15, 21 hours on Apollo 14, 18 hours on Apollo 12 and two hours on Apollo 11.

The solar wind detector consists of an aluminum and platinum foil .37 square meters ( 4 square ft.) in area and about 0.5 mils thick rimmed by Teflon for resistance to tearing during deployment. The platinum foil strips have been added to the experiment on Apollo 16 to reduce contamination. This will allow a more accurate determination of solar wind constituents. A staff and yard arrangement will be used to deploy the foil and to maintain the foil approximately perpendicular to the solar wind flux. Solar wind particles will penetrate into the foil, while cosmic rays pass through. The particles will be firmly trapped at a depth of several hundred atomic layers. After exposure on the lunar surface, the foil is rolled up and returned to Earth. Professor Johannes Geiss, University of Berne, Switzerland, is principal investigator. Professor Geiss is sponsored and funded by the Swiss Committee for Space Research.

## Cosmic Ray Detector

A four-panel detector array is mounted on the lunar module descent stage for measuring the charge, mass and energy of cosmic ray and solar wind particles impacting the detector array on the way to the Moon and during the stay on the lunar surface. The detector array will be brought back to Earth for analysis.

Energy ranges for the two types of particles to be measured are from 0.5 to 10 thousand electron volts/nucleon and from 0.2 to 200 million electron volts/nucleon. Additionally, various types of glass detectors will be evaluated and lunar surface thermal neutron flux will be measured.

Cosmic ray and solar wind particles will impact three portions of the detector during translunar coast, and the fourth panel will be uncovered early in the first lunar surface EVA to gather data on lunar cosmic ray and solar wind particles. The detector will be folded and bagged during the third EVA and returned to Earth.

Detector panel 1 is a sandwich of 31 sheets of Lexan, each 0.025 cm thick, and covered by perforated aluminized Teflon.

Panel 2 is almost identical to panel 1, except that two plastic sheets are pre-irradiated for data analysis calibration.

Panel 3 is made up of 40 layers of 0.2-cm-thick Kodacel cellulose triacetate sheets, overlaid on the upper half by 10 five-micron thick Lexan sheets. Five specimens of glass are imbedded in the panel's lower portion.

Panel 4 is similar in makeup to panel 3, except that the sheets in the lower part of the panel may be shifted. A 0.076-cm-thick aluminum plate, to which are bonded small fragments of mica, glass and natural crystals, covers the lower quarter of the panel. The next highest quarter of the panel is covered by a bonded 2-micron thick foil. A lanyard-actuated slide made of 0.0005-cm thick aluminum foil bonded to a platinum base covers the upper half of panel four. The panel upper half is exposed to the lunar environment when the crewman pulls the lanyard during EVA 1.

Principal investigators for the experiment are Dr. R. L. Fleischer, General Electric Co., Dr. P. B. Price, University of California at Berkely, and Dr. R. M. Walker, Washington University.

## Lunar Geology Investigation

The fundamental objective of the lunar geology investigation experiment is to provide data in the vicinity of the landing site for use in the interpretation of the geologic history of the Moon. Apollo lunar landing missions offer the opportunity to correlate carefully collected samples with a variety of observational data on at least the upper portions of the mare basin filling and the lunar highlands, the two major geologic subdivisions of the Moon. The nature and origin of the maria and highlands will bear directly on the history of lunar differentiation and differentiation processes. From the lunar bedrock, structure, land forms and special materials, information will be gained about the internal processes of the Moon. The nature and origin of the debris layer (regolith) and the land forms superimposed on the maria and highland regions are a record of lunar history subsequent to their formation. This later history predominately reflects the history of the extralunar environment. Within and on the regolith, there will also be materials that will aid in the understanding of geologic units elsewhere on the Moon and the broader aspects of lunar history.

The primary data for the lunar geology investigation experiment come from photographs, verbal data, and returned lunar samples. Photographs taken according to specific procedures will supplement and illustrate crew comments, record details not discussed by the crew, provide a framework for debriefing, and record a wealth of lunar surface information that cannot be returned or adequately described by any other means.

In any Hasselblad picture taken from the lunar surface, as much as 90 percent of the total image information may be less than 100 feet from the camera, depending on topography and how far the camera is depressed below horizontal. Images of distant surface detail are so foreshortened that they are difficult to interpret. Therefore, it is important that panoramas be taken at intervals during the traverse and at the farthest excursion of the traverse. This procedure will extend the high resolution photographic coverage to the areas examined and discussed by the astronaut, and will show the regional context of areas of specific interest that have been discussed and photographed in detail.

The polarizing filters will permit the measurement of the degree of polarization and orientation of the plane of polarization contained in light reflected from the lunar surface. Different lunar materials (i.e., fine-grained glass and/or fragments, strongly shocked rocks, slightly shocked rocks and shock-lithified fragmental material) have different polarimetric functions, in other words, different polarimetric "signatures." Comparison of the polarimetric function of known material, such as returned samples and close-up lunar surface measurements, with materials photographed beyond the traverse of the astronaut will allow the classification and correlation of these materials even though their textures are not resolvable. The polarimetric properties of lunar materials and rock types are a useful tool for correlation and geologic mapping of each landing site, and for extrapolation of geologic data from site to site across the lunar surface.

The "in situ" photometric properties of both fine-grained materials and coarse rock fragments will serve as a basis for delineating, recognizing, describing, and classifying lunar materials. The gnomon, with photometric chart attached, will be photographed beside a representative rock and, if practical, beside any rock or fine-grained material with unusual features.

The long focal length (500 mm) lens with the HEDC will be used to provide high resolution data. A 5 to 10 centimeter resolution is anticipated at a distance of 1 to 2 km (0.6 to 1.2 mi.). The high degree of resolution will make it possible to analyze the stratigraphic layering in North Ray Crater walls and potential outcrops and exposed bedrock in distant areas.

Small exploratory trenches, several centimeters deep, are to be dug to determine the character of the regolith down to these depths. The trenches should be dug in the various types of terrain and in areas where the surface characteristics of the regolith are of significant interest as determined by the astronaut crew. The main purpose of the trenches will be to determine the small scale stratigraphy (or lack of) in the upper few inches of the regolith in terms of petrological characteristics and particle size.



The organic control sample, carried in each sample return case (SRC) will be analyzed after the mission in the Lunar Receiving Laboratory to determine the level of contamination in each SRC. This will then be compared to an organic control sample which was removed from the SRC prior to the SRC being shipped to KSC for loading onto the LM.

In order to more fully sample the major geological features of the Apollo 16 landing site, various groupings of sampling tasks are combined and will be accomplished in concentrated areas. This will aid in obtaining vertical as well as lateral data to be obtained in the principal geological settings. Thus, some trench samples, core tube samples and lunar environmental soil samples will be collected in association with comprehensive samples. In addition, sampling of crater rims of widely differing sizes in a concentrated area will give a sampling of the deeper stratigraphic divisions at that site. Repeating this sampling technique at successive traverse stations will show the continuity of the main units within the Cayley formation.

Sampling and photographic techniques used to gather data in the Descartes region include:

- \* Documented samples of lunar surface material which, prior to gathering, are photographed in color and stereo -- using the gnomon and photometric chart for comparison of position and color properties -- to show the sample's relation to other surface features.

- \* Rock and soil samples of Imbrian age rocks from deep layers, and soil samples from the regolith in the immediate area where the rocks are gathered.

- \* Radial sampling of material on the rim of a fresh crater -- material that should be from the deepest strata.

- \* Photopanoramas for building mosaics which will allow accurate control for landing site map correlation.

- \* Polarimetric photography for comparison with known materials.

- \* Double drive tube samples to depths of 60 cm (23.6 in.) for determining the stratigraphy in multi-layer areas.

\* Single drive tube samples to depths of 38 cm (15 in.) in the comprehensive sample area and in such target of opportunity areas as mounds and fillets.

\* Drill core sample of the regolith which will further spell out the stratigraphy of the area sampled.

\* A small exploratory trench, ranging from 6 to 24 cm (2.4 to 9.7 in.) in depth, to determine regolith particle size and small-scale stratigraphy.

\* Large equidimensional rocks ranging from 15 to 24 cm (6 to 9.4 in.) in diameter for data on the history of solar radiation. Similar sampling of rocks from 6 to 15 cm (2.4 to 6 in.) in diameter will also be made.

\* Fillet sampling which may reveal a relationship between fillet volume and rock size to the length of time the fillet has been in place.

\* Vacuum-packed lunar environment soil and rock samples kept biologically pure for postflight gas, chemical and microphysical analysis.

\* Special surface samples to determine properties of the upper 10 - 100 microns of the lunar surface.

## Apollo Lunar Geology Hand Tools

Sample scale - The scale is used to weigh the loaded sample return containers, sample bags, and other containers to maintain the weight budget for return to Earth. The scale has graduated markings in increments of 5 pounds to a maximum capacity of 80 pounds. The scale is stowed and used in the lunar module ascent stage.

Tongs - The tongs are used by the astronaut while in a standing position to pick up lunar samples from pebble size to fist size. The tines of the tongs are made of stainless steel and the handle of aluminum. The tongs are operated by squeezing the T-bar grips at the top of the handle to open the tines. In addition to picking up samples, the tongs are used to retrieve equipment the astronaut may inadvertently drop. This tool is 81 cm (32 inches) long overall.

Lunar rake - The rake is used to collect discrete samples of rocks and rock chips ranging from 1.3 cm (one-half inch) to 2.5 cm (one inch) in size. The rake is adjustable for ease of sample collection and stowage. The tines, formed in the shape of a scoop, are stainless steel. A handle, approximately 25 cm (10 inches) long, attaches to the extension handle for sample collection tasks.

Adjustable scoop - The sampling scoop is used to collect soil material or other lunar samples too small for the rake or tongs to pick up. The stainless steel pan of the scoop, which is 5 cm (2 inches) by 11 cm (4 1/2 inches) by 15 cm (6 inches) has a flat bottom flanged on both sides and a partial cover on the top to prevent loss of contents. The pan is adjustable from horizontal to 55 degrees and 90 degrees from the horizontal for use in scooping and trenching. The scoop handle is compatible with the extension handle.

Hammer - This tool serves three functions; as a sampling hammer to chip or break large rocks, as a pick, and as a hammer to drive the drive tubes or other pieces of lunar equipment. The head is made of impact resistant tool steel, has a small hammer face on one end, a broad flat blade on the other, and large hammering flats on the sides. The handle, made of aluminum, is 36 cm (14 inches) long; its lower end fits the extension handle when the tool is used as a hoe.

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Extension handle - The extension handle extends the astronaut's reach to permit working access to the lunar surface by adding 76 cm (30 inches) of length to the handles of the scoop, rake, hammer, drive tubes, and other pieces of lunar equipment. This tool is made of aluminum alloy tubing with a malleable stainless steel cap designed to be used as an anvil surface. The lower end has a quick-disconnect mount and lock designed to resist compression, tension, torsion, or a combination of these loads. The upper end is fitted with a sliding "T" handle to facilitate any torquing operation.

Drive Tubes - These nine tubes are designed to be driven or augured into soil, loose gravel, or soft rock such as pumice. Each is a hollow thin-walled aluminum tube 41 cm (16 inches) long and 4 cm (1.75 inch) diameter with an integral coring bit. Each tube can be attached to the extension handle to facilitate sampling. A deeper core sample can be obtained by joining tubes in series of two or three. When filled with sample, a Teflon cap is used to seal the open end of the tube, and a keeper device within the drive tube is positioned against the top of the core sample to preserve the stratigraphic integrity of the core. Three Teflon caps are packed in a cap dispenser that is approximately a 5.7 cm (2.25 inch) cube.

Gnomon and Color Patch - The gnomon is used as a photographic reference to establish local vertical Sun angle, scale, and lunar color. This tool consists of a weighted staff mounted on a tripod. It is constructed in such a way that the staff will right itself in a vertical position when the legs of the tripod are on the lunar surface. The part of the staff that extends above the tripod gimbal is painted with a gray scale from 5 to 35 percent reflectivity and a color scale of blue, orange, and green. The color patch, similarly painted in gray scale and color scale, mounted on one of the tripod legs provides a larger target for accurately determining colors in color photography.

Apollo Lunar Hand Tool Carrier - This is an aluminum framework with a handle and legs that unfold to provide a steady base. The tools described above may be stowed in special fittings on this framework during lunar surface EVAs. The framework also provides support positions for two sample collection bags and a 20-bag documented sample bag dispenser. The hand tool carrier mounts on the Quad III LRV pallet during launch and stays on that pallet when it is transferred to the aft end of the lunar roving vehicle.

Sample Bags - Several different types of bags are furnished for collecting lunar surface samples. The Teflon documented sample bag (DSB), 19 by 20 cm (7-1/2 by 8 inches) in size, is prenumbered and packed in a 20-bag dispenser that can be mounted on the hand tool carrier or on a bracket on the Hasselblad camera. Documented sample bags (140) will be available during the lunar surface EVAs. The sample collection bag (SCB), also of Teflon, has interior pockets along one side for holding drive tubes and exterior pockets for the special environmental sample container and for a drive tube cap dispenser. This bag is 17 by 23 by 41 cm (6-3/4 by 9 by 16 inches) in size (exclusive of the exterior pockets) and fits inside the sample return containers. During the lunar surface EVAs this bag is hung on the hand tool carrier or on the portable life support system tool carrier. Four SCBs will be carried on Apollo 16. The extra sample collection bag (ESCB) is identical to the SCB except that the interior and exterior pockets are omitted. During EVAs it is handled in the same way as an SCB. Four ESCB bags will be carried on the mission. A sample return bag, 13 by 33 by 57 cm (5 by 13 by 22.5 inches) in size, replaces the third sample return container and is used for the samples collected on the third EVA. It hangs on the LRV pallet during this EVA.

A special type of sample bag, the padded sample bag, is carried on Apollo 16. Although generally similar to the DSB, it has an inner padding of knit Teflon that forms an open-topped box 6 cm (2-1/2 inches) thick and a velcro strap to insure satisfactory closure for return to Earth. Only two of these special purpose bags will be carried on the flight.

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Sample Return Container - This container maintains a vacuum environment and padded protection for lunar samples. It is an aluminum box 20 by 28 by 48 cm (8 by 11.5 by 19 inches) in size, with a knife-edge indium-silver seal, a strap latch system for closing, and a lever and pin system to support the container in the LM and CM stowage compartments under all vibration and g-force conditions. The drive tubes, special environmental sample container, and the core sample vacuum container as well as some other specialized pieces of equipment are flown outbound and inbound within the sample return containers, two of which will be carried on Apollo 16.

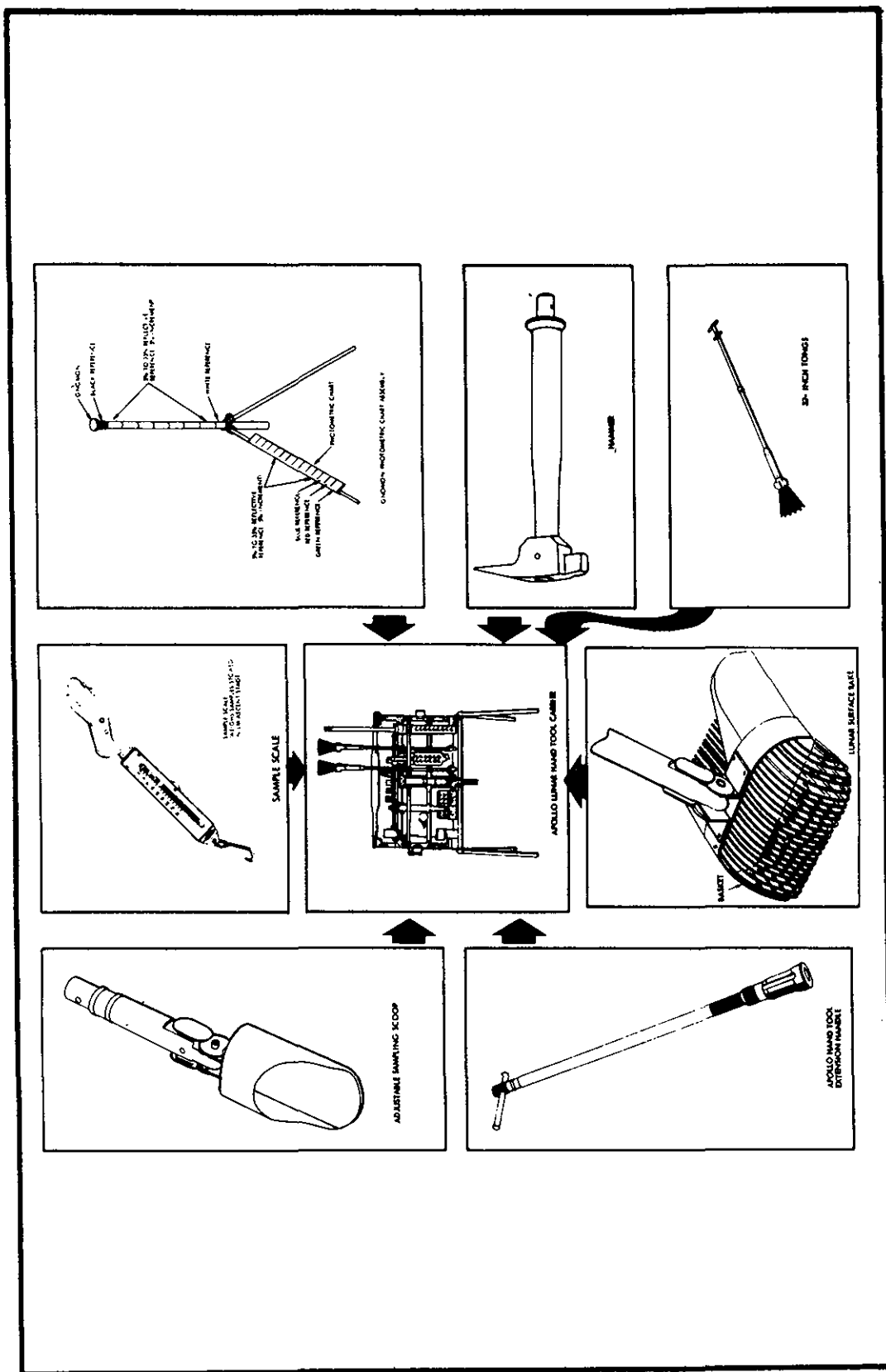
Special Environmental Sample Containers - This container is used to protect the vacuum environment of selected samples of lunar soil or rocks to be studied in specific experiments upon return to Earth. It is a thin-walled stainless steel can with a knife edge at the top and three-legged press assembly attached to the lid to effect a vacuum-proof seal when used on the lunar surface. Until used upon collection of the sample, the seal surfaces are covered with Teflon protectors that are then discarded.

Core Sample Vacuum Container - The core sample vacuum container is a receptacle for vacuum storage and transport to Earth of a lunar surface drive tube. The core sample vacuum container is about twice as long as the special environmental sample container and includes an insert to grip the drive tube, providing lateral and longitudinal restraint.

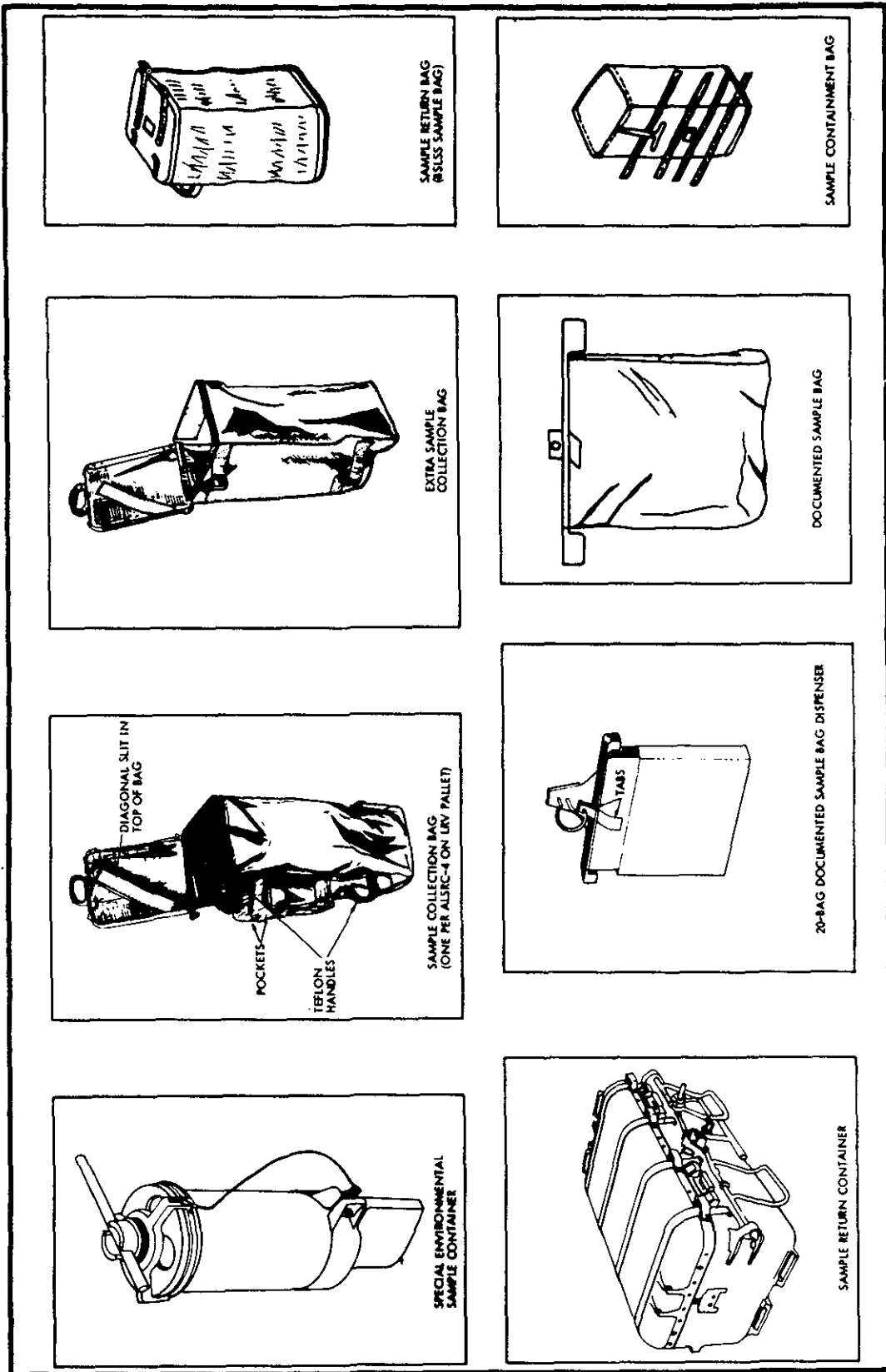
Surface Sampler Tool - The purpose of the surface sampler tool is to capture and return to Earth for analysis a sample from the very top of the lunar surface. The surface sampler tool hopefully will capture 300 to 500 milligrams of material only 100 to 500 microns deep. Each sampler consists of a 1.25-cm (1/2-inch) deep box which attaches to the universal hand tool. The 11.25-by-12.5-cm (2.5-by-5-inch) boxes each contain a plate which is floating in channels inside the box. One plate is covered with a deep pile velvet cloth and the other plate will be covered with either beta cloth or a thin layer of grease.

The astronaut will open the spring-loaded door at the box bottom and gently lower the box until the floating plate touches the lunar surface. The lunar surface grains will be trapped in the fabric pile or grease. The astronaut will lift the box, close the lid, and place the box in a numbered bag for return to Earth.

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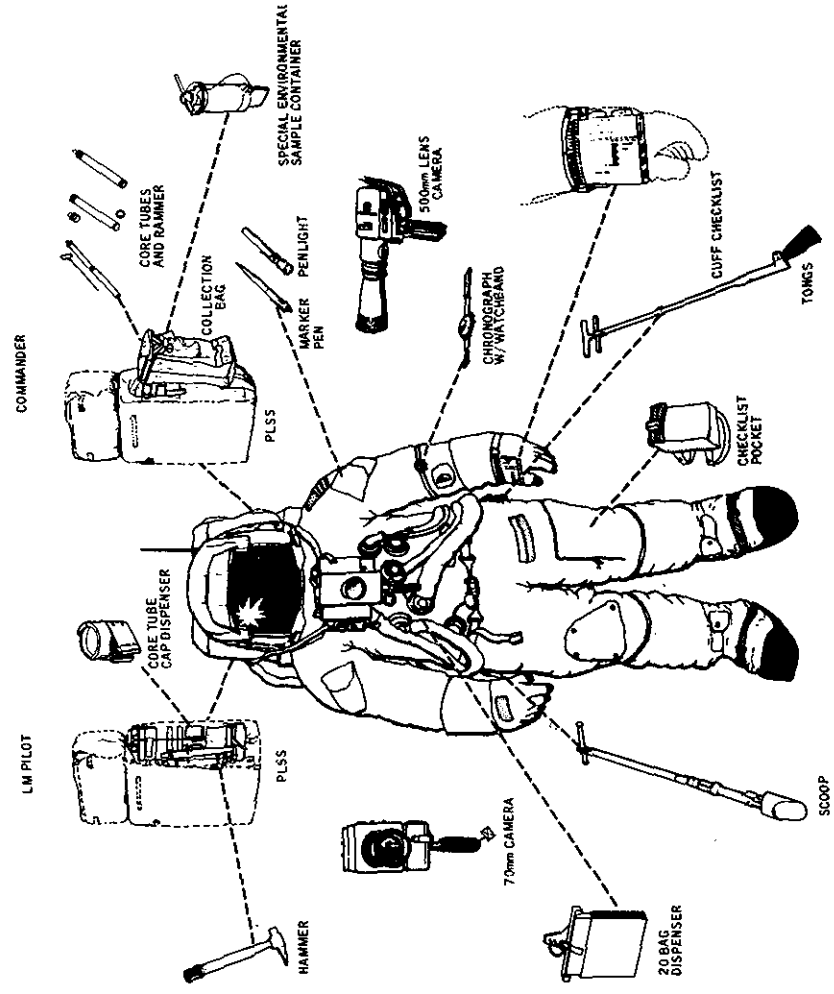
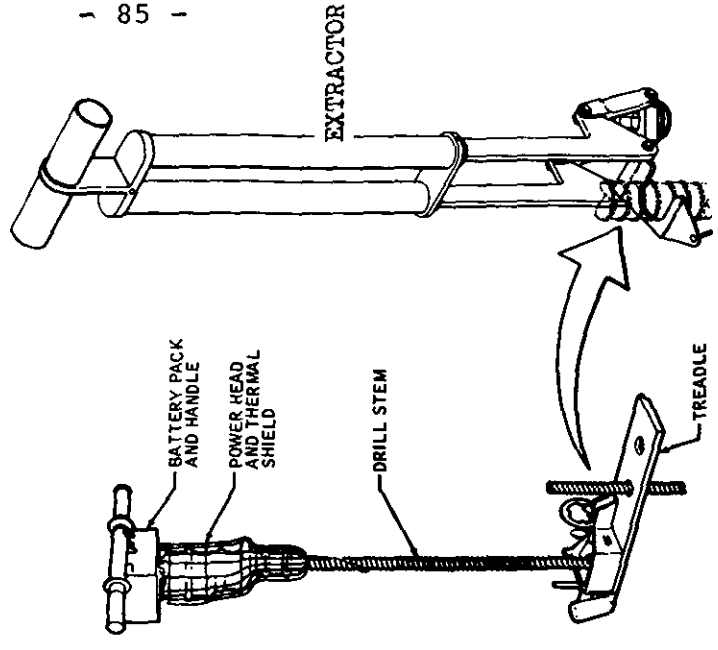


Lunar Geology Hand Tools



Lunar Geology Sample Containers





LUNAR ORBITAL SCIENCE

Service Module Sector 1 houses the Scientific Instrument Module (SIM) bay. Eight experiments are carried in the SIM bay: X-ray fluorescence spectrometer, gamma ray spectrometer, alpha-particle spectrometer, panoramic camera, 76-millimeter (3-inch) mapping camera, laser altimeter and a mass spectrometer; a subsatellite carries three integral experiments (particle detectors, magnetometer and S-band transponder) comprising the eighth SIM bay experiment and will be placed into lunar orbit.

Gamma-Ray Spectrometer: On a 7.6 meter (25-foot) extendable boom, the gamma-ray spectrometer measures the chemical composition of the lunar surface in conjunction with the X-ray and alpha-particle experiments to gain a compositional "map" of the lunar surface ground track. It detects natural and cosmic rays, induced gamma radioactivity and will operate on the Moon's dark and light sides. Additionally, the experiment will be extended in transearth coast to measure the radiation flux in cislunar space and record a spectrum of cosmological gamma-ray flux. The device can measure energy ranges between 0.1 to 10 million electron volts. The extendable boom is controllable from the command module cabin. Principal investigator is Dr. James R. Arnold, University of California at San Diego.

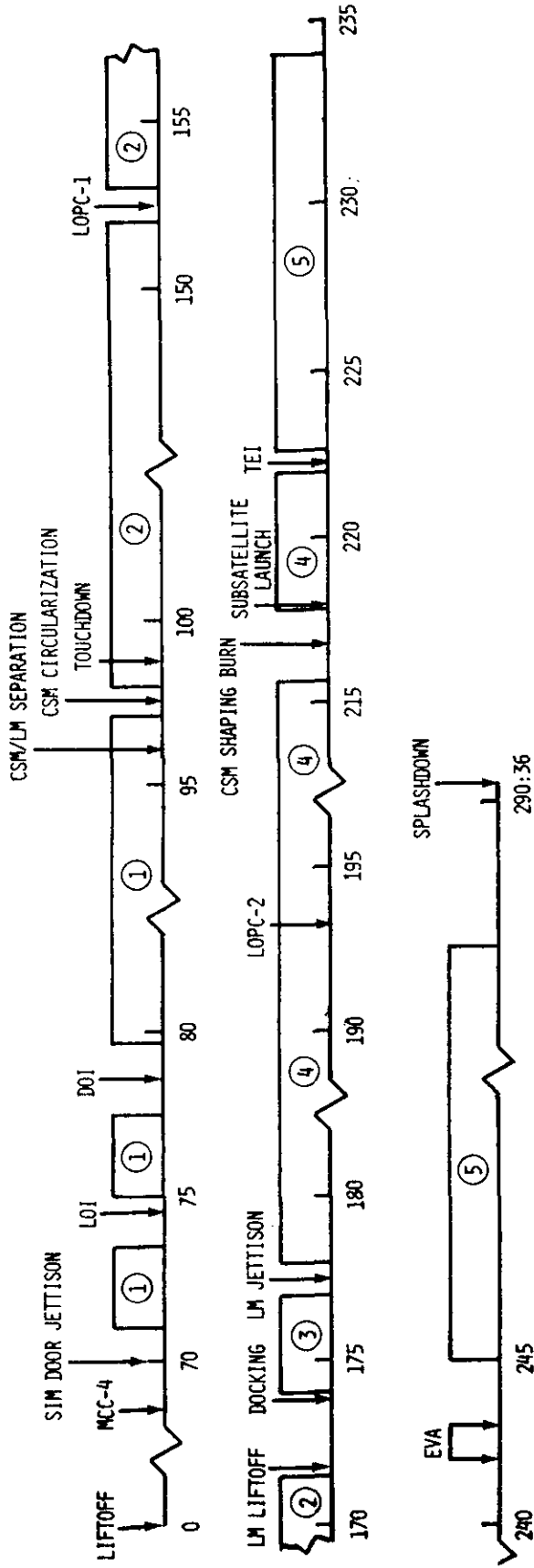
X-Ray Fluorescence Spectrometer: This geochemical experiment measures the composition of the lunar surface from orbit, and detects X-ray fluorescence caused by solar X-ray interaction with the Moon. It will analyze the sunlit portion of the Moon. The experiment will measure the galactic X-ray flux during transearth coast. The device shares a compartment on the SIM bay lower shelf with the alpha-particle experiment, and the protective door may be opened and closed from the command module cabin. Principal investigator is Dr. Isidore Adler, NASA Goddard Space Flight Center, Greenbelt, Md.

Alpha-Particle Spectrometer: This spectrometer measures monoenergetic alpha particles emitted from the lunar crust and fissures as products of radon gas isotopes in the energy range of 4.7 to 9.3 million electron volts. The sensor is made up of an array of 10 silicon surface barrier detectors. The experiment will construct a "map" of lunar surface alpha-particle emissions along the orbital track and is not constrained by solar illumination. It will also measure deep-space alpha-particle background emissions in lunar orbit and in transearth coast. Protective door operation is controlled from the cabin. Principal investigator is Dr. Paul Gorenstein, American Science and Engineering, Inc., Cambridge, Mass.

	APOLLO MISSIONS					
	11	12	14	15	16	17
<u>SERVICE MODULE EXPERIMENTS</u>						
S-160 GAMMA-RAY SPECTROMETER				X	X	
S-161 X-RAY SPECTROMETER				X	X	
S-162 ALPHA-PARTICLE SPECTROMETER				X	X	
S-164 S-BAND TRANSPONDER (CSM/LM)			X	X	X	X
S-165 MASS SPECTROMETER				X	X	
S-169 FAR UV SPECTROMETER					X	X
S-170 BISTATIC RADAR			X	X	X	
S-171 IR SCANNING RADIOMETER						X
S-209 LUNAR SOUNDER						X
SUBSATELLITE:						
S-164 S-BAND TRANSPONDER				X	X	
S-173 PARTICLE MEASUREMENT				X	X	
S-174 MAGNETOMETER				X	X	
SM PHOTOGRAPHIC TASKS:						
24" PANORAMIC CAMERA				X	X	X
3" MAPPING CAMERA				X	X	X
LASER-ALTIMETER				X	X	X
<u>COMMAND MODULE EXPERIMENTS</u>						
S-158 MULTISPECTRAL PHOTOGRAPHY		X				
S-176 APOLLO WINDOW METEOROID			X	X	X	X
S-177 UV PHOTOGRAPHY OF EARTH AND MOON			X	X	X	X
S-178 GEGENSCHN FROM LUNAR ORBIT			X	X	X	X

LUNAR ORBITAL SCIENCE EXPERIMENT ASSIGNMENTS

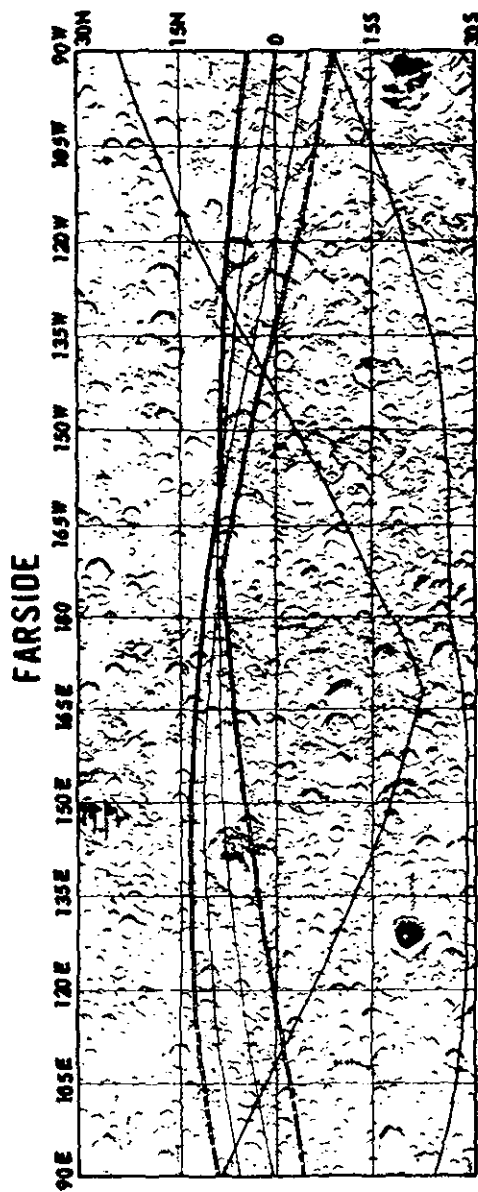
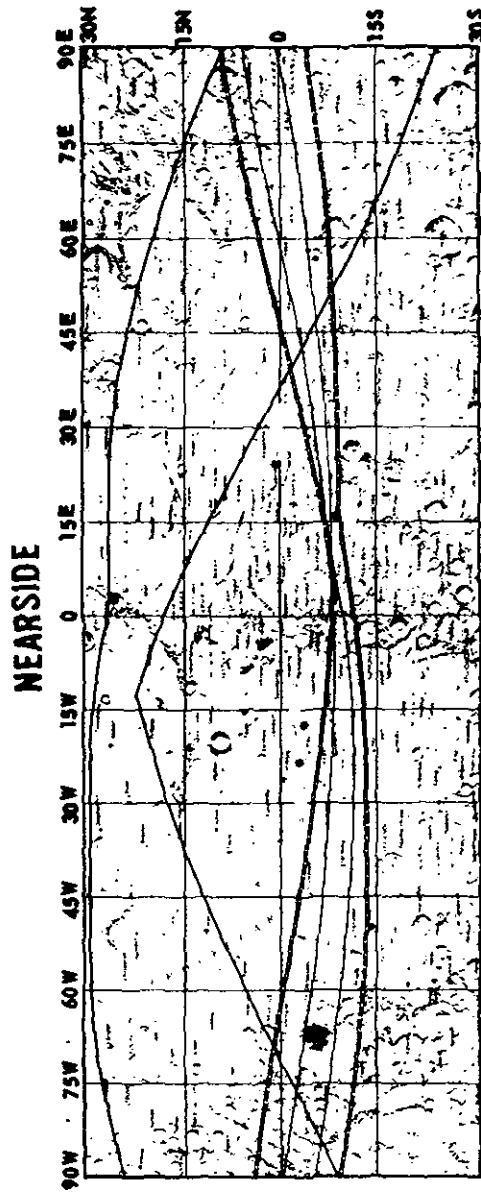
# APOLLO 16 ORBITAL TIMELINE






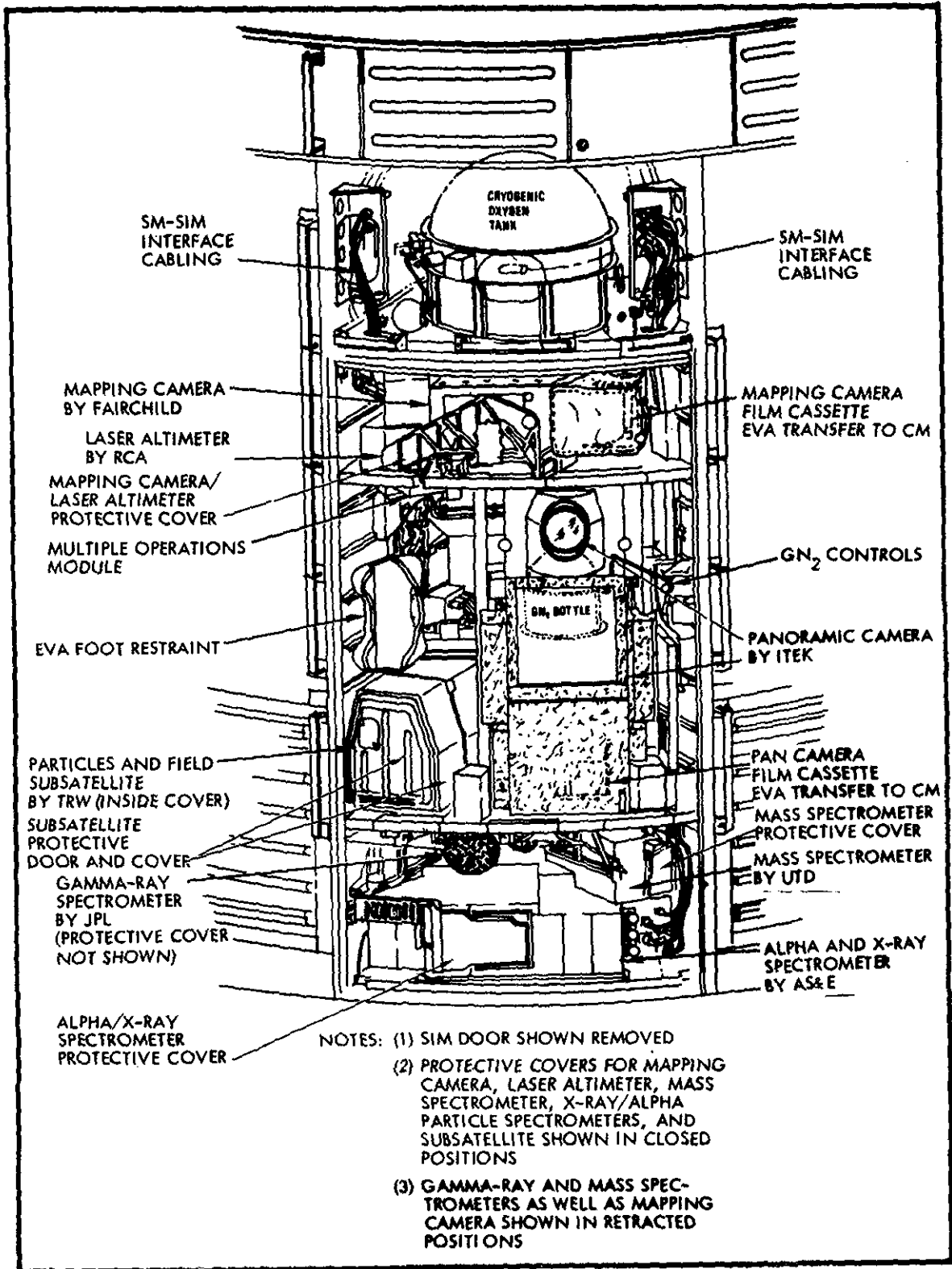
## SIM OPERATION PERIODS (NON-CONTINUOUS)

ACTIVITY PERIOD	CONFIGURATION	γ - RAY SPEC	α - PARTICLE SPEC	X - RAY SPEC	MASS SPEC	MAP CAMERA	PAN CAMERA	LASER ALTIMETER
①	CSM-LM							
②	CSM							
③	CSM-LM							
④	CSM							
⑤	CSM							
TOTAL TIME (HOURS:MIN IN LUNAR ORBIT)								
		140:15	140:15	110:53	110:28	19:24	2:44	19:46

# APOLLO 16 POTENTIAL LUNAR ORBIT COVERAGE



-  LO1 TO LOPC1 - 77 HR. 57 MIN. 9° INCLINATION
-  LOPC1 TO LOPC2 - 41 HR. 34 MIN. 10.4° INCLINATION
-  LOPC2 TO TE1 - 28 HR. 16 MIN. 13.4° INCLINATION



Mission SIM Bay Science Equipment Installation

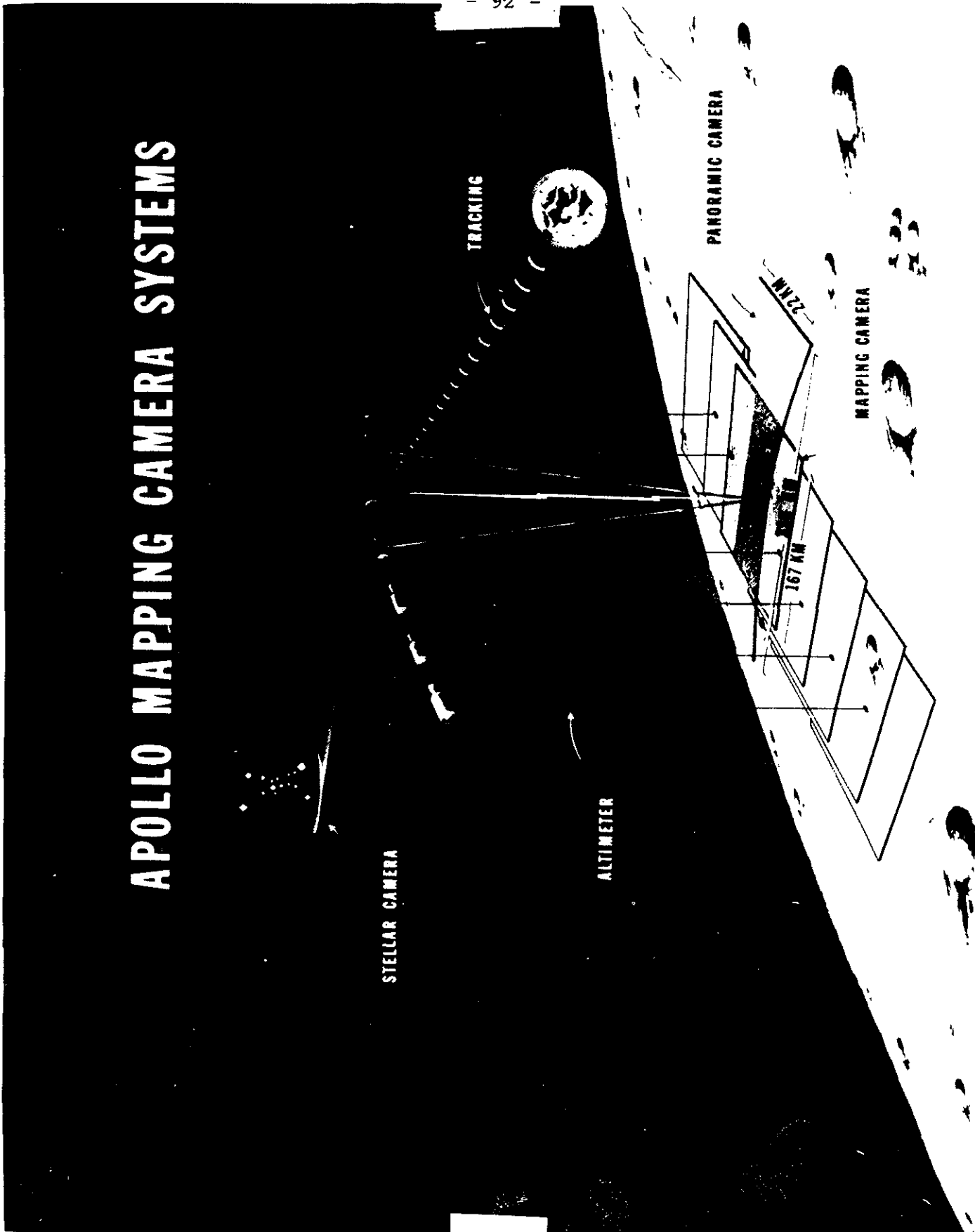
Mass Spectrometer: This spectrometer measures the composition and distribution of the ambient lunar atmosphere, identifies active lunar sources of volatiles, and pinpoints contamination in the lunar atmosphere. The sunset and sunrise terminators are of special interest, since they are predicted to be regions of concentration of certain gases. Measurements over at least five lunar revolutions are desired. The mass spectrometer is on a 7.3-meter (24-foot) extendable boom. The instrument can identify species from 12 to 28 atomic mass units (AMU) with the No. 1 ion counter, and 28-66 AMU with the No. 2 counter. Principal investigator is Dr. John H. Hoffman, University of Texas at Dallas.

Panoramic Camera: 610mm (24-inch) SM orbital photo task: The camera gathers mono or stereo high-resolution (2m) photographs of the lunar surface from orbit. The camera produces an image size of 28 x 334 kilometers (17 x 208 nm) with a field of view 11° along the track and 108° cross track. The rotating lens system can be stowed face-inward to avoid contamination during effluent dumps and thruster firings. The 33-kilogram (72-pound) film cassette of 1,650 frames will be retrieved by the command module pilot during a transearth coast EVA. The camera works in conjunction with the mapping camera and the laser altimeter to gain data to construct a comprehensive map of the lunar surface ground track flown by this mission ---about 2.97 million square meters (1.16 million square miles) or 8 percent of the lunar surface.

Mapping Camera 76mm (3-inch): Combines 20-meter resolution terrain mapping photography on five-inch film with 76mm (3-inch) focal length lens with stellar camera shooting the star field on 35mm film simultaneously at 96° from the surface camera optical axis. The stellar photos allow accurate orientation of mapping photography postflight by comparing simultaneous star field photography with lunar surface photos of the nadir (straight down). Additionally, the stellar camera provides pointing vectors for the laser altimeter during dark-side passes. The mapping camera metric lens covers a 74° square field of view, or 170 x 170 km (92 x 92 nm) from 111.5 km (60 nm) in altitude. The stellar camera is fitted with a 76mm (3-inch) f/2.8 lens covering a 24° field with cone flats. The 9-kg (20-lb) film cassette containing mapping camera film (3,600 frames) and the stellar camera film will be retrieved during the same EVA described in the panorama camera discussion. The Apollo Orbital Science Photographic Team is headed by Frederick J. Doyle of the U.S. Geological Survey, McLean, Va.

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# APOLLO MAPPING CAMERA SYSTEMS



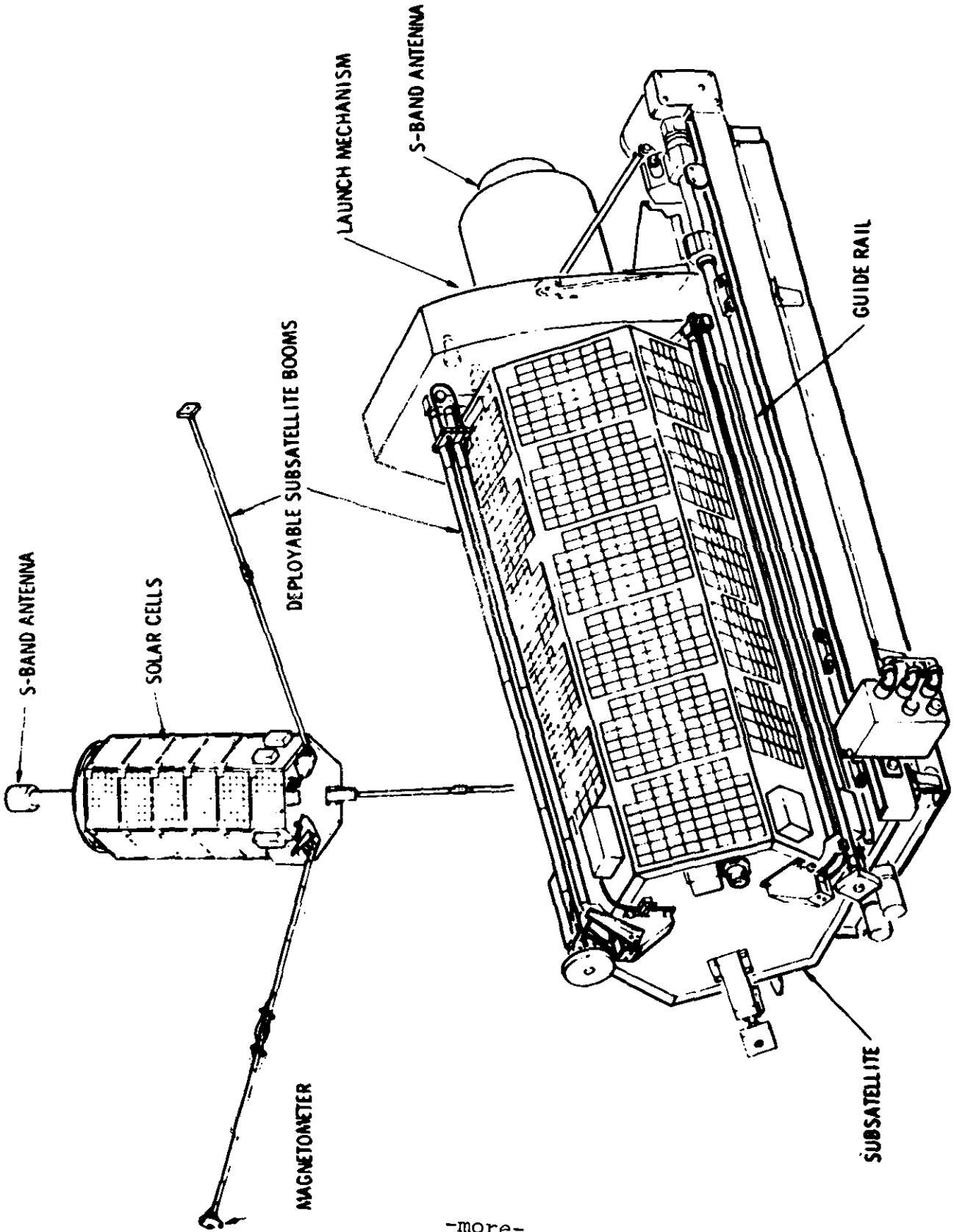
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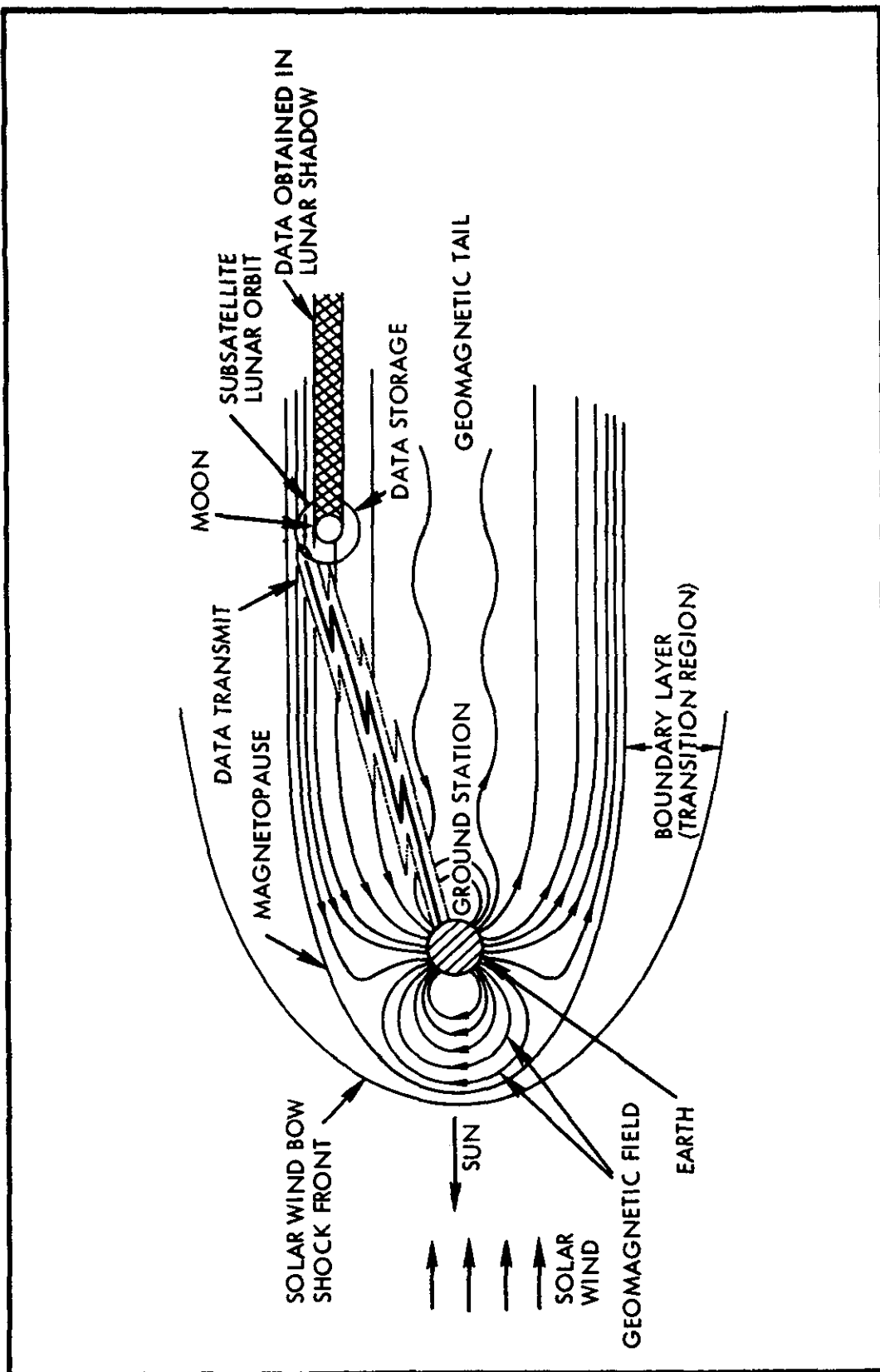
Laser Altimeter: This altimeter measures spacecraft altitude above the lunar surface to within two meters. The instrument is boresighted with the mapping camera to provide altitude correlation data for the mapping camera as well as the panoramic camera. When the mapping camera is running, the laser altimeter automatically fires a laser pulse to the surface corresponding to mid-frame ranging for each frame. The laser light source is a pulsed ruby laser operating at 6,943 angstroms, and 200-millijoule pulses of 10 nanoseconds duration. The laser has a repetition rate up to 3.75 pulses per minute. The laser altimeter working group of the Apollo Orbital Science Photographic Team is headed by Dr. William M. Kaula of the UCLA Institute of Geophysics and Planetary Physics.

Subsatellite: The subsatellite is ejected into lunar orbit from the SIM bay and carries three experiments. The subsatellite is housed in a container resembling a rural mailbox and when deployed, is spring-ejected out-of-plane at 1.2 meters per second (4 feet per second) with a spin rate of 140 revolutions per minute. After the satellite booms are deployed, the spin rate is stabilized at about 12 rpm. The subsatellite is 77 centimeters (30 inches) long, has a 35.6 cm (14-inch hexagonal diameter and weighs 40 kg (90 pounds). The folded booms deploy to a length of 1.5 m (five feet). Subsatellite electrical power is supplied by a solar cell array outputting 24 watts for dayside operation and a rechargeable silver-cadmium battery for nightside passes.

Experiments carried aboard the subsatellite are: S-band transponder for gathering data on the lunar gravitational field, especially gravitational anomalies such as the so-called mascons particle shadows/boundary layer for gaining knowledge of the formation and dynamics of the Earth's magnetosphere, interaction of plasmas with the Moon and the physics of solar flares using telescope particle detectors and spherical electrostatic particle detectors; and subsatellite magnetometer for gathering physical and electrical property data on the Moon and of plasma interaction with the Moon using a biaxial flux-gate magnetometer deployed on one of the three 1.5-m (5-foot) folding booms. Principal investigators for the subsatellite experiments are: particle shadows/boundary layer, Dr. Kinsey A. Anderson, University of California Berkeley; magnetometer, Dr. Paul J. Coleman, UCLA; and S-band transponder, Mr. William Sjogren, Jet Propulsion Laboratory.



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SIM Bay Subsatellite Experiments Concepts

Other CSM orbital science experiments and tasks not in SIM bay include UV photography-Earth and Moon, Gegenschein from lunar orbit, CSM/LM S-band transponder (in addition to that in the subsatellite), bistatic radar, Apollo window meteoroid experiments, microbial response, Skylab contamination, and visual flash phenomenon.

UV Photography-Earth and Moon: This experiment is aimed toward gathering ultraviolet photos of the Earth and Moon for planetary atmosphere studies and investigation of lunar surface short wavelength radiation. The photos will be made with an electric Hasselblad camera bracket-mounted in the right side window of the command module. The window is fitted with a special quartz pane that passes a large portion of the incident UV spectrum. A four-filter pack---three passing UV electromagnetic radiation and one passing visible electromagnetic radiation---is used with a 105mm lens for black and white photography; the visible spectrum filter is used with color film.

Gegenschein from Lunar Orbit: This experiment involves long exposures with a 35mm camera with 55mm f/1.2 lens on high speed black and white film (ASA 6,000). All photos must be made while the command module is in total darkness in lunar orbit.

The Gegenschein is a faint light source covering a 20° field of view along the Earth-Sun line on the opposite side of the Earth from the Sun (anti-solar axis). One theory on the origin of Gegenschein is that particles of matter are trapped at the moulton point and reflect sunlight. Moulton point is a theoretical point located 15,131,000 km (817,000 nm) from the Earth along the anti-solar axis where the sum of all gravitational forces is zero. From lunar orbit, the moulton point region can be photographed from about 15 degrees off the Earth-Sun axis, and the photos should show whether Gegenschein results from the moulton point theory or stems from zodiacal light or from some other source. The experiment was conducted on Apollo 14 and 15. The principal investigator is Lawrence Dunkelmann of the Goddard Space Flight Center.

CSM/LM S-Band Transponder: The objective of this experiment is to detect variations in lunar gravity along the lunar surface track. These anomalies in gravity result in minute perturbations of the spacecraft motion and are indicative of magnitude and location of mass concentrations on the Moon. The Spaceflight Tracking and Data Network (STDN) and the Deep Space Network (DSN) will obtain and record S-band doppler tracking measurements from the docked CSM/LM and the undocked CSM while in lunar orbit; S-band doppler tracking measurements of the LM during non-powered portions of the lunar descent; and S-band doppler tracking measurements of the LM ascent stage during non-powered portions of the descent for lunar impact. The CSM and LM S-band transponders will be operated during the experiment period. The experiment was conducted on Apollo 14 and 15.

S-band doppler tracking data have been analyzed from the Lunar Orbiter missions and definite gravity variations were detected. These results showed the existence of mass concentrations (mascons) in the ringed maria. Confirmation of these results has been obtained with Apollo tracking data.

With appropriate spacecraft orbital geometry much more scientific information can be gathered on the lunar gravitational field. The CSM and/or LM in low-altitude orbits can provide new detailed information on local gravity anomalies. These data can also be used in conjunction with high-altitude data to possibly provide some description on the size and shape of the perturbing masses. Correlation of these data with photographic and other scientific records will give a more complete picture of the lunar environment and support future lunar activities. Inclusion of these results is pertinent to any theory of the origin of the Moon and the study of the lunar subsurface structure. There is also the additional benefit of obtaining better navigational capabilities for future lunar missions in that an improved lunar gravity model will be known. William Sjogren, Jet Propulsion Laboratory, Pasadena, California is principal investigator.

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Bistatic Radar Experiment (BRE): The downlink bistatic radar experiment seeks to measure the electromagnetic properties of the lunar surface by monitoring that portion of the spacecraft telemetry and communications beacons which are reflected from the Moon.

The CSM S-band telemetry beacon ( $f = 2.2875$  gigahertz), the VHF voice communications link ( $f = 259.7$  megahertz), and the spacecraft omni-directional and high gain antennas are used in the experiment. The spacecraft is oriented so that the radio beacon is incident on the lunar surface and is successively reoriented so that the angle at which the signal intersects the lunar surface is varied. The radio signal is reflected from the surface and is monitored on Earth. The strength of the reflected signal will vary as the angle at which it intersects the surface is varied.

The electromagnetic properties of the surface can be determined by measuring the reflected signal strength as a function of angle of incidence on the lunar surface. The angle at which the reflected signal strength is a minimum is known as the Brewster angle and determines the dielectric constant. The reflected signals can also be analyzed for data on lunar surface roughness and surface electrical conductivity.

The S-band signal will primarily provide data on the surface. However, the VHF signal is expected to penetrate the gardened debris layer (regolith) of the Moon and be reflected from the underlying rock strata. The reflected VHF signal will then provide information on the depth of the regolith over the Moon.

The S-band BRE signal will be monitored by the 210-foot antenna at the Goldstone, California site and the VHF portion of the BRE signal will be monitored by the 150-foot antenna at the Stanford Research Institute in California. The experiment was flown on Apollos 14 and 15.

Lunar bistatic radar experiments were also performed using the telemetry beacons from the unmanned Lunar Orbiter I in 1966 and from Explorer 35 in 1967. Taylor Howard, Stanford University, is the principal investigator.

Apollo Window Meteoroid: This is a passive experiment in which command module windows are scanned under high magnification pre- and postflight for evidence of meteoroid cratering flux of one-trillionth gram or larger. Such particle flux may be a factor in degradation of surfaces exposed to space environment. Principal investigator is Burton Cour-Palais, NASA Manned Spacecraft Center.

MEDICAL EXPERIMENTS AND TESTS

Apollo 16 will carry four medical experiments and tests, two of which are passive and require no crew manipulation and two in which the crew participates. The experiments are: microbial response in space environment, visual light flash phenomenon, biostack and bone mineral measurement.

Microbial Response in Space Environment: A rectangular container with some 60 million microbial passengers aboard will be attached to the command module hatch camera boom for a 10-minute period during the CMP's transearth EVA. The experiment will measure the effects of reduced oxygen pressure, vacuum, zero-g and solar ultraviolet irradiation upon five strains of bacteria, fungi and viruses. Specific strains chosen for the experiment are Rhodotorula rubra, bacillus thuringiensis, bacillus subtilis, aeromonas proteolytica and chaetomium globosum. None of these bacteria are harmful to man.

The 11.6x11.6x24.8 cm (4.5x4.5x9.75 inch) container--- microbial ecology evaluation device (MEED)---contains three separate trays, each with 280 chambers for temperature sensors, ultraviolet measuring solutions, and the microorganisms. About two-thirds of the microorganisms will be in a dry state while the remainder will be in water suspension. The MEED will be opened and pointed toward the Sun for the 10-minute test period, then capped and returned to Earth for analysis.

Microbial experiments run on Gemini 9 and 12, Biosatellite 2 and in the Soviet Union's Vostok spacecraft suggest that perhaps zero-g coupled with a reduced partial pressure of oxygen has an effect upon growth and mutation rates of microorganisms.

Experiment principal investigators are: Dr. Paul Volz, Eastern Michigan University, Ypsilanti, Mich.; Dr. Bill G. Foster, Texas A&M University, College Station, Tex.; and Dr. John Spizien, Scripps Clinic and Research Foundation, La Jolla, Calif.

Visual Light Flash Phenomenon: Mysterious specks of light penetrating closed eyelids have been reported by crewmen of every Apollo lunar mission since Apollo 11. Usually the light specks and streaks are observed in a darkened command module cabin while the crew is in a rest period. Averaging two flashes a minute, the phenomena was observed in previous missions in translunar and trans-earth coast and in lunar orbit.

Two theories have been proposed on the origin of the flashes. One theory is that the flashes stem from visual phosphenes induced by cosmic rays. The other theory is that Cerenkov radiation by high-energy atomic particles either enter the eyeball or ionize upon collision with the retina or cerebral cortex.

The Apollo 16 crew will run a controlled experiment during translunar and transearth coast in an effort to correlate light flashes to incident primary cosmic rays. One crewman will wear an emulsion plate device on his head called the Apollo light flash moving emulsion detector (ALFMED), while his crewmates wear eye shields. The ALFMED emulsion plates cover the front and sides of the wearer's head and will provide data on time, strength, and path of high-energy atomic particles penetrating the emulsion plates. This data will be correlated with the crewman's verbal reports on flash observations during the tests.

Dr. R. E. Benson of the NASA Manned Spacecraft Center Preventive Medicine Division is the principal investigator.

Biostack: The German biostack experiment is a passive experiment requiring no crew action. Selected biological material will be exposed to high-energy heavy ions in cosmic radiation and the effects analyzed postflight. Heavy ion energy measurements cannot be gathered from ground-based radiation sources.

The experiment results will add to the knowledge of how these heavy ions may present a hazard for man during long space flights.

Alternate layers of biological materials and radiation track detectors are hermetically sealed in a cylindrical aluminum container 12.5 cm in diameter by 9.8 cm high (3.4 x 4.8 inches) and weighing 2.4 kg (5.3 lbs). The biostack container will be mounted in the command module in a position to minimize shielding to cosmic radiation. This container has no organisms harmful to man.

After command module recovery, the container will be returned to the principal investigator, Dr. Horst Bucker, University of Frankfurt, Frankfurt am Main, Federal Republic of Germany, whose participation is funded and sponsored by the German Ministry for Education and Science. Dr. Bucker will be assisted in his investigations by scientists at the University of Strasbourg, France, and at the Aerospace Medicine Research Center in Paris. The experiment is endorsed by the Working Party on Space Biophysics of the Council of Europe's parliamentary Committee on Science and Technology.

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Bone Mineral Measurement: Mineral changes in human bones caused by reduced gravity are measured in this passive experiment. X-ray absorption techniques pre- and post-flight will measure bone mineral content of the radius, ulna, and os calcis (heel) for comparisons.

Principal investigator is Dr. J. M. Vogel, U.S. Public Health Service Hospital, San Francisco, Calif.

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ENGINEERING/OPERATIONAL TESTS AND DEMONSTRATION

Four tests aimed at gathering data for improving operations in future space flight missions will be flown aboard Apollo 16. An investigation into external spacecraft contamination and an evaluation of the Skylab food packaging system will provide data useful to next year's Skylab series of long-duration missions. Tests of an improved gas/water separator for removing hydrogen gas bubbles from potable water generated as a fuel cell byproduct and evaluation of a new type of fecal collection bag also will be conducted. An electrophoresis separation demonstration will also be conducted.

Skylab Contamination Study: Since John Glenn reported seeing "fireflies" outside the tiny window of his Mercury spacecraft Friendship 7 a decade ago, space crews have noted light-scattering particles that hinder visual observations as well as photographic tasks. Opinions on the origin of the clouds of particles surrounding spacecraft have ranged from ice crystals generated by water vapor dumped from the spacecraft to a natural phenomenon of particles inhabiting the space environment.

The phenomenon could be of concern in the Skylab missions during operation of the solar astronomy experiments. The Apollo 16 tests will attempt to further identify the sources of contamination outside the spacecraft. The crew will use a combination of photography and visual observations to gather the data, which in turn will serve as baselines for predicting contamination in the vicinity of the Skylab space station and for devising methods for minimizing contaminate levels around the Skylab vehicle.

Skylab Food Package: Since the Skylab orbital workshop must carry enough food to last nine men for 140 days, the methods of packaging the food must be somewhat different than the methods used in packaging food for the relatively short Apollo missions.

Packed in with the Apollo 16 crew's regular fare of meals will be several Skylab food items for the crew to evaluate. Among the types of packaging to be checked are two sizes of snap-top cans containing foods ranging from dried peaches and puddings to peanuts, wet-pack spoon-bowl foods, postage-stamp size salt dispensers, and plastic-bellows drink containers.

The Apollo 16 crew will take still and motion pictures of the food packages in use and make subjective comments on ease of handling and preparation of the food.

Improved Gas/Water Separator: During transearth coast the Apollo 16 crew will unstow an improved gas/water separator and use it on the food preparation water spigot for one meal period. Command module potable water is a byproduct of the fuel cell powerplants and contains hydrogen gas bubbles which cause crew discomfort when ingested. Gas/water separators flown previously have had leaks around the seals and have not adequately separated gas bubbles from the water.

The improved separator is expected to deliver bubble-free drinking and food preparation water.

Improved Fecal Collection Bag: Defecation bags used in previous Apollo missions are virtually identical to the Gemini "blue bags". During previous missions, the crews have experienced some difficulty in attaching the bag to the body, in post-defecation sealing, and personal hygiene clean-up. The improved fecal collection bag has been re-designed for better fit and sealing.

Electrophoretic Separation Demonstration: The Apollo 16 astronauts will use the natural weightless environment in space flight to again demonstrate an improved process in materials purification which may permit separation of materials of higher purity than can now be produced on Earth.

The space demonstration is called electrophoretic separation, referring to the movement of electrically charged particles under the influence of an electric field.

Most organic molecules become electrically charged when they are placed in a solution and will move through such a solution if an electric field is applied. Since molecules of different size and shape move at different speeds, the faster molecules in a mixture will "outrun" the slower ones as they move from one end of the solution to the other.

Thus, like particles separate into bands as they drift towards the attracting electrode. Separation is accomplished by removing the desired bands of particles.

On Earth the purification or separation process is generally performed with filters or other supporting devices because materials of any significant size rapidly sink or settle in the solution before separation occurs. Additionally, light materials remaining are easily mixed by convective currents, thus reducing purity.

The Apollo 14 electrophoretic separation demonstration experienced some technical problems which prohibited obtaining information on two of the three samples. Results with the third sample (a mixture of red and blue dyes) indicated the feasibility of obtaining sharper separations in space than on Earth. The Apollo 16 demonstration has been modified to overcome the problems encountered with the Apollo 14 demonstration and will use polystyrene particles to simulate separation of large biological particles. The Apollo 16 demonstration will allow a more accurate evaluation of the separation process.

If successful, the demonstration could show that one of the practical uses for future manned space stations may be to economically produce vaccine and medical preparations of very high purity.

## LUNAR ROVING VEHICLE

The lunar roving vehicle (LRV) will transport two astronauts on three exploration traverses of the Moon's Descartes region during the Apollo 16 mission. The LRV will also carry tools, scientific and communications equipment, and lunar samples.

The four-wheel, lightweight vehicle greatly extends the lunar area that can be explored by man. It is the first manned surface transportation system designed to operate on the Moon, and it represents a solution to challenging new problems without precedent in Earth-bound vehicle design and operation.

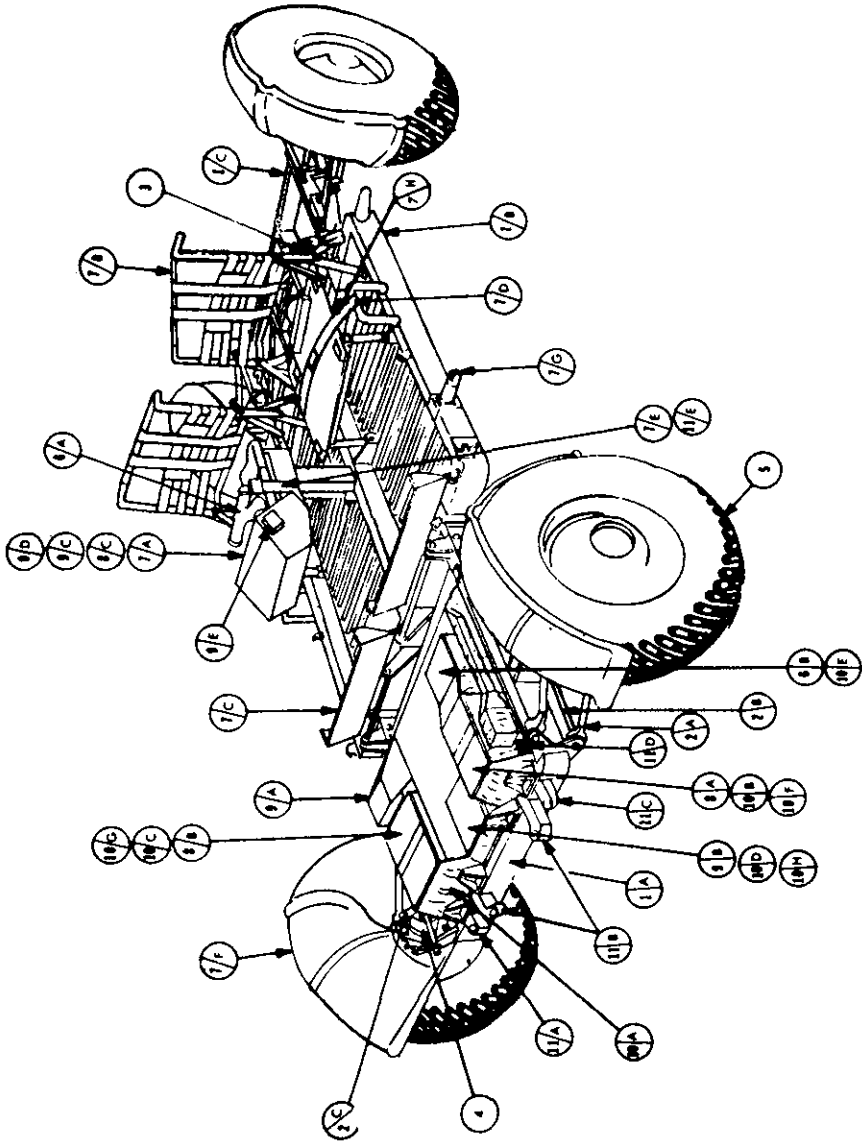
The LRV must be folded into a small package within a wedge-shaped storage bay of the lunar module descent stage for transport to the Moon. After landing, the vehicle must be unfolded from its stowed position and deployed on the surface. It must then operate in an almost total vacuum under extremes of surface temperatures, low gravity, and on unfamiliar terrain.

The first lunar roving vehicle, used on the Apollo 15 lunar mission, was driven for three hours during its exploration traverses, covering a distance of 27.8 kilometers (17.3 statute miles) at an average speed of 9.2 kilometers an hour (5.7 miles an hour).

### General Description

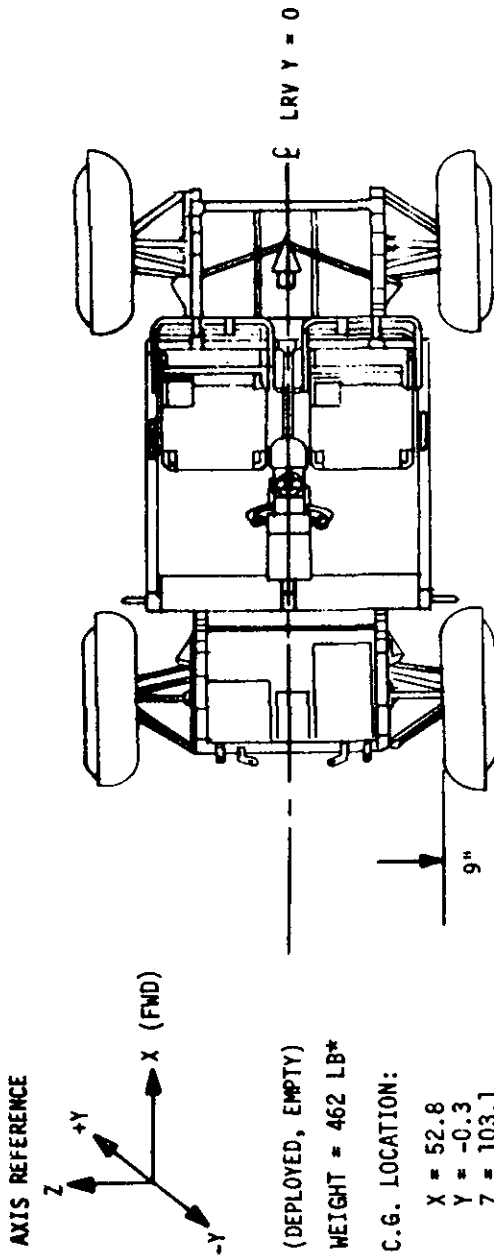
The LRV is 3.1 meters long (10.2 feet); has a 1.8-meter (six-foot) tread width; is 1.14 meters high (44.8 inches); and has a 2.3-meter wheel base (7.5 feet). Each wheel is powered by a small electric motor. The maximum speed reached on the Apollo 15 mission was about 13 km/hr (eight mph).

Two 36-volt batteries provide vehicle power, and either battery can run all systems. The front and rear wheels have separate steering systems; if one fails it can be disconnected and the LRV will operate with the other system.

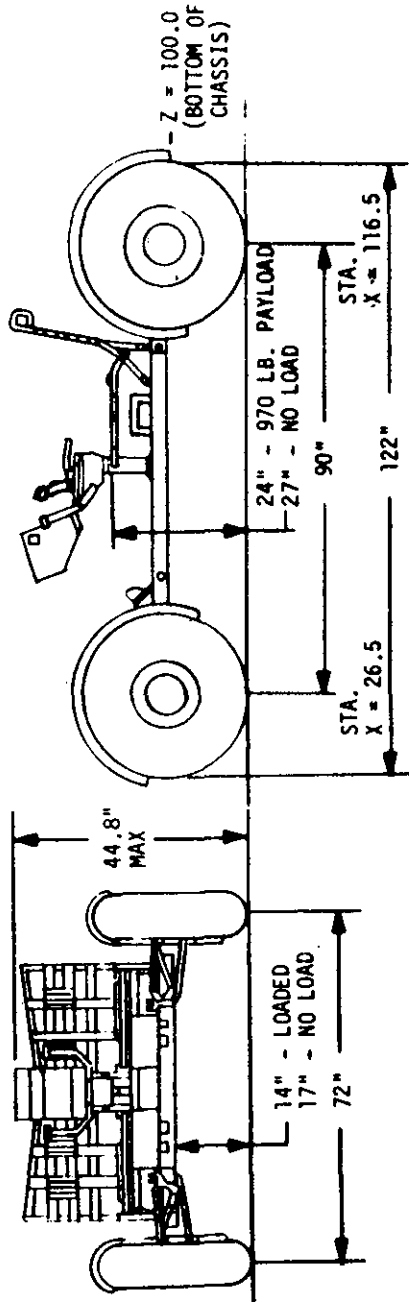


- 1** CHASSIS  
 A. FORWARD CHASSIS  
 B. CENTER CHASSIS  
 C. AFT CHASSIS
- 2** SUSPENSION SYSTEM  
 A. SUSPENSION ARMS (UPPER AND LOWER)  
 B. TORSION BARS (UPPER AND LOWER)  
 C. DAMPER
- 3** STEERING SYSTEM (FORWARD AND AFT)
- 4** TRACTION DRIVE
- 5** WHEEL
- 6** DRIVE CONTROL  
 A. HAND CONTROLLER  
 B. DRIVE CONTROL ELECTRONICS (DC)
- 7** CREW STATION  
 A. CONTROL AND DISPLAY CONSOLE  
 B. SEAT  
 C. FOOTREST  
 D. OUTBOARD HANDHOLD  
 E. INBOARD HANDHOLD  
 F. TORSION BAR  
 G. SEAT BELT
- 8** POWER SYSTEM  
 A. BATTERY #1  
 B. BATTERY #2  
 C. INSTRUMENTATION
- 9** NAVIGATION  
 A. DIRECTIONAL GYRO UNIT (DGU)  
 B. SIGNAL PROCESSING UNIT (SPU)  
 C. INTEGRATED POSITION INDICATOR (IPI)  
 D. SUN SHADOW SENSOR (SSS)
- 10** THERMAL CONTROL  
 A. INSULATION BLANKET  
 B. BATTERY NO. 1 DUST COVER  
 C. BATTERY NO. 2 DUST COVER  
 D. SPU DUST COVER  
 E. DCE THERMAL CONTROL UNIT  
 F. BATTERY NO. 1 RADIATOR  
 G. BATTERY NO. 2 RADIATOR  
 H. SPU THERMAL CONTROL UNIT
- 11** PAYLOAD INTERFACE  
 A. TV CAMERA RECEPTACLE  
 B. LGRU RECEPTACLE  
 C. HIGH GAIN ANTENNA RECEPTACLE  
 D. AUXILIARY CONNECTOR RECEPTACLE  
 E. LOW GAIN ANTENNA RECEPTACLE

LRV WITHOUT STOWED PAYLOAD



\*INCLUDES BATTERIES  
& PAYLOAD SUPPORTS,  
EXCLUDES SSE.



LRV COMPONENTS AND DIMENSIONS

Weighing about 208 kilograms (457 pounds), Earth weight when deployed on the Moon, the LRV can carry a total payload of about 490 kilograms (1,080 pounds), more than twice its own weight. The payload includes two astronauts and their portable life support systems (about 363 kilograms; 800 pounds), 45.4 kilograms (100 pounds) of communications equipment, 54.5 kilograms (120 pounds) of scientific equipment and photographic gear, and 27.2 kilograms (60 pounds) of lunar samples.

The LRV is designed to operate for a minimum of 78 hours during the lunar day. It can make several exploration sorties to a cumulative distance of 92 kilometers (57 miles). The maximum distance the LRV will be permitted to range from the lunar module will be approximately 9.7 kilometers (six miles), the distance the crew could safely walk back to the LM in the unlikely event of a total LRV failure. This walkback distance limitation is based upon the quantity of oxygen and coolant available in the astronauts' portable life support systems. This area contains about 292 square kilometers (113 square miles) available for investigation, 10 times the area that can be explored on foot.

The vehicle can negotiate obstacles 30.5 centimeters (one foot) high, and cross crevasses 70 centimeters wide (28 inches). The fully loaded vehicle can climb and descend slopes as steep as 25 degrees, and park on slopes up to 35 degrees. Pitch and roll stability angles are at least 45 degrees, and the turn radius is three meters (10 feet).

Both crewmen sit so the front wheels are visible during normal driving. The driver uses an on-board dead reckoning navigation system to determine direction and distance from the lunar module, and total distance traveled at any point during a traverse.

The LRV has five major systems: mobility, crew station, navigation, power, and thermal control. Secondary systems include the deployment mechanism, LM attachment equipment, and ground support equipment.



The aluminum chassis is divided into three sections that support all equipment and systems. The forward and aft sections fold over the center one for stowage in the LM. The forward section holds both batteries, part of the navigation system, and electronics gear for the traction drive and steering systems. The center section holds the crew station with its two seats, control and display console, and hand controller. The floor of beaded aluminum panels can support the weight of both astronauts standing in lunar gravity. The aft section holds the scientific payload.

Auxiliary LRV equipment includes the lunar communications relay unit (LCRU) and its high and low gain antennas for direct communications with Earth, the ground commanded television assembly (GCTA), a motion picture camera, scientific equipment, tools, and sample stowage bags.

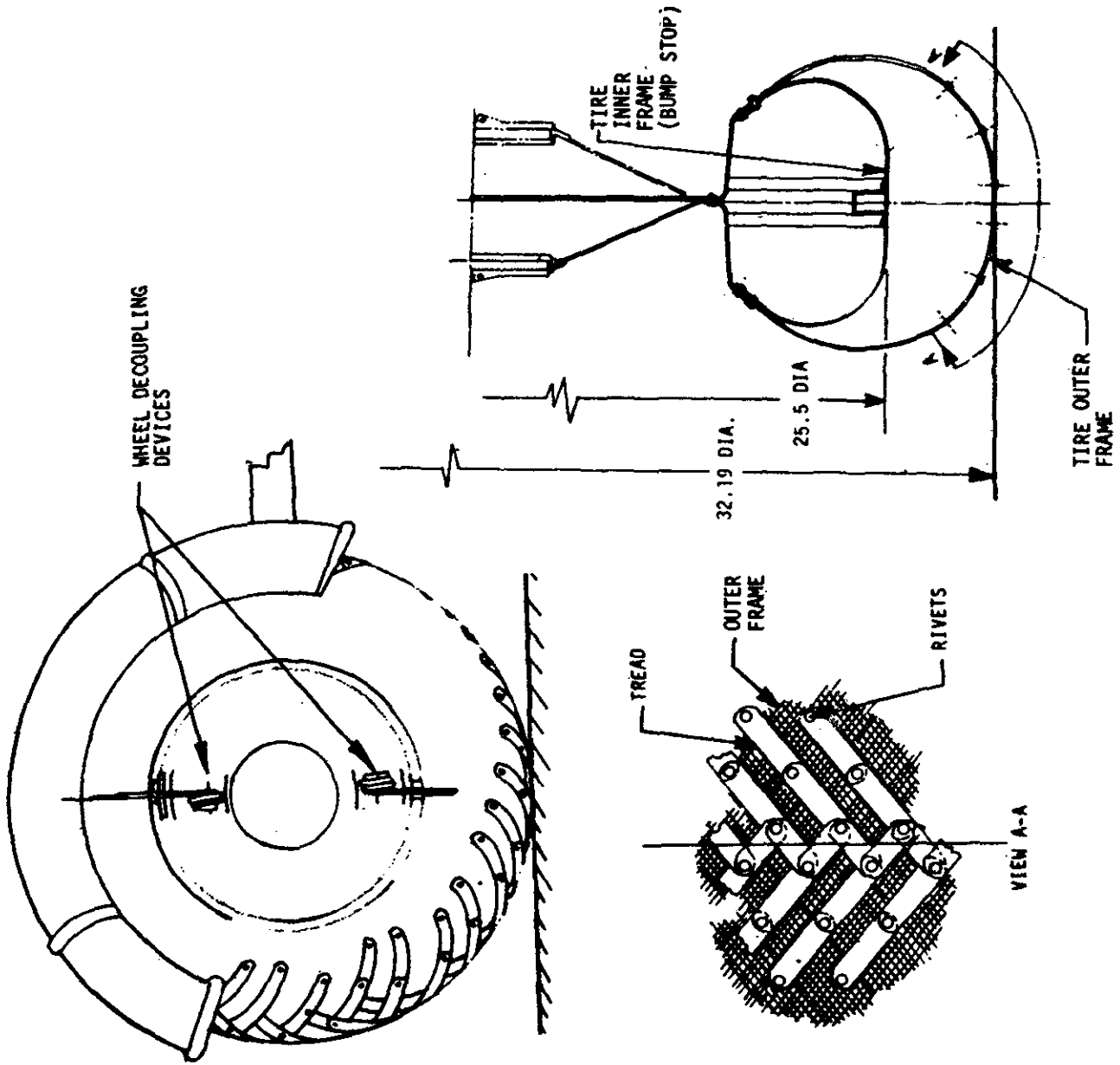
### Mobility System

The mobility system is the major LRV system, containing the wheels, traction drive, suspension, steering, and drive control electronics subsystems.

The vehicle is driven by a T-shaped hand controller located on the control and display console post between the crewmen. Using the controller, the astronaut maneuvers the LRV forward, reverse, left and right.

Each LRV wheel has a spun aluminum hub and a titanium bump stop (inner frame) inside the tire (outer frame). The tire is made of a woven mesh of zinc-coated piano wire to which titanium treads are riveted in a chevron pattern around the outer circumference. The bump stop prevents excessive inflection of the mesh tire during heavy impact. Each wheel weighs 5.4 kilograms (12 pounds) on Earth and is designed to be driven at least 180 kilometers (112 miles). The wheels are 81.3 centimeters (32 inches) in diameter and 22.9 centimeters (nine inches) wide.

A traction drive attached to each wheel has a motor harmonic drive gear unit, and a brake assembly. The harmonic drive reduces motor speed at an 80-to-1 rate for continuous operation at all speeds without gear shifting. The drive has an odometer pickup (measuring distance traveled) that sends data to the navigation system. Each motor develops 0.18 kilowatt (1/4-horsepower) and operates from a 36-volt input.



LRV WHEEL

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Each wheel has a mechanical brake connected to the hand controller. Moving the controller rearward de-energizes the drive motors and forces brake shoes against a drum, stopping wheel hub rotation. Full rear movement of the controller engages and locks a parking brake.

The chassis is suspended from each wheel by two parallel arms mounted on torsion bars and connected to each traction drive. Tire deflection allows a 35.6-centimeter (14-inch) ground clearance when the vehicle is fully loaded, and 43.2 centimeters (17 inches) when unloaded.

Both front and rear wheels have independent steering systems that allow a "wall-to-wall" turning radius of 3.1 meters (122 inches), exactly the vehicle length. If either set of wheels has a steering failure, its steering system can be disengaged and the traverse can continue with the active steering assembly. Each wheel can also be manually uncoupled from the traction drive and brake to allow "free wheeling" about the drive housing.

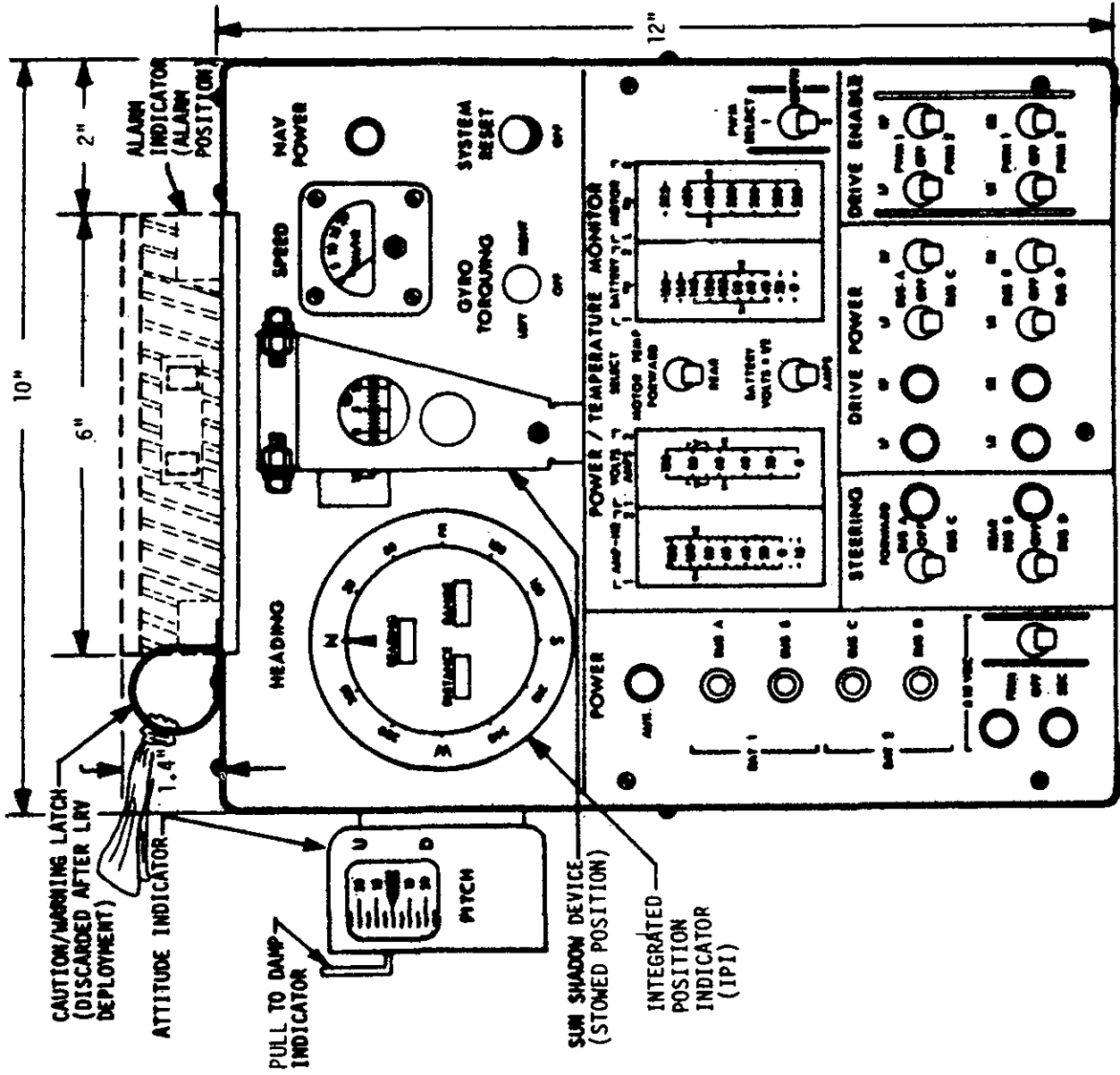
Pushing the hand controller forward increases forward speed; rear movement reduces speed. Forward and reverse are controlled by a knob on the controller's vertical stem. With the knob pushed down, the controller can only be pivoted forward; with it pushed up, the controller can be pivoted to the rear for reverse.

### Crew Station

The crew station consists of the control and display console, seats, seat belts, an armrest, footrests, inboard and outboard handholds, toeholds, floor panels, and fenders.

The control and display console is separated into two main parts: The top portion holds navigation system displays; the lower portion contains monitors and controls. Attached to the upper left side of the console is an attitude indicator that shows vehicle pitch and roll.

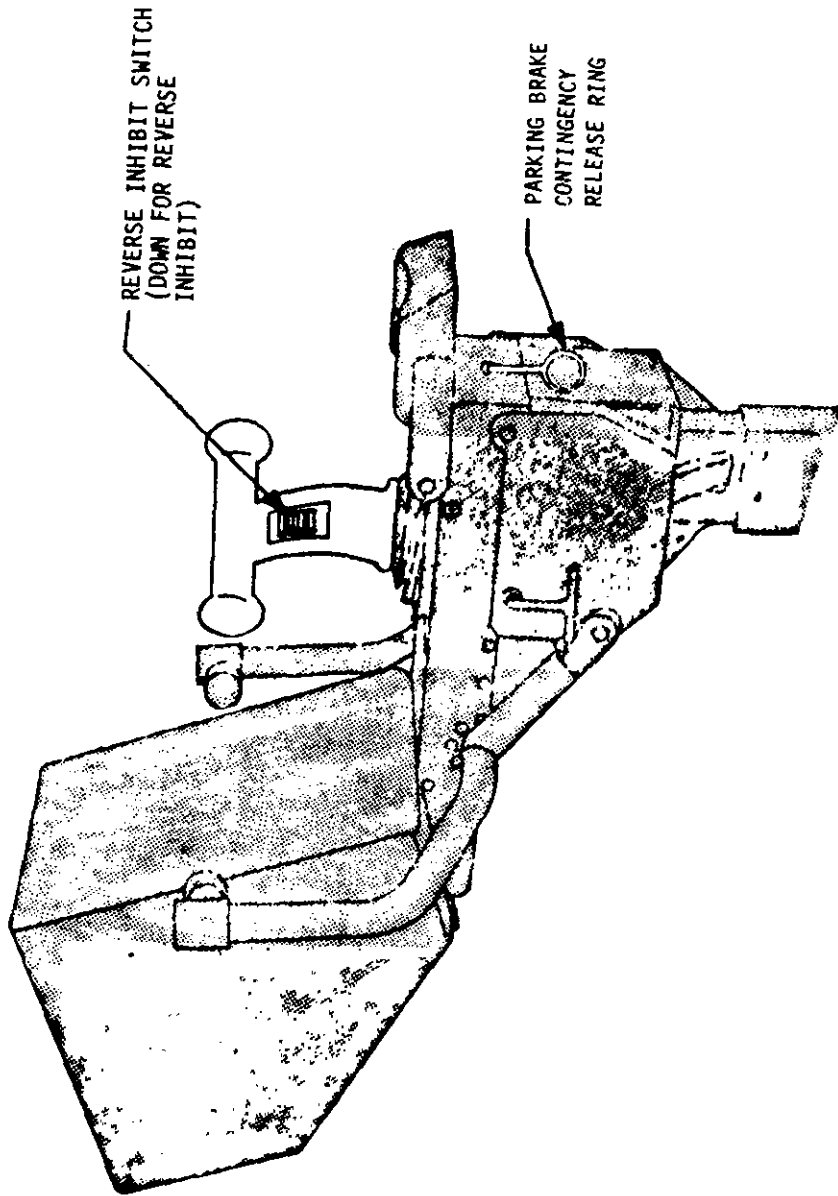
At the console top left is a position indicator. Its outer circumference is a large dial that shows vehicle heading (direction) with respect to lunar north. Inside the dial are three digital indicators that show bearing and range to the LM and distance traveled by the LRV. In the middle of the console upper half is a Sun compass device that is used to update the LRV's navigation system. Down the left side of the console lower half are control switches for power distribution, drive and steering, and monitors for power and temperature. A warning flag atop the console pops up if a temperature goes above limits in either battery or in any drive motor.



LRV CREW STATION COMPONENTS - CONTROL AND DISPLAY CONSOLE

HAND CONTROLLER OPERATION:

- T-HANDLE PIVOT FORWARD - INCREASED DEFLECTION FROM NEUTRAL INCREASES FORWARD SPEED.
- T-HANDLE PIVOT REARWARD - INCREASED DEFLECTION FROM NEUTRAL INCREASES REVERSE SPEED.
- T-HANDLE PIVOT LEFT - INCREASED DEFLECTION FROM NEUTRAL INCREASES LEFT STEERING ANGLE.
- T-HANDLE PIVOT RIGHT - INCREASED DEFLECTION FROM NEUTRAL INCREASES RIGHT STEERING ANGLE.
- T-HANDLE DISPLACED REARWARD - REARWARD MOVEMENT INCREASES BRAKING FORCE. FULL 3 INCH REARWARD APPLIES PARKING BRAKE. MOVING INTO BRAKE POSITION DISABLES THROTTLE CONTROL AT 15° MOVEMENT REARWARD.



HAND CONTROLLER

The LRV seats are tubular aluminum frames spanned by nylon webbing. They are folded flat during launch and erected by crewmen after deployment. The seat backs support the astronaut portable life support systems. Nylon webbing seat belts, custom fitted to each crewman, snap over the outboard handholds with metal hooks.

The armrest, located directly behind the LRV hand controller, supports the arm of the driving crewman. The footrests, attached to the center floor section, are adjusted before launch to fit each crewman. Inboard handholds help crewmen get in and out of the LRV, and have receptacles for a 16 mm camera and the low gain antenna of the LCRU.

The lightweight, fiberglass fenders keep lunar dust from being thrown on the astronauts, their equipment, sensitive vehicle parts, and from obstructing vision while driving. Front and rear fender sections are retracted during flight and extended by crewmen after LRV deployment on the lunar surface.

#### Navigation System

The navigation system is based on the principle of starting a sortie from a known point, recording speed, direction and distance traveled, and periodically calculating vehicle position.

The system has three major components: a directional gyroscope to provide vehicle headings; odometers on each wheel's traction drive unit to give speed and distance data; and a signal processing unit (a small, solid-state computer) to determine heading, bearing, range, distance traveled, and speed.

All navigation system readings are displayed on the control console. The system is reset at the beginning of each traverse by pressing a system reset button that moves all digital displays and internal registers to zero.

The directional gyroscope is aligned by measuring the inclination of the LRV (using the attitude indicator) and measuring vehicle orientation with respect to the Sun (using the Sun compass). This information is relayed to ground controllers and the gyro is adjusted to match calculated values read back to the crew.

Each LRV wheel revolution generates odometer magnetic pulses that are sent to the console displays.

### Power System

The power system consists of two 36-volt, non-rechargeable batteries and equipment that controls and monitors electrical power. The batteries are in magnesium cases, use plexiglass monoblock (common cell walls) for internal construction, and have silver-zinc plates in potassium hydroxide electrolyte. Each battery has 23 cells and a 121-ampere-hour capacity.

Both batteries are used simultaneously with an approximately equal load during LRV operation. Each battery can carry the entire electrical load; if one fails, its load can be switched to the other.

The batteries are activated when installed on the LRV at the launch pad about five days before launch. During LRV operation all mobility system power is turned off if a stop exceeds five minutes, but navigation system power remains on throughout each sortie. The batteries normally operate at temperatures of 4.4 to 51.7 degrees C. (40-125 degrees F.).

An auxiliary connector at the LRV's forward end supplies 150 watts of 36-volt power for the lunar communications relay unit.

### Thermal Control

The basic concept of LRV thermal control is heat storage during vehicle operation and radiation cooling when it is parked between sorties. Heat is stored in several thermal control units and in the batteries. Space radiators are protected from dust during sorties by covers that are manually opened at the end of each sortie; when battery temperatures cool to about 7.2 degrees C. (45 degrees F.), the covers automatically close.

A multi-layer insulation blanket protects forward chassis components. Display console instruments are mounted to an aluminum plate isolated by radiation shields and fiberglass mounts. Console external surfaces are coated with thermal control paint and the face plate is anodized, as are handholds, footrests, tubular seat sections, and center and aft floor panels.

### Stowage and Deployment

Space support equipment holds the folded LRV in the lunar module during transit and deployment at three attachment points with the vehicle's aft end pointing up.

Deployment is essentially manual. One crewman releases a cable attached to the top (aft end) of the folded LRV as the first step in the deployment. This cable is held taut during deployment, until all four LRV wheels are on the lunar surface.

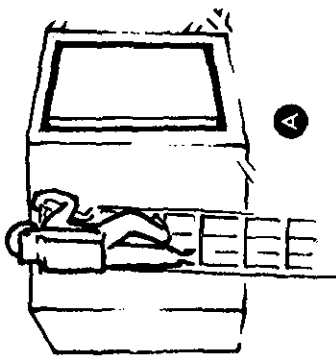
One of the crewmen then ascends the LM ladder part way and pulls a D-ring on the side of the descent stage. This releases the LRV, and lets the vehicle swing out at the top about 12.7 centimeters (five inches) until it is stopped by two steel cables. Descending the ladder, the crewman walks to the LRV's right side, takes the end of a deployment tape from a stowage bag, and pulls the tape hand-over-hand. This unreels two support cables that swivel the vehicle outward from the top. As the aft chassis is unfolded, the aft wheels automatically unfold and deploy, and all latches are engaged. The crewman continues to unwind the tape, lowering the LRV's aft end to the surface, and the forward chassis and wheels spring open and into place.

When the aft wheels are on the surface, the crewman removes the support cables and walks to the vehicle's left side. There he pulls a second tape that lowers the LRV's forward end to the surface and causes telescoping tubes to push the vehicle away from the LM. The two crewmen then deploy the fender extensions, set up the control and display console, unfold the seats, and deploy other equipment.

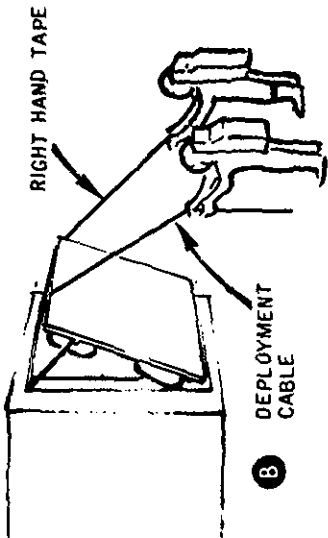
One crewman will board the LRV and make sure all controls are working. He will back the vehicle away slightly and drive it to the LM quadrant that holds the auxiliary equipment. The LRV will be powered down while the crewmen load auxiliary equipment aboard the vehicle.



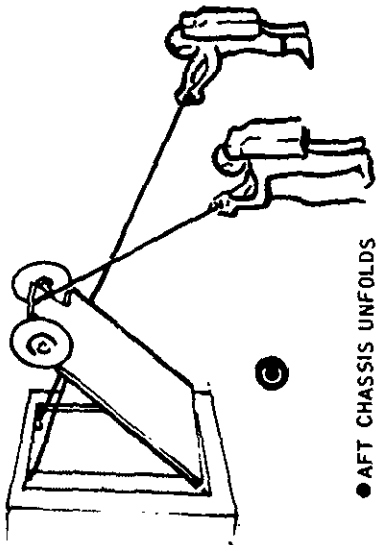
LRV DEPLOYMENT SEQUENCE



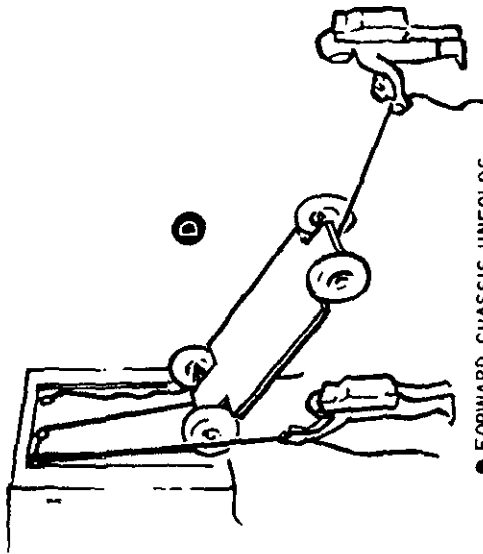
- LRV STOWED IN QUADRANT
- ASTRONAUT REMOVES INSULATION BLANKET, OPERATING TAPES
- ASTRONAUT REMOTELY INITIATES DEPLOYMENT



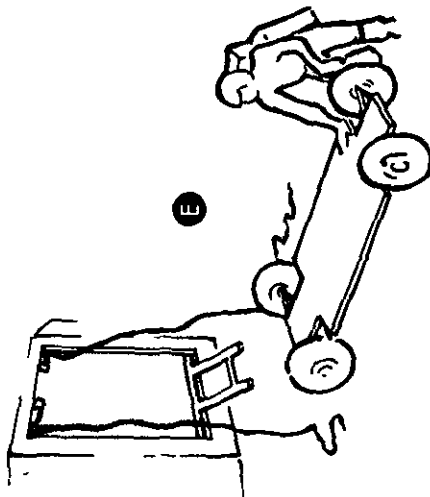
- ASTRONAUT LOWERS LRV FROM STORAGE BAY WITH RIGHT HAND TAPE



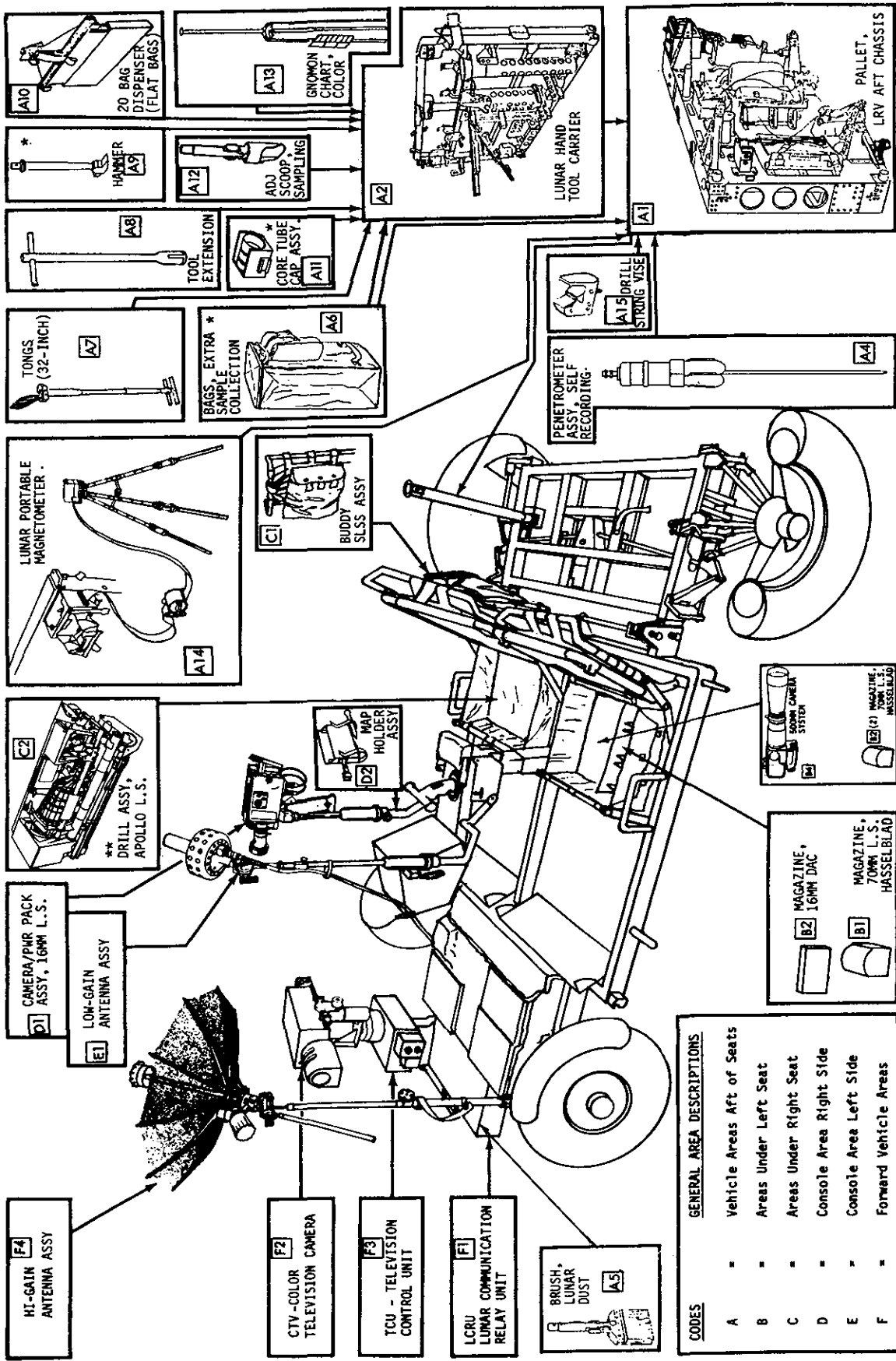
- AFT CHASSIS UNFOLDS
- REAR WHEELS UNFOLD
- AFT CHASSIS LOCKS IN POSITION



- FORWARD CHASSIS UNFOLDS AND LOCKS
- FRONT WHEELS UNFOLD
- ASTRONAUT LOWERS LRV TO SURFACE WITH LEFT HAND TAPE



- ASTRONAUT DISCONNECTS SPACE SUPPORT EQUIPMENT (SSE)



**GENERAL AREA DESCRIPTIONS**

CODES	DESCRIPTIONS
A	Vehicle Areas Aft of Seats
B	Areas Under Left Seat
C	Areas Under Right Seat
D	Console Area Right Side
E	Console Area Left Side
F	Forward Vehicle Areas

\*Normally carried on the LMP PLSS tool carrier  
 \*\*Only carried from LM to ALSEP site

LUNAR FIELD GEOLOGY EQUIP. STORAGE ON LRV

### LUNAR COMMUNICATIONS RELAY UNIT (LCRU)

The range from which an Apollo crew can operate from the lunar module during EVAs while maintaining contact with the Earth is extended over the lunar horizon by a suitcase-size device called the lunar communications relay unit (LCRU). The LCRU acts as a portable relay station for voice, TV, and telemetry directly between the crew and Mission Control Center instead of through the lunar module communications system. First use of the LCRU was on Apollo 15.

Completely self-contained with its own power supply and erectable hi-gain S-Band antenna, the LCRU may be mounted on a rack at the front of the lunar roving vehicle (LRV) or hand-carried by a crewman. In addition to providing communications relay, the LCRU receives ground-command signals for the ground commanded television assembly (GCTA) for remote aiming and focusing the lunar surface color television camera. The GCTA is described in another section of this press kit.

Between stops with the lunar roving vehicle, crew voice is beamed Earthward by a wide beam-width helical S-Band antenna. At each traverse stop, the crew must boresight the high-gain parabolic antenna toward Earth before television signals can be transmitted. VHF signals from the crew portable life support system (PLSS) transceivers are converted to S-band by the LCRU for relay to the ground, and conversely, from S-Band to VHF on the uplink to the EVA crewmen.

The LCRU measures 55.9 x 40.6 x 15.2 cm (22 x 16 x 6 inches) not including antennas, and weighs 25 Earth kg (55 Earth pounds) (9.2 lunar pounds). A protective thermal blanket around the LCRU can be peeled back to vary the amount of radiation surface which consists of 1.26 m<sup>2</sup> (196 square inches) of radiating mirrors to reflect solar heat. Additionally, wax packages on top of the LCRU enclosure stabilize the LCRU temperature by a melt-freeze cycle. The LCRU interior is pressurized to 7.5 psia differential (one-half atmosphere).

Internal power is provided to the LCRU by a 19-cell silver-zinc battery with a potassium hydroxide electrolyte. The battery weighs 4.1 kg (nine Earth pounds) (1.5 lunar pounds) and measures 11.8 x 23.9 x 11.8 cm (4.7 x 9.4 x 4.65 inches). The battery is rated at 400 watt hours, and delivers 29 volts at a 3.1-ampere current load. The LCRU may also be operated from the LRV batteries. The nominal plan is to operate the LCRU using LRV battery power during EVA-1 and EVA-2. The LCRU battery will provide the power during EVA-3.

Three types of antennas are fitted to the LCRU system: a low-gain helical antenna for relaying voice and data when the LRV is moving and in other instances when the high-gain antenna is not deployed; a .76 m (three-foot) diameter parabolic rib-mesh high-gain antenna for relaying a television signal; and a VHF omni-antenna for receiving crew voice and data from the PLSS transceivers. The high-gain antenna has an optical sight which allows the crewman to boresight on Earth for optimum signal strength. The Earth subtends one-half degree angle when viewed from the lunar surface.

The LCRU can operate in several modes: mobile on the LRV, fixed base such as when the LRV is parked, or hand-carried in contingency situations such as LRV failure.

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TELEVISION AND  
GROUND COMMANDED TELEVISION ASSEMBLY

Two different color television cameras will be used during the Apollo 16 mission. One, manufactured by Westinghouse, will be used in the command module. It will be fitted with a 5 cm (2 in) black and white monitor to aid the crew in focus and exposure adjustment.

The other camera, manufactured by RCA, is for lunar surface use and will be operated from three different positions-- mounted on the LM MESA, mounted on a tripod and connected to the LM by a 30.5 m (100 ft) cable, and installed on the LRV with signal transmission through the lunar communication relay unit rather than through the LM communications system as in the other two positions.

While on the LRV, the camera will be mounted on the ground commanded television assembly (GCTA). The camera can be aimed and controlled by astronauts or it can be remotely controlled by personnel located in the Mission Control Center. Remote command capability includes camera "on" and "off", pan, tilt, zoom, iris open/closed (f2.2 to f22) and peak or average automatic light control.

The GCTA is capable of tilting the TV camera upward 85 degrees, downward 45 degrees, and panning the camera 340 degrees between mechanical stops. Pan and tilt rates are three degrees per second.

The TV lens can be zoomed from a focal length of 12.5mm to 75mm corresponding to a field of view from three to nine degrees.

At the end of the third EVA, the crew will park the LRV about 91.4 m (300 ft) east of the LM so that the color TV camera can cover the LM ascent from the lunar surface. Because of a time delay in a signal going the quarter million miles out to the Moon, Mission Control must anticipate ascent engine ignition by about two seconds with the tilt command.

The GCTA and camera each weigh approximately 5.9 kg (13 lb). The overall length of the camera is 46 cm (18.0 in) its width is 17 cm (6.7 in), and its height is 25 cm (10 in). The GCTA and LCRU are built by RCA.

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# APOLLO 16 TELEVISION EVENTS

DATE	TIME (GET)	TIME (EST)	DURATION (HRS:MIN)	EVENT
APRIL 16	3:05	1559	0:19	TD & E
APRIL 20	102:25	1919	6:48	EVA-1
APRIL 21	124:50	1744	6:30	EVA-2
APRIL 22	148:25	1719	6:40	EVA-3
APRIL 23	171:40	1634	0:14	LM LIFT-OFF
	173:20	1814	0:06	RENDEZVOUS
	173:44	1838	0:07	DOCKING
APRIL 26	241:55	1449	1:10	CMP EVA
TBD				TRANSEARTH COAST

## PHOTOGRAPHIC EQUIPMENT

Still and motion pictures will be made of most spacecraft maneuvers and crew lunar surface activities. During lunar surface operations, emphasis will be on documenting placement of lunar surface experiments, documenting lunar samples, and on recording in their natural state the lunar surface features.

Command module lunar orbit photographic tasks and experiments include high-resolution photography to support future landing missions, photography of surface features of special scientific interest and astronomical phenomena such as solar corona, Gegenschein, zodiacal light, libration points, and galactic poles.

Camera equipment stowed in the Apollo 16 command module consists of one 70mm Hasselblad electric camera, a 16mm Maurer motion picture camera, and a 35mm Nikon F single-lens reflex camera. The command module Hasselblad electric camera is normally fitted with an 80mm f/2.8 Zeiss Planar lens, but a bayonet-mount 250mm lens can be fitted for long-distance Earth/Moon photos. A 105mm f/4.3 Zeiss UV Sonnar is provided for the ultraviolet photography experiment.

The 35mm Nikon F is fitted with a 55mm f/1.2 lens for the Gegenschein and dim-light photographic experiments.

The Maurer 16mm motion picture camera in the command module has lenses of 10, 18 and 75mm focal length available. Accessories include a right-angle mirror, a power cable and a sextant adapter which allows the camera to film through the navigation sextant optical system.

Cameras stowed in the lunar module are two 70mm Hasselblad data cameras fitted with 60mm Zeiss Metric lenses, an electric Hasselblad with 500mm lens and two 16mm Maurer motion picture cameras with 10mm lenses. One of the Hasselblads and one of the motion picture cameras are stowed in the modular equipment stowage assembly (MESA) in the LM descent stage.

The LM Hasselblads have crew chest mounts that fit dovetail brackets on the crewman's remote control unit, thereby leaving both hands free. One of the LM motion picture cameras will be mounted in the right-hand window to record descent, landing, ascent and rendezvous. The 16mm camera stowed in the MESA will be carried aboard the lunar roving vehicle to record portions of the three EVAs.

Descriptions of the 24-inch panoramic camera and the 3-inch mapping/stellar camera are in the orbital science section of this press kit.

- more -



TV AND PHOTOGRAPHIC EQUIPMENT

NOMENCLATURE	CSM AT LAUNCH	LM AT LAUNCH	CM TO LM	LM TO CM	CM AT ENTRY
TV, COLOR, ZOOM LENS (MONITOR WITH CM SYSTEM)	1	1			1
CAMERA, DATA ACQUISITION, 16 MM	1	1			1
LENS - 10 MM	1	1			1
- 18 MM	1				1
- 75 MM	1				1
FILM MAGAZINES	13				13
CAMERA, 35 MM NIKON	1				1
LENS - 55 MM	1				1
CASSETTE, 35 MM	9				9
CAMERA, 16 MM, BATTERY OPERATED (LUNAR SURFACE)		1			
LENS - 10 MM		1			
FILM MAGAZINES	8		8	8	8
CAMERA, HASSELBLAD, 70 MM ELECTRIC	1				1
LENS - 80 MM	1				1
- 250 MM	1				1
- 105 MM UV (4 BAND-PASS FILTERS)	1				1
FILM MAGAZINES	7				7
FILM MAGAZINE, 70 MM UV	1				1
CAMERA, HASSELBLAD ELECTRIC DATA (LUNAR SURFACE)		2			
LENS - 60 MM		2			
FILM MAGAZINES	11		11	11	11
POLARIZING FILTER		1			
CAMERA, 24-IN. PANORAMIC (IN SIM)	1				1
FILM MAGAZINE (EVA TRANSFER)	1				1
CAMERA, LUNAR SURFACE ELECTRIC		1			
LENS - 500 MM		1			
FILM MAGAZINES	2		2	2	2
CAMERA, 3-IN MAPPING STELLAR(SIM)	1				1
FILM MAGAZINE CONTAINING 5-IN. MAPPING AND 35 MM STELLAR FILM (EVA TRANSFER)	1				1
CAMERA, ULTRAVIOLET, LUNAR SURFACE		1			
FILM MAGAZINE, UV, LS		1		1	1

## ASTRONAUT EQUIPMENT

### Space Suit

Apollo crewmen wear two versions of the Apollo space suit: the command module pilot version (A-7LB-CMP) for intravehicular operations in the command module and for extravehicular operations during SIM bay film retrieval during transearth coast; and the extravehicular version (A-7LB-EV) worn by the commander and lunar module pilot for lunar surface EVAs.

The A-7LB-EV suit differs from Apollo suits flown prior to Apollo 15 by having a waist joint that allows greater mobility while the suit is pressurized--stooping down for setting up lunar surface experiments, gathering samples and for sitting on the lunar roving vehicle.

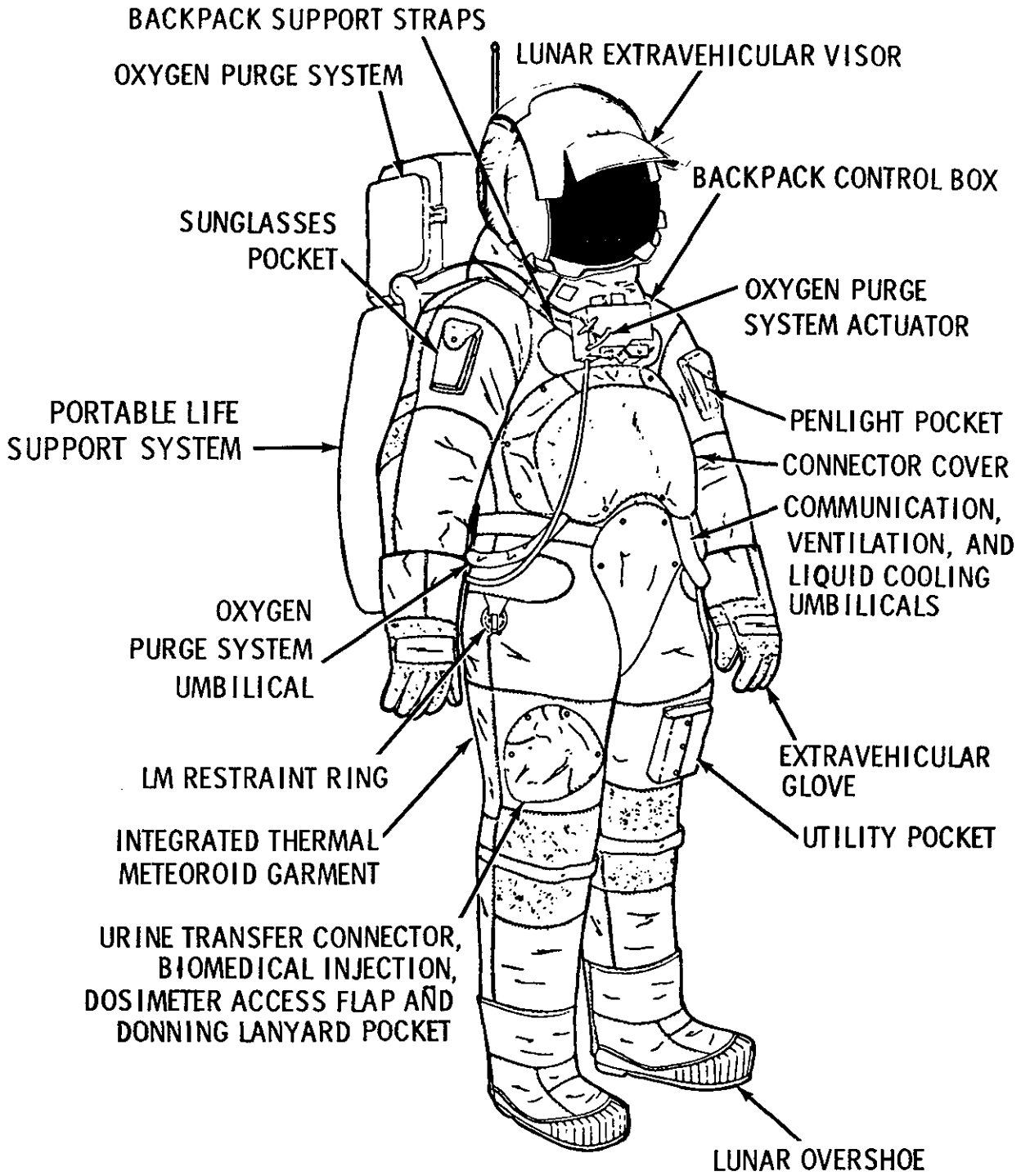
From the inside out, an integrated thermal meteoroid suit cover layer worn by the commander and lunar module pilot starts with rubber-coated nylon and progresses outward with layers of nonwoven Dacron, aluminized Mylar film and Beta marquisette for thermal radiation protection and thermal spacers, and finally with a layer of nonflammable Teflon-coated Beta cloth and an abrasion-resistant layer of Teflon fabric--a total of 18 layers.

Both types of the A-7LB suit have a pressure retention portion called a torso limb suit assembly consisting of neoprene coated nylon and an outer structural restraint layer.

The space suit with gloves, and dipped rubber convolutes which serve as the pressure layer liquid cooling garment, portable life support system (PLSS), oxygen purge system, lunar extravehicular visor assembly, and lunar boots make up the extravehicular mobility unit (EMU). The EMU provides an extravehicular crewman with life support for a seven-hour mission outside the lunar module without replenishing expendables.

Lunar extravehicular visor assembly - The assembly consists of polycarbonate shell and two visors with thermal control and optical coatings on them. The EVA visor is attached over the pressure helmet to provide impact, micrometeoroid, thermal and ultraviolet-infrared light protection to the EVA crewmen.

-more-



-more-

## EXTRAVEHICULAR MOBILITY UNIT

After Apollo 12, a sunshade was added to the outer portion of the LEVA in the middle portion of the helmet rim.

Extravehicular gloves - Built of an outer shell of Chromel-R fabric and thermal insulation the gloves provide protection when handling extremely hot and cold objects. The finger tips are made of silicone rubber to provide more sensitivity.

Constant-wear garment - A one-piece constant-wear garment, similar to "long johns", is worn as an undergarment for the space suit in intravehicular and on CSM EV operations, and with the inflight coveralls. The garment is porous-knit cotton with a waist-to neck zipper for donning. Biomedical harness attach points are provided.

Liquid-cooling garment - The knitted nylon-spandex garment includes a network of plastic tubing through which cooling water from the PLSS is circulated. It is worn next to the skin and replaces the constant-wear garment during lunar surface EVA.

Portable life support system (PLSS) - The backpack supplies oxygen at 3.7 psi and cooling water to the liquid cooling garment. Return oxygen is cleansed of solid and gas contaminants by a lithium hydroxide and activated charcoal canister. The PLSS includes communications and telemetry equipment, displays and controls, and a power supply. The PLSS is covered by a thermal insulation jacket, (two stowed in LM).

Oxygen purge system (OPS) - Mounted atop the PLSS, the oxygen purge system provides a contingency 30-75 minute supply of gaseous oxygen in two bottles pressurized to 5,880 psia, (a minimum of 30 minutes in the maximum flow rate and 75 minutes in the low flow rate). The system may also be worn separately on the front of the pressure garment assembly torso for contingency EVA transfer from the LM to the CSM or behind the neck for CSM EVA. It serves as a mount for the VHF antenna for the PLSS, (two stowed in LM).

Coveralls - During periods out of the space suits, crewmen wear two-piece Teflon fabric inflight coveralls for warmth and for pocket stowage of personal items.

Communications carriers - "Snoopy hats" with redundant microphones and earphones are worn with the pressure helmet; a light-weight headset is worn with the inflight coveralls.

Water Bags - .9 liter (1 qt.) drinking water bags are attached to the inside neck rings of the EVA suits. The crewman can take a sip of water from the 6-by-8-inch bag through a 1/8-inch-diameter tube within reach of his mouth. The bags are filled from the lunar module potable water dispenser.

Buddy Secondary Life Support System - A connecting hose system which permits a crewman with a failed PLSS to share cooling water in the other crewman's PLSS. The BSLSS lightens the load on the oxygen purge system in the event of a total PLSS failure in that the OPS would supply breathing and pressurizing oxygen while the metabolic heat would be removed by the shared cooling water from the good PLSS. The BSLSS will be stowed on the LRV.

Lunar Boots - The lunar boot is a thermal and abrasion protection device worn over the inner garment and boot assemblies. It is made up of layers of several different materials beginning with Teflon coated beta cloth for the boot liner to Chromel R metal fabric for the outer shell assembly. Aluminized Mylar, Nomex felt, Dacron, Beta cloth and Beta marquisette Kapton comprise the other layers. The lunar boot sole is made of high-strength silicone rubber.

### Personal Hygiene

Crew personal hygiene equipment aboard Apollo 16 includes body cleanliness items, the waste management system, and one medical kit.

Packaged with the food are a toothbrush and a two-ounce tube of toothpaste for each crewman. Each man-meal package contains a 3.5-by-4-inch wet-wipe cleansing towel. Additionally, three packages of 12-by-12-inch dry towels are stowed beneath the command module pilot's couch. Each package contains seven towels. Also stowed under the command module pilot's couch are seven tissue dispensers containing 53 three-ply tissues each.

Solid body wastes are collected in plastic defecation bags which contain a germicide to prevent bacteria and gas formation. The bags are sealed after use, identified, and stowed for return to Earth for post-flight analysis.

Urine collection devices are provided for use while wearing either the pressure suit or the inflight coveralls. The urine is dumped overboard through the spacecraft urine dump valve in the CM and stored in the LM. On Apollo 16 urine specimens will be returned to Earth for analysis.

### Survival Kit

The survival kit is stowed in two rucksacks in the right-hand forward equipment bay of the CM above the lunar module pilot.

Contents of rucksack No. 1 are: two combination survival lights, one desalter kit, three pairs of sunglasses, one radio beacon, one spare radio beacon battery and spacecraft connector cable, one knife in sheath, three water containers- two containers of Sun lotion, two utility knives, three survival blankets and one utility netting.

Rucksack No. 2: one three-man life raft with CO<sub>2</sub> inflater, one sea anchor, two sea dye markers, three sunbonnets, one mooring lanyard, three manlines and two attach brackets.

The survival kit is designed to provide a 48-hour post-landing (water or land) survival capability for three crewmen between 40 degrees North and South latitudes.

MEDICAL KITS

The command module crew medical supplies are contained in two kits. Included in the larger medical accessories kit are antibiotic ointment, skin cream, eye drops, nose drops, spare biomedical harnesses, oral thermometer and pills of the following types: 18 pain, 12 stimulant, 12 motion sickness, 24 diarrhea, 60 decongestant, 21 sleeping, 72 aspirin and 60 each of two types of antibiotic. A smaller command module auxiliary drug kit contains 80 and 12 of two types of pills for treatment of cardiac arrhythmia and two injectors for the same symptom.

The lunar module medical kit contains eye drops, nose drops, antibiotic ointment, bandages and the following pills: 4 stimulant, 4 pain, 8 decongestant, 8 diarrhea, 12 aspirin and 6 sleeping. A smaller kit in the LM contains 8 and 4 units of injectable drugs for cardiac arrhythmia and 2 units for pain suppression.

- more -

### Crew Food System

The Apollo 16 crew selected menus for their flight from the largest variety of foods ever available for a U.S. manned mission. However, some menu constraints have been imposed by a series of medical requirements. This has limited to some degree the latitude of crew menu selection. For the first time since the flight of Gemini 7 in December 1965, the preflight, inflight, and postflight diets are being precisely controlled to facilitate interpretation of the most extensive series of medical tests to be performed on an Apollo mission.

Menus were designed upon individual crew member physiological requirements in the unique conditions of weightlessness and one-sixth gravity on the lunar surface. Daily menus provide 2750, 2500, and 2650 calories per day for the Commander, Command Module Pilot, and Lunar Module Pilot, respectively.

Food items are assembled into meal units and identified as to crew member and sequence of consumption. Foods stored in a "pantry" section may be used as substitutions for nominal meal items so long as the nutrient intake for a 24-hour period is not altered significantly.

There are various types of food used in the menus. These include freeze-dried rehydratables in spoon-bowl packages; thermostabilized foods (wet packs) in flexible packages and metal easy-open cans; intermediate moisture foods; dry bite-size cubes, and beverages.

Water for drinking and rehydrating food is obtained from two sources in the command module -- a portable dispenser for drinking water and a water spigot at the food preparation station which supplies water at about 145 degrees and 55 degrees Fahrenheit. The potable water dispenser provides a continuous flow of water as long as the trigger is held down, and the food preparation spigot dispenses water in one-ounce increments.

A continuous flow water dispenser similar to the one in the command module is used aboard the lunar module for cold water reconstitution of food stowed aboard the lunar module.



Water is injected into a food package and the package is kneaded and allowed to sit for several minutes. The bag top is then cut open and the food eaten with a spoon. After a meal, germicide tablets are placed in each bag to prevent fermentation and gas formation. The bags are then rolled and stowed in waste disposal areas in the spacecraft.

Several prototype food packages which are intended for use in Skylab missions in 1973 will be tested by the Apollo 16 crew. These include an improved beverage package design, a salt dispenser, and an improved rehydratable package design. Functional aspects of the package and the behavior of liquid food during extended periods of weightlessness will be observed.

The in-suit drink device, which was used for water previously only on the Apollo 15 mission, will contain a specially formulated beverage powder which will be reconstituted with water prior to extravehicular activities on the lunar surface. This beverage will provide the crewman with fluid, electrolytes (especially potassium), and energy during each of the 3 scheduled EVAs. As on Apollo 15, the crewmen on the lunar surface will have an in-suit food bar to snack on.

New foods for the Apollo 16 mission are limited to thermostabilized ham steak, rehydratable grits, and an intermediate moisture cereal bar.

APOLLO 16 MENU - BLUE

<u>MEAL</u>	<u>Day 1 5**, 9, 13**</u>	<u>Day 2, 10</u>	<u>Day 3, 11</u>	<u>Day 4, 8***, 12</u>		
A	Peaches <sup>+</sup> Scrambled Eggs Bacon Squares (8) Grits Orange Juice Cocoa (+Peaches-Day 13	Fruit Cocktail Sausage Patties Spiced Fruit Cereal Orange Juice Cocoa	R Peaches R Scrambled Eggs RSB Bacon Squares (8) R Grits R Orange Juice Cocoa	RSB Mixed Fruit <sup>+</sup> RSB Ham Steak IMB Cornflakes RSB White Bread (1), Jelly <sup>++</sup> R Orange Juice R Cocoa (+Fruit Cocktail-Day 12 (++Delete on Day 12)	WP RSB IMB RSB R R R)	WP WP RSB WP R R R)
B	Chicken & Rice Soup Hamburger & White Bread (1) Pears Inst. Breakfast Cereal Bar Citrus Beverage	Corn Chowder Turkey & Gravy Vanilla Pudding White Bread (1) & Peanut Butter Apple Food Bar (2) Orange Drink	RSB Lobster Bisque WP Bread Rye (2) WP Tuna Spread Cherry Food Bar (2) Graham Cracker Cubes(6) IMB Citrus Beverage R	RSB Pea Soup Meatballs w/Sauce Lemon Pudding <sup>+</sup> Sugar Cookies (4) Peaches Orange-Grapefruit Drink (+Pork and Scalloped Potatoes-Day 8 & 12	RSB WP WP DB IMB R RSB)	RSB WP WP DB IMB R RSB)
C	Cr. Tomato Soup Spaghetti/Meat Sauce Peach Ambrosia Apricot Cereal Cubes (4) Pecans (6) Cocoa	Cr. Potato Soup Frankfurters (4) Chocolate Pudding Orange-Grapefruit Drink	RSB Romaine Soup Beef Steak WP Chicken & Rice RSB Fln. Fruitcake (4) Pecans (6) R Grape Drink	RSB Beef & Gravy Chicken Stew Butterscotch Pudding Chocolate Bar Gingerbread (4) Citrus Beverage	WP RSB RSB DB DB R R)	WP RSB RSB DB DB DB R R)

DB = Dry Bite  
IMB = Intermediate Moisture Bite  
R = Rehydratable  
RSB = Rehydratable Spoon Bowl  
WP = Wet Pack  
RC = Rehydratable Can  
SBD = Skylab Beverage Dispenser

3B SKYLAB MEAL

Turkey & Rice Soup	RC
Rye Bread (2)	WP
Chicken Spread (1/3)	WP
Peaches	WP
Peanuts	CAN
Orange Beverage	SBD

\* Meal C only  
\*\* Meal A only  
\*\*\* Meal B and C only

LM MENU (continued)

APOLLO 16 - LM11 MENU (Blue Velcro LMP, Charles M. Duke)

MEAL	DAY 5	DAY 6	DAY 7	DAY 8	IME	
B	Cream of Tomato Soup Rye Bread (2) Tuna Spread Apple Food Bar (2) Chocolate Bar Orange-Grapefruit Beverage	A Peaches (39 gms) Ham Steak Scrambled Eggs Cinn. Toasted Bread Cubes (6) Instant Breakfast Orange-Grapefruit Beverage Lemon Food Bar (2)	A Peaches (39 gms) Beef Steak Bacon Squares (8) Spiced Fruit Cereal Instant Breakfast Orange-Grapefruit Beverage Cherry Food Bar (2)	A Peaches (39 gms) Ham Steak Scrambled Eggs Cereal Bar Apricot Cereal Cubes (6) Orange Beverage Cocoa	RSB WP WP IMB DB R	WP RSE DE DE R R
C	Shrimp Cocktail Turkey & Gravy Chocolate Pudding Graham Cracker Cubes (6) Cocoa Citrus Beverage	B Pea Soup Salmon Salad Frankfurters (4) Peach Ambrosia Pears Cereal Bar Citrus Beverage Cocoa	B Romaine Soup Tuna Salad Meatballs w/Sauce Chicken &-Rice Butterscotch Pudding Gingerbread (6) Citrus Beverage Cocoa	RSB RSB WP RSB RSB DB R R	RSB RSB WP RSB RSB DB R R	

APOLLO XVI

PANTRY STOWAGE ITEMS

P/N: 14-0123

Line Items 17W & 17X

<u>BEVERAGES</u>	<u>QTY</u>	<u>SOUPS/SALADS/MEATS</u>	<u>QTY</u>
Cocoa	6	Salmon Salad	3
Coffee (B)	16	Tuna Salad	3
Instant Breakfast	12	Shrimp Cocktail	3
Grapefruit Drink	6	Romaine Soup	3
Orange Beverage	6	Potato Soup	3
Orange-Grapefruit Beverage	6	Pea Soup	3
Orange Juice	12		
Orange-Pineapple Drink	6	Spaghetti w/Meat Sauce	3
		Chicken Stew	3

BREAKFAST ITEMS

Bacon Squares (8)	6
Spiced Fruit Cereal	3
Cornflakes	3
Scrambled Eggs	6
Grits	3
Peach Ambrosia	3
Sausage Patties	3

SANDWICH SPREADS

Peanut Butter	3
Jelly	3
Ham Salad	1
Catsup*	7
Mustard*	7

SNACK ITEMS

Pecans (6)	3
Apricots (IMB) (38.5 gm)	6
Peaches (IMB) (39 gm)	8
Pears (IMB) (42 gm)	6
Apricot Food Bar (1) (26 gm)	9
Apple Food Bar (1) (26 gm)	9
Lemon Food Bar (1) (26 gm)	9
Cherry Food Bar (1) (26 gm)	9
Cereal Bar	6
Chocolate Bar	3
Sugar Cookies (4)	3
Graham Crackers (6)	3
Cheese Cracker Cubes (4)	3

ACCESSORIES

Wet Skin Cleaning Towels	9
Contingency Feeding System	
3 Food Restrainer Pouches	
3 Beverage Packages	
1 Valve Adapter (pontube)	
Germicidal Tablets	
Index Card	

\*Stowage locations TBD

APOLLO 16 FLAGS, LUNAR MODULE PLAQUE

The United States flag to be erected on the lunar surface measures 78 by 125 cm (30 by 48 inches) and will be deployed on a two-piece aluminum tube 2.1 meters (eight feet) long. The nylon flag will be stowed in the lunar module descent stage modularized equipment stowage assembly.

Also carried on the mission and returned to Earth will be 25 United States flags, 50 individual state flags, flags of United States territories, flags of other national states which are generally accepted as independent in the world community, and flags of the United Nations and other international organizations. These flags are 10 by 15 cm (four by six inches).

An 18 by 23 cm (seven by nine inch) stainless steel plaque, similar to that flown on Apollo 15, will be fixed to the LM front leg. The plaque has on it the words "Apollo 16" with "April 1972" and the signatures of the three crewmen located beneath.

## SATURN V LAUNCH VEHICLE

The Saturn V launch vehicle (SA-511) assigned to the Apollo 16 mission is very similar to the vehicles used for the missions of Apollo 8 through Apollo 15.

### First Stage

The five first stage (S-1C) F-1 engines develop about 34 million newtons (7.7 million pounds) of thrust at launch. Major stage components are the forward skirt, oxidizer tank, intertank structure, fuel tank, and thrust structure. Propellant to the five engines normally flows at a rate of about 13,300 kilograms (29,300 pounds; 3,390 gallons) a second. One engine is rigidly mounted on the stage's centerline; the outer four engines are mounted on a ring at 90-degree angles around the center engine. These outer engines are gimbaled to control the vehicle's attitude during flight.

### Second Stage

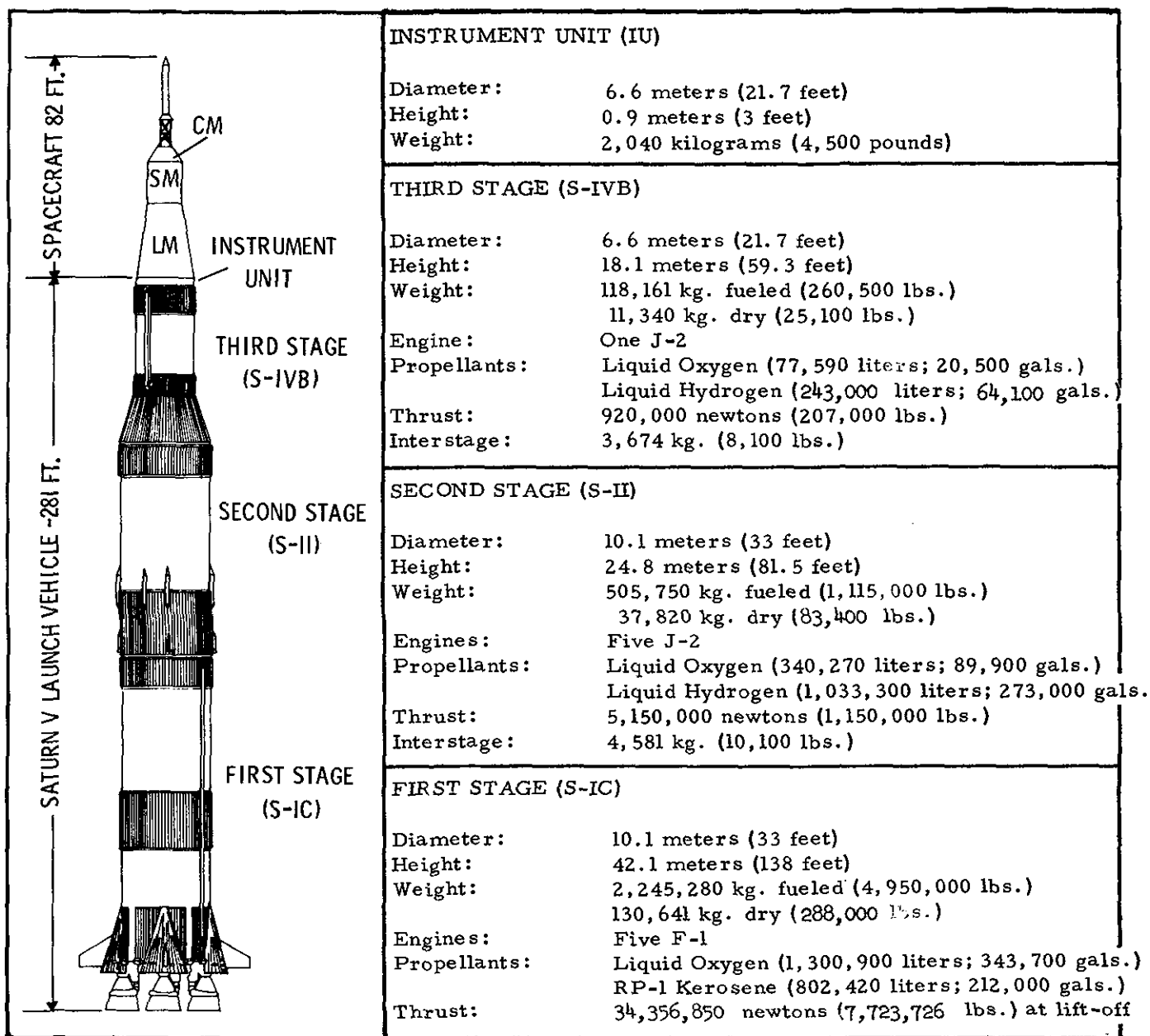
The five second stage (S-II) J-2 engines develop a total of about 5.15 million newtons (1.15 million pounds) of thrust during flight. Major components are the forward skirt, liquid hydrogen and liquid oxygen tanks (separated by an insulated common bulkhead), a thrust structure, and an interstage section that connects the first and second stages. The engines are mounted and used in the same arrangement as the first stage's F-1 engines: four outer engines can be gimbaled; the center one is fixed.

### Third Stage

Major components of the third stage (S-IVB) are a single J-2 engine, aft interstage and skirt, thrust structure, two propellant tanks with a common bulkhead, and forward skirt. The gimbaled engine has a maximum thrust of 1.01 million newtons (230,000 pounds), and can be restarted in Earth orbit.

### Instrument Unit

The instrument unit (IU) contains navigation, guidance and control equipment to steer the Saturn V into Earth orbit and translunar trajectory. The six major systems are structural, environmental control, guidance and control, measuring and telemetry, communications, and electrical.



NOTE: Weights and measures given above are for the nominal vehicle configuration for Apollo. The figures may vary slightly due to changes before launch to meet changing conditions. Weights of dry stages and propellants do not equal total weight because frost and miscellaneous smaller items are not included in chart.

## SATURN V LAUNCH VEHICLE

-more-

The IU's inertial guidance platform provides space-fixed reference coordinates and measures acceleration during flight. If the platform should fail during boost, systems in the Apollo spacecraft are programmed to provide launch vehicle guidance. After second stage ignition, the spacecraft commander can manually steer the vehicle if its guidance platform is lost.

### Propulsion

The Saturn V has 31 propulsive units, with thrust ratings ranging from 311 newtons (70 pounds) to more than 6.8 million newtons (1.53 million pounds). The large main engines burn liquid propellants; the smaller units use solid or hypergolic (self-igniting) propellants.

The five F-1 engines give the first stage a thrust range of from 34,356,850 newtons (7,723,726 pounds) at liftoff to 40,576,160 newtons (9,121,883 pounds) at center engine cutoff. Each F-1 engine weighs almost nine metric tons (10 short tons), is more than 5.5 meters long (18 feet), and has a nozzle exit diameter of nearly 4.6 meters (14 feet). Each engine uses almost 2.7 metric tons (3 short tons) of propellant a second.

J-2 engine thrust on the second and third stages averages 960,000 newtons (216,000 pounds) and 911,000 newtons (205,000 pounds) respectively during flight. The 1,590-kilogram (3,500-pound) engine uses high-energy, low-molecular-weight liquid hydrogen as propellant.

The first stage has eight solid-fuel retro-rockets that fire to separate the first and second stages. Each rocket produces a thrust of 237,000 newtons (75,800 pounds) for 0.54 seconds.

Four retrorockets, located in the third stage's aft inter-stage, separate the second and third stages. Two jettisonable ullage rockets settle propellants before engine ignition. Six smaller engines in two auxiliary propulsion system modules on the third stage provide three-axis attitude control.

### Significant Vehicle Changes

Saturn vehicle SA-511 is similar in configuration to the Apollo 15 launch vehicle. The first stage (S-1C) has eight retro-rocket motors, double the number on the SA-510 vehicle, because flight evaluation of the Apollo 15 mission revealed that the separation distance between the first and second stages was less than predicted. Eight retrorockets will give a greater safety margin should one motor fail during separation.



APOLLO SPACECRAFT

The Apollo spacecraft consists of the command module, service module, lunar module, a spacecraft lunar module adapter (SLA), and a launch escape system. The SLA houses the lunar module and serves as a mating structure between the Saturn V instrument unit and the SM.

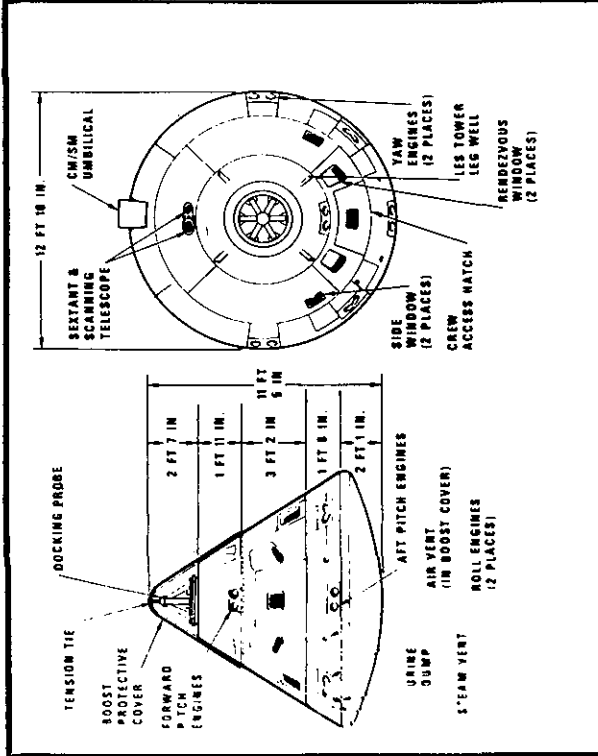
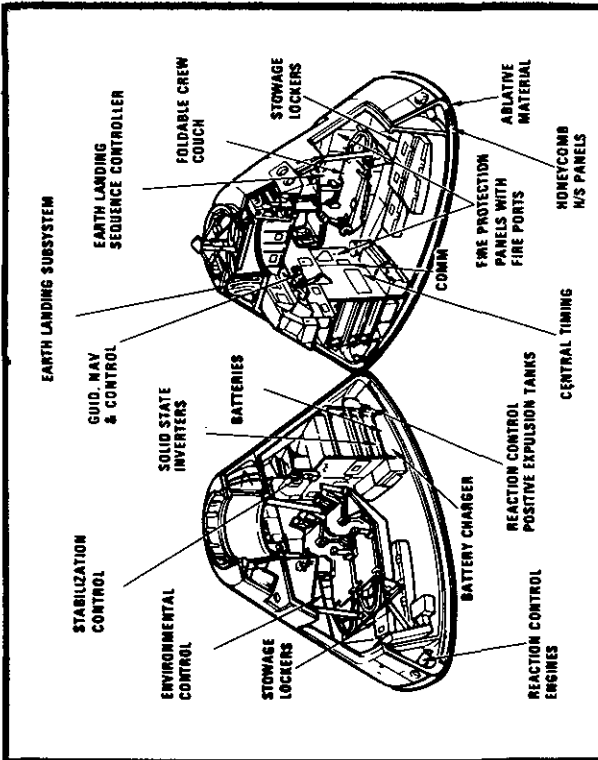
Launch Escape System (LES) -- The function of the LES is to propel the command module to safety in an aborted launch. It has three solid-propellant rocket motors: a 658,000-newton (147,000-pound)-thrust launch escape system motor, a 10,750-newton (2,400-pound)-thrust pitch control motor, and a 141,000 newton (31,500-pound)-thrust tower jettison motor. Two canard vanes deploy to turn the command module aerodynamically to an attitude with the heat-shield forward. The system is 10 meters (33 feet) tall and 1.2 meters (four feet) in diameter at the base, and weighs 4,158 kilograms (9,167 pounds).

Command Module (CM) -- The command module is a pressure vessel encased in heat shields, cone-shaped, weighing 5,843.9 kg (12,874 lb.) at launch.

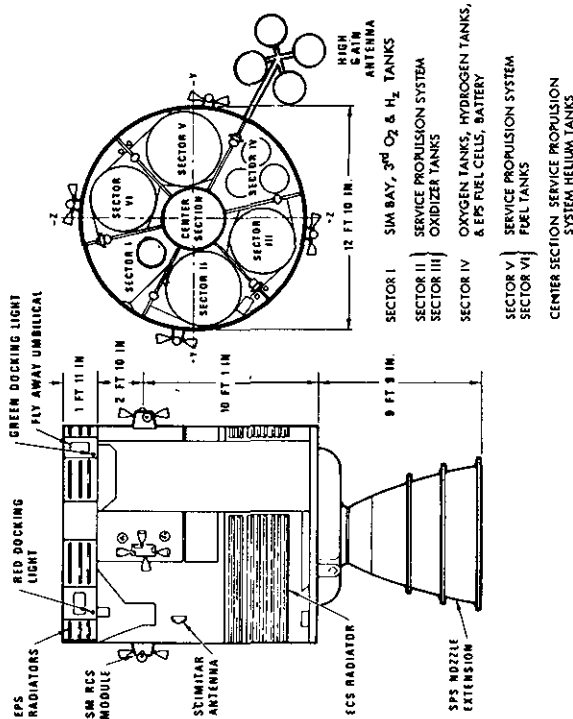
The command module consists of a forward compartment which contains two reaction control engines and components of the Earth landing system; the crew compartment or inner pressure vessel containing crew accommodations, controls and displays, and many of the spacecraft systems; and the aft compartment housing ten reaction control engines, propellant tankage, helium tanks, water tanks, and the CSM<sub>3</sub>umbilical<sub>3</sub>cable. The crew compartment contains 6 m<sup>3</sup> (210 ft.<sup>3</sup>) of habitable volume.

Heat-shields around the three compartments are made of brazed stainless steel honeycomb with an outer layer of phenolic epoxy resin as an ablative material.

The CSM and LM are equipped with the probe-and-drogue docking hardware. The probe assembly is a powered folding coupling and impact attenuating device mounted in the CM tunnel that mates with a conical drogue mounted in the LM docking tunnel. After the 12 automatic docking latches are checked following a docking maneuver, both the probe and drogue are removed to allow crew transfer between the CSM and LM.



# COMMAND MODULE



# SERVICE MODULE

Service Module (SM) -- The Apollo 16 service module will weigh 24,514 kg (54,044 lb.) at launch, of which 18,415 kg (40,594 lb.) is propellant for the 91,840-newton (20,500-pound)-thrust service propulsion engine: (fuel: 50/50 hydrazine and unsymmetrical dimethyl-hydrazine; oxidizer: nitrogen tetroxide). Aluminum honeycomb panels 2.54 centimeters (one inch) thick form the outer skin, and milled aluminum radial beams separate the interior into six sections around a central cylinder containing service propulsion system (SPS) helium pressurant tanks. The six sectors of the service module house the following components: Sector I -- oxygen tank 3 and hydrogen tank 3, J-mission SIM bay; Sector II -- space radiator, +Y RCS package, SPS oxidizer storage tank; Sector III -- space radiator, +Z RCS package, SPS oxidizer storage tank; Sector IV -- three fuel cells, two oxygen tanks, two hydrogen tanks, auxiliary battery; Sector V -- space radiator, SPS fuel sump tank, -Y RCS package; Sector VI -- space radiator, SPS fuel storage tank, -Z RCS package.

Spacecraft-LM adapter (SLA) Structure -- The spacecraft-LM adapter is a truncated cone 8.5 m (28 ft.) long tapering from 6.7 m (21.6 ft.) in diameter at the base to 3.9 m (12.8 ft.) at the forward end at the service module mating line. The SLA weighs 1,841 kg (4,059 lb.) and houses the LM during launch and the translunar injection maneuver until CSM separation, transposition, and LM extraction. The SLA quarter panels are jettisoned at CSM separation.

### Lunar Module (LM)

The lunar module is a two-stage vehicle designed for space operations near and on the Moon. The lunar module stands 7 m (22 ft. 11 in.) high and is 9.5 m (31 ft.) wide (diagonally across landing gear). The ascent and descent stages of the LM operate as a unit until staging, when the ascent stage functions as a single spacecraft for rendezvous and docking with the CM.

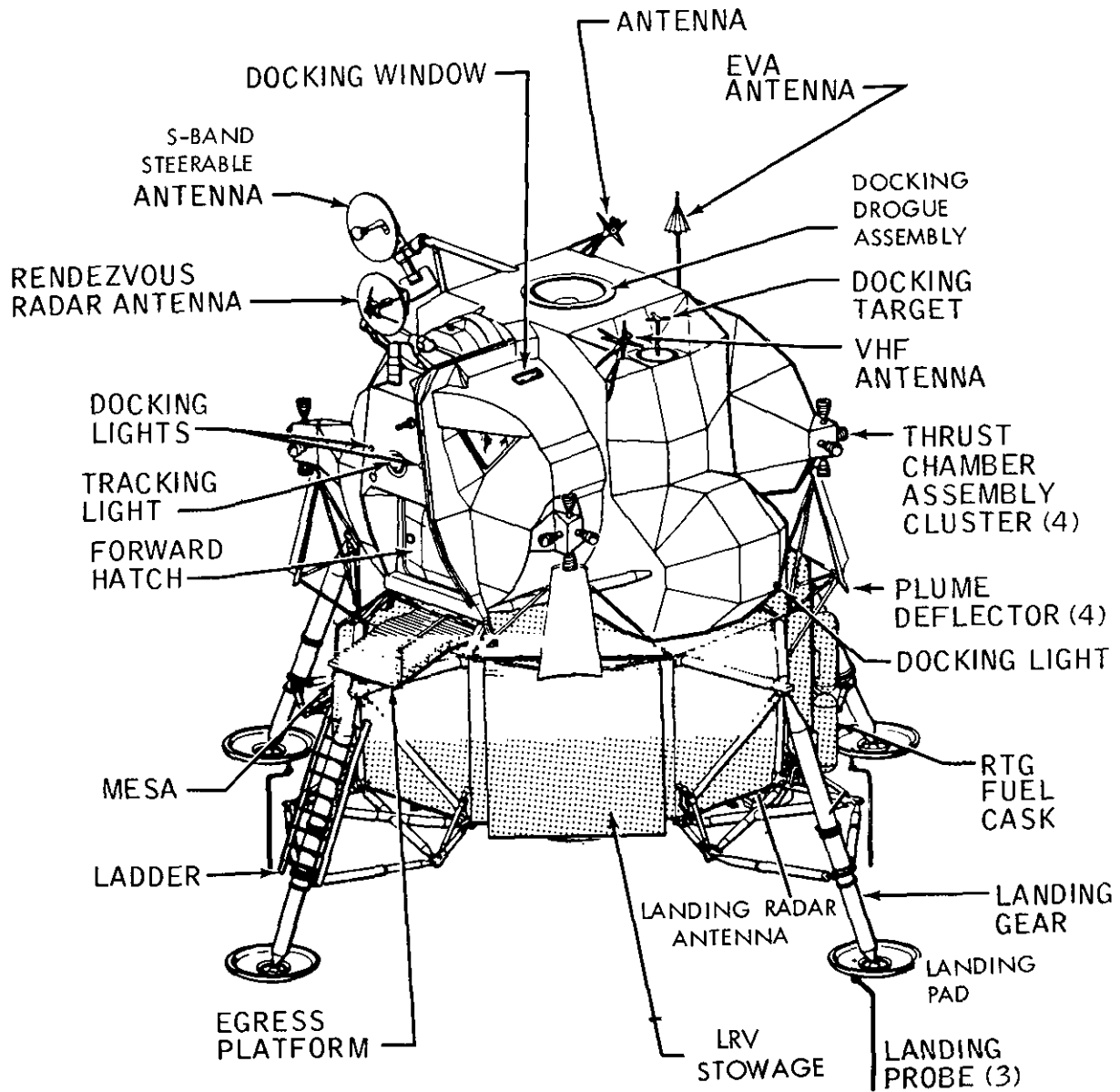
Ascent Stage -- Three main sections make up the ascent stage: the crew compartment, midsection, and aft equipment bay. Only the crew compartment and midsection are pressurized 337.5 grams per square centimeter (4.8 pounds per square inch gauge). The cabin volume is 6.7 cubic meters (235 cubic feet). The stage measures 3.8 m (12 ft. 4 in.) high by 4.3 m (14 ft. 1 in.) in diameter. The ascent stage has six substructural areas: crew compartment, midsection, aft equipment bay, thrust chamber assembly cluster supports, antenna supports, and thermal and micro-meteoroid shield.

The cylindrical crew compartment is 2.35 m (7 ft. 10 in.) in diameter and 1.07 m (3 ft. 6 in.) deep. Two flight stations are equipped with control and display panels, armrests, body restraints, landing aids, two front windows, an overhead docking window, and an alignment optical telescope in the center between the two flight stations. The habitable volume is 4.5 m<sup>3</sup> (160 ft.<sup>3</sup>).

A tunnel ring atop the ascent stage meshes with the command module docking latch assemblies. During docking, the CM docking ring and latches are aligned by the LM drogue and the CSM probe.

The docking tunnel extends downward into the mid-section 40 cm (16 in.). The tunnel is 81 cm (32 in.) in diameter and is used for crew transfer between the CSM and LM. The upper hatch on the inboard end of the docking tunnel opens inward and cannot be opened without equalizing pressure on both hatch surfaces.

A thermal and micrometeoroid shield of multiple layers of Mylar and a single thickness of thin aluminum skin encases the entire ascent stage structure.



## LUNAR MODULE

-more-

Descent Stage -- The descent stage center compartment houses the descent engine, and descent propellant tanks are housed in the four bays around the engine. Quadrant II contains ALSEP. The radioisotope thermoelectric generator (RTG) is externally mounted. Quadrant IV contains the MESA. The descent stage measures 3.2 m (10 ft. 7 in.) high by 4.3 m (14 ft. 1 in.) in diameter and is encased in the Mylar and aluminum alloy thermal and micrometeoroid shield. The LRV is stowed in Quadrant I.

The LM egress platform or "porch" is mounted on the forward outrigger just below the forward hatch. A ladder extends down the forward landing gear strut from the porch for crew lunar surface operations.

The landing gear struts are released explosively and are extended by springs. They provide lunar surface landing impact attenuation. The main struts are filled with crushable aluminum honeycomb for absorbing compression loads. Footpads 0.95 m (37 in.) in diameter at the end of each landing gear provide vehicle support on the lunar surface.

Each pad (except forward pad) is fitted with a 1.7-m (68-in.) long lunar surface sensing probe which upon contact with the lunar surface signals the crew to shut down the descent engine.

The Apollo LM has a launch weight of 16,429 kg (36,218 lb.). The weight breakdown is as follows:

	<u>kilograms</u>	<u>pounds</u>
1. Ascent stage, dry*	2,134	4,704
2. APS propellants (loaded)	2,378	5,242
3. Descent stage, dry	2,759	6,083
4. DPS propellants (loaded)	8,872	19,558
5. RCS propellants (loaded)	286	631
	<hr/>	<hr/>
	16,429 kg	36,218 lbs

\* Includes water and oxygen; no crew.

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

WASHINGTON, D. C. 20546

**BIOGRAPHICAL DATA**

**NAME:** John W. Young (Captain, USN)  
Apollo 16 Mission Commander  
NASA Astronaut

**BIRTHPLACE AND DATE:** Born in San Francisco, California,  
on September 24, 1930. His parents, Mr. and Mrs.  
William H. Young, reside in Orlando, Florida.

**PHYSICAL DESCRIPTION:** Brown hair; green eyes, height:  
5 feet 9 inches; weight: 165 pounds.

**EDUCATION:** Graduated from Orlando High School, Orlando,  
Florida; received a Bachelor of Science degree in  
Aeronautical Engineering from the Georgia Institute  
of Technology in 1952; recipient of an Honorary  
Doctorate of Laws degree from Western State Univer-  
sity College of Law in 1969, and an Honorary Doc-  
torate of Applied Science from Florida Technological  
University in 1970.

**MARITAL STATUS:** Married to the former Susy Feldman of  
St. Louis, Missouri.

**CHILDREN:** Sandy, April 30, 1957; John, January 17, 1959  
(by a previous marriage).

**RECREATIONAL INTERESTS:** He plays handball, runs and works  
out in the full pressure suit to stay in shape.

**ORGANIZATIONS:** Fellow of the American Astronautical  
Society, Associate Fellow of the Society of  
Experimental Test Pilots, and Member of the  
American Institute of Aeronautics and Astronautics.

**SPECIAL HONORS:** Awarded the NASA Distinguished Service  
Medal, two NASA Exceptional Service Medals, the  
MSC Certificate of Commendation (1970), the Navy  
Astronaut Wings, the Navy Distinguished Service  
Medals, and three Navy Distinguished Flying Crosses.

**EXPERIENCE:** Upon graduation from Georgia Tech, Young entered the U.S. Navy in 1952; he holds the rank of Captain in that service.

He completed test pilot training at the U.S. Naval Test Pilot School in 1959, and was then assigned as a test pilot at the Naval Air Test Center until 1962. Test projects in which he participated include evaluations of the F8D "Crusader" and F4B "Phantom" fighter weapons systems, and in 1962, he set world time-to-climb records to 3,000 and 25,000 meter altitudes in the Phantom. Prior to his assignment to NASA, he was maintenance officer of All-Weather-Fighter Squadron 143 at the Naval Air Station, Miramar, California. He has logged more than 5,900 hours flying time, including more than 4,900 hours in jet aircraft, and completed three space flights totaling 267 hours and 42 minutes. Captain Young was selected as an astronaut by NASA in September 1962. He served as pilot with command pilot Gus Grissom on the first manned Gemini flight -- a 3-orbit mission, launched on March 23, 1965, during which the crew accomplished the first manned space-craft orbital trajectory modifications and lifting reentry, and flight tested all systems in Gemini 3.

After this flight, he was backup pilot for Gemini 6.

On July 18, 1966, Young occupied the command pilot seat for the Gemini 10 mission and, with Michael Collins as pilot, effected a successful rendezvous and docking with the Agena target vehicle. The large Agena main engine was subsequently ignited, propelling the docked combination to a record altitude of approximately 475 miles above the earth, the first manned operation of a large rocket engine in space. They later performed a completely optical rendezvous (without radar) on a second, passive Agena which had been placed in orbit during the Gemini 8 mission. After the rendezvous, Young flew formation on the slowly rotating passive Agena while Collins performed extra-vehicular activity to it and recovered a micrometeorite detection experiment, accomplishing an in-space retrieval of the detector which had been orbiting the earth for three months. The flight was concluded, after 3 days and 44 revolutions, with a precise splashdown in the West Atlantic, 2.6 miles from the recovery ship USS GUADALCANAL.



He was then assigned as the backup command module pilot for Apollo 7.

Young was command module pilot for Apollo 10, May 18-26, 1969, the comprehensive lunar-orbital qualification test of the Apollo lunar module. He was accompanied on the 248,000 nautical mile lunar mission by Thomas P. Stafford (spacecraft commander) and Eugene A. Cernan (lunar module pilot). In achieving all mission objectives, Apollo 10 confirmed the operational performance, stability, and reliability of the command-service module/lunar module configuration during translunar coast, lunar orbit insertion, and lunar module separation and descent to within 8 nautical miles of the lunar surface. The latter maneuvers employed all but the final landing phase and facilitated extensive evaluations of the lunar module landing radar devices and propulsion systems and lunar module and command-service module rendezvous radars in the subsequent lunar rendezvous. In addition to discovering unexpectedly that the lunar gravitational field targeted the lunar module over 4 miles south of the Apollo 11 lunar landing site, Apollo 10 photographed and accurately located this site for the lunar landing.

Captain Young served as backup spacecraft commander for Apollo 13.

He was assigned as spacecraft commander for the Apollo 16 flight March 3, 1971.

- end -

March 1972

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

WASHINGTON, D. C. 20546

**BIOGRAPHICAL DATA**

**NAME:** Thomas K. Mattingly II (Lieutenant Commander, USN)  
Apollo 16 Command Module Pilot  
NASA Astronaut

**BIRTHPLACE AND DATE:** Born in Chicago, Illinois, March 17, 1936. His parents, Mr. and Mrs. Thomas K. Mattingly, now reside in Hialeah, Florida.

**PHYSICAL DESCRIPTION:** Brown hair; blue eyes; height: 5 feet 10 inches; weight: 140 pounds.

**EDUCATION:** Attended Florida elementary and secondary schools and is a graduate of Miami Edison High School, Miami, Florida; received a Bachelor of Science degree in Aeronautical Engineering from Auburn University in 1958.

**MARITAL STATUS:** Married to the former Elizabeth Dailey of Hollywood, California.

**RECREATIONAL INTERESTS:** Enjoys water skiing and playing handball and tennis.

**ORGANIZATIONS:** Member of the American Institute of Aeronautics and Astronautics and the U.S. Naval Institute.

**SPECIAL HONORS:** Presented the MSC Certificate of Commendation (1970).

**EXPERIENCE:** Prior to reporting for duty at the Manned Spacecraft Center, he was a student at the Air Force Aerospace Research Pilot School.

He began his Naval career as an Ensign in 1958 and received his wings in 1960. He was then assigned to VA-35 and flew A1H aircraft aboard the USS SARATOGA from 1960 to 1963. In July 1963, he served in VAH-11 deployed aboard the USS FRANKLIN D. ROOSEVELT where he flew the A3B aircraft for two years.

He logged 4,200 hours of flight time -- 2,300 hours in jet aircraft.

Lt. Commander Mattingly is one of the 19 astronauts selected by NASA in April 1966. He served as a member of the astronaut support crews for the Apollo 8 and 9 missions.

He was then designated command module pilot for Apollo 13 but was removed from flight status 72 hours prior to the scheduled launch due to exposure to the german measles. Mattingly was replaced on the flight of Apollo 13, April 13-17, 1970, by backup command module pilot John L. Swigert, Jr.

He was designated to serve as command module pilot for the Apollo 16 flight March 3, 1971.

- end -

March 1972

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

WASHINGTON, D. C. 20546

**BIOGRAPHICAL DATA**

**NAME:** Charles Moss Duke, Jr. (Lieutenant Colonel, USAF)  
Apollo 15 Lunar Module Pilot  
NASA Astronaut

**BIRTHPLACE AND DATE:** Born in Charlotte, North Carolina,  
on October 3, 1935. His parents, Mr. and Mrs.  
Charles M. Duke, make their home in Lancaster,  
South Carolina.

**PHYSICAL DESCRIPTION:** Brown hair; brown eyes; height:  
5 feet 11 1/2 inches; weight: 155 pounds.

**EDUCATION:** Attended Lancaster High School in Lancaster,  
South Carolina, and was graduated valedictorian  
from the Admiral Farragut Academy in St. Petersburg,  
Florida; received a Bachelor of Science degree in  
Naval Sciences from the U.S. Naval Academy in 1957  
and a Master of Science degree in Aeronautics and  
Astronautics from the Massachusetts Institute of  
Technology in 1964.

**MARITAL STATUS:** Married to the former Dorothy Meade  
Claiborne of Atlanta, Georgia; her parents are  
Dr. and Mrs. T. Sterling Claiborne of Atlanta.

**CHILDREN:** Charles M., March 8, 1965; Thomas C., May 1, 1967.

**RECREATIONAL INTERESTS:** Hobbies include hunting,  
fishing, reading, and playing golf.

**ORGANIZATIONS:** Member of the Air Force Association, the  
Society of Experimental Test Pilots, the Rotary  
Club, the American Legion, and the American Fighter  
Pilots Association.

**SPECIAL HONORS:** Awarded the MSC Certificate of Commendation (1970).

**EXPERIENCE:** When notified of his selection as an astronaut, Duke was at the Air Force Aerospace Research Pilot School as an instructor teaching control systems and flying in the F-104, F-101, and T-33 aircraft. He was graduated from the Aerospace Research Pilot School in September 1965 and stayed on there as an instructor.

He is an Air Force Lt. Colonel and was commissioned in 1957 upon graduation from the Naval Academy. Upon entering the Air Force, he went to Spence Air Base, Georgia, for primary flight training and then to Webb Air Force Base, Texas, for basic flying training, where in 1958 he became a distinguished graduate. He was again a distinguished graduate at Moody Air Force Base, Georgia, where he completed advanced training in F-86L aircraft. Upon completion of this training he was assigned to the 526th Fighter Interceptor Squadron at Ramstein Air Base, Germany, where he served three years as a fighter interceptor pilot.

He has logged 3,000 hours flying time, which includes 2,750 hours in jet aircraft.

Lt. Colonel Duke is one of the 19 astronauts selected by NASA in April 1966. He served as a member of the astronaut support crew for the Apollo 10 flight and as backup lunar module pilot for the Apollo 13 flight.

He was designated March 3, 1971 to serve as lunar module pilot for the Apollo 16 mission.

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D. C. 20546

### BIOGRAPHICAL DATA

**NAME:** Fred Wallace Haise, Jr. (Mr.)  
Apollo 16 Backup Commander  
NASA Astronaut

**BIRTHPLACE AND DATE:** Born in Biloxi, Mississippi, on November 14, 1933; his mother, Mrs. Fred W. Haise, Sr., resides in Biloxi.

**PHYSICAL DESCRIPTION:** Brown hair; brown eyes, height: 5 feet 9 1/2 inches; weight: 155 pounds.

**EDUCATION:** Graduated from Biloxi High School, Biloxi, Mississippi; attended Perkinston Junior College (Association of Arts); received a Bachelor of Science degree with honors in Aeronautical Engineering from the University of Oklahoma in 1959, and an Honorary Doctorate of Science from Western Michigan University in 1970.

**MARITAL STATUS:** Married to the former Mary Griffin Grant of Biloxi, Mississippi. Her parents, Mr. and Mrs. William J. Grant, Jr., reside in Biloxi.

**CHILDREN:** Mary M., January 25, 1956; Frederick T., May 13, 1958; Stephen W., June 30, 1961; Thomas J., July 6, 1970.

**ORGANIZATIONS:** Fellow of the American Astronautical Society, and member of the Society of Experimental Test Pilots, Tau Beta Pi, Sigma Gamma Tau, and Phi Theta Kappa.

**SPECIAL HONORS:** Awarded the Presidential Medal for Freedom (1970), the NASA Distinguished Service Medal, the AIAA Haley Astronautics Award for 1971, the American Astronautical Society Flight Achievement Award for 1970, the City of New York Gold Medal in 1970, the City of Houston Medal for Valor in 1970, the Jeff Davis Award (1970), the Mississippi Distinguished Civilian Service Medal (1970), the American Defense Ribbon, the Society of Experimental Test Pilots Ray E. Tenhoff Award for 1966, and the A.B. Honts Trophy as the outstanding graduate of Class 64A from the Aerospace Research Pilot School in 1964.

EXPERIENCE: Haise was a research pilot at the NASA Flight Research Center at Edwards, California, before coming to Houston and the Manned Spacecraft Center; and from September 1959 to March 1963, he was a research pilot at the NASA Lewis Research Center in Cleveland, Ohio. During this time he authored the following papers which have been published: a NASA TND, entitled "An Evaluation of the Flying Qualities of Seven General-Aviation Aircraft"; NASA TND 3380, "Use of Aircraft for Zero Gravity Environment, May 1966"; SAE Business Aircraft Conference Paper, entitled "An Evaluation of General-Aviation Aircraft Flying Qualities, March 30 - April 1, 1966"; and a paper delivered at the Tenth Symposium of the Society of Experimental Test Pilots, entitled "A Quantitative/Qualitative Handling Qualities Evaluation of Seven General-Aviation Aircraft, 1966."

He was the Aerospace Research Pilot School's outstanding graduate of Class 64A and served with the U.S. Air Force from October 1961 to August 1962 as a tactical fighter pilot and as chief of the 164th Standardization-Evaluation Flight of the 164th Tactical Fighter Squadron at Mansfield, Ohio. From March 1957 to September 1959, Haise was a fighter interceptor pilot with the 185th Fighter Interceptor Squadron in the Oklahoma Air National Guard.

He also served as a tactics and all weather flight instructor in the U.S. Navy Advanced Training Command at NAAS Kingsville, Texas, and was assigned as a U.S. Marine Corps fighter pilot to VMF-533 and 114 at MCAS Cherry Point, North Carolina, from March 1954 to September 1956.

His military career began in October 1952 as a Naval Aviation Cadet at the Naval Air Station in Pensacola, Florida.

He has accumulated 6,700 hours flying time, including 3,300 hours in jets.

Mr. Haise is one of the 19 astronauts selected by NASA in April 1966. He served as backup lunar module pilot for the Apollo 8 and 11 missions.

Haise was lunar module pilot for Apollo 13, April 11-17, 1970. Apollo 13 was programmed for ten days and was committed to our first landing in the hilly, upland Fra Mauro region of the Moon; however, the original flight plan was modified enroute to the Moon due to a failure of the service module cryogenic oxygen system which occurred at approximately 55 hours into the flight. Haise and fellow crewmen, James A. Lovell (spacecraft commander) and John L. Swigert (command module pilot), working closely with Houston ground controllers, converted their lunar module "Aquarius" into an effective lifeboat. Their emergency activation and operation of lunar module systems conserved both electrical power and water in sufficient supply to assure their safety and survival while in space and for the return to Earth.

In completing his first space flight, Mr. Haise logged a total of 142 hours and 54 minutes in space.

He was designated as backup spacecraft commander for the Apollo 16 mission March 3, 1971.

- end -

March 1972



**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

WASHINGTON, D. C. 20546

**BIOGRAPHICAL DATA**

**NAME:** Stuart Allen Roosa (Lieutenant Colonel, USAF)  
Apollo 16 Backup Command Module Pilot  
NASA Astronaut

**BIRTHPLACE AND DATE:** Born August 16, 1933, in Durango, Colorado. His parents, Mr. and Mrs. Dewey Roosa, now reside in Tucson, Arizona.

**PHYSICAL DESCRIPTION:** Red hair; blue eyes, height: 5 feet 10 inches; weight: 155 pounds.

**EDUCATION:** Attended Justice Grade School and Claremore High School in Claremore, Oklahoma; studied at Oklahoma State University and the University of Arizona and was graduated with honors and a Bachelor of Science degree in Aeronautical Engineering from the University of Colorado; presented an Honorary Doctorate of Letters from the University of St. Thomas (Houston, Texas) in 1971.

**MARITAL STATUS:** His wife is the former Joan C. Barrett of Tupello, Mississippi; and her mother, Mrs. John T. Barrett, resides in Sessums, Mississippi.

**CHILDREN:** Christopher A., June 29, 1959; John D., January 2, 1961; Stuart A., Jr., March 12, 1962; Rosemary D., July 23, 1963.

**RECREATIONAL INTERESTS:** His hobbies are hunting, boating, and fishing.

**ORGANIZATIONS:** Associate Member of the Society of Experimental Test Pilots.

**SPECIAL HONORS:** Presented the NASA Distinguished Service Medal, the MSC Superior Achievement Award (1970), the Air Force Command Pilot Astronaut Wings, the Air Force Distinguished Service Medal, the Arnold Air Society's John F. Kennedy Award (1971), and the City of New York Gold Medal in 1971.

EXPERIENCE: Roosa, a lt. colonel in the Air Force, has been on active duty since 1953. Prior to joining NASA, he was an experimental test pilot at Edwards Air Force Base, Calif. -- an assignment he held from September 1965 to May 1966, following graduation from the Aerospace Research Pilots School. He was a maintenance flight test pilot at Olmstead Air Force Base, Pennsylvania, from July 1962 to August 1964, flying F-101 aircraft. He served as Chief of Service Engineering (AFLC) at Tachikawa Air Base for two years following graduation from the University of Colorado under the Air Force Institute of Technology Program. Prior to this tour of duty, he was assigned as a fighter pilot at Langley Air Force Base, Virginia, where he flew the F-84F and F-100 aircraft.

He attended Gunnery School at Del Rio and Luke Air Force Bases and is a graduate of the Aviation Cadet Program at Williams Air Force Base, Arizona, where he received his flight training and commission in the Air Force. Since 1953, he has acquired 4,600 flying hours -- 4,100 hours in jet aircraft.

Lt. Colonel Roosa is one of the 19 astronauts selected by NASA in April 1966. He was a member of the astronaut support crew for the Apollo 9 flight.

He completed his first space flight as command module pilot on Apollo 14, January 31-February 9, 1971. With him on man's third lunar landing mission were Alan B. Shepard (spacecraft commander) and Edgar D. Mitchell (lunar module pilot).

Maneuvering their lunar module, "Antares," to a landing in the hilly upland Fra Mauro region of the moon, Shepard and Mitchell subsequently deployed and activated various scientific equipment and experiments and proceeded to collect almost 100 pounds of lunar samples for return to earth. Throughout this 33-hour period of lunar surface activities, Roosa remained in lunar orbit aboard the command module, "Kittyhawk," to conduct a variety of assigned photographic and visual observations. Apollo 14 achievements include: first use of Mobile Equipment Transporter (MET); largest payload placed in lunar orbit; longest distance traversed on the lunar surface; largest payload returned from the lunar surface; longest lunar surface stay time (33 hours); longest lunar surface EVA (9 hours and 17 minutes); first use of shortened lunar orbit rendezvous techniques; first use of colored TV with new vidicon tube on lunar surface; and first extensive orbital science period conducted during CSM solo operations.

In completing his first space flight, Roosa logged a total of 216 hours and 42 minutes.

He was designated to serve as backup command module pilot for Apollo 16 on March 3, 1971.

- end -

March 1972

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

WASHINGTON, D. C. 20546

**BIOGRAPHICAL DATA**

**NAME:** Edgar Dean Mitchell (Captain, USN)  
Apollo 16 Backup Lunar Module Pilot  
NASA Astronaut

**BIRTHPLACE AND DATE:** Born in Hereford, Texas, on September 17, 1930, but considers Artesia, New Mexico, his hometown. His mother, Mrs. J. T. Mitchell, now resides in Tahlequah, Oklahoma.

**PHYSICAL DESCRIPTION:** Brown hair; green eyes; height: 5 feet 11 inches; weight: 180 pounds.

**EDUCATION:** Attended primary schools in Roswell, New Mexico, and is a graduate of Artesia High School in Artesia, New Mexico; received a Bachelor of Science degree in Industrial Management from the Carnegie Institute of Technology in 1952, a Bachelor of Science degree in Aeronautical Engineering from the U.S. Naval Postgraduate School in 1961, and a Doctorate of Science degree in Aeronautics/Astronautics from the Massachusetts Institute of Technology in 1964; presented an Honorary Doctorate of Science from New Mexico State University in 1971, and an Honorary Doctorate of Engineering from Carnegie-Mellon University in 1971.

**MARITAL STATUS:** Married to the former Louise Elizabeth Randall of Muskegon, Michigan. Her mother, Mrs. Winslow Randall, now resides in Pittsburgh, Pennsylvania.

**CHILDREN:** Karlyn L., August 12, 1953; Elizabeth R., March 24, 1959.

**RECREATIONAL INTERESTS:** He enjoys handball and swimming, and his hobbies are scuba diving and soaring.

**ORGANIZATIONS:** Member of the American Institute of Aeronautics and Astronautics; the Society of Experimental Test Pilots; Sigma Xi; and Sigma Gamma Tau.

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**SPECIAL HONORS:** Presented the Presidential Medal of Freedom (1970), the NASA Distinguished Service Medal, the MSC Superior Achievement Award (1970), the Navy Astronaut Wings, the Navy Distinguished Service Medal, the City of New York Gold Medal (1971), and the Arnold Air Society's John F. Kennedy Award (1971).

**EXPERIENCE:** Captain Mitchell's experience includes Navy operational flight, test flight, engineering, engineering management, and experience as a college instructor. Mitchell came to the Manned Spacecraft Center after graduating first in his class from the Air Force Aerospace Research Pilot School where he was both student and instructor.

He entered the Navy in 1952 and completed his basic training at the San Diego Recruit Depot. In May 1953, after completing instruction at the Officers' Candidate School at Newport, Rhode Island, he was commissioned as an ensign. He completed flight training in July 1954 at Hutchinson, Kansas, and subsequently was assigned to Patrol Squadron 29 deployed to Okinawa.

From 1957 to 1958, he flew A3 aircraft while assigned to Heavy Attack Squadron Two deployed aboard the USS BON HOMME RICHARD and USS TICONDEROGA; and he was a research project pilot with Air Development Squadron Five until 1959. His assignment from 1964 to 1965 was as Chief, Project Management Division of the Navy Field Office for Manned Orbiting Laboratory.

He has accumulated 4,000 hours flight time -- 1,900 hours in jets.

Captain Mitchell was in the group selected for astronaut training in April 1966. He served as a member of the astronaut support crew for Apollo 9 and as backup lunar module pilot for Apollo 10.

He completed his first space flight as lunar module pilot on Apollo 14, January 31 - February 9, 1971. With him on man's third lunar landing mission were Alan B. Shepard (spacecraft commander) and Stuart A. Roosa (command module pilot).

Maneuvering their lunar module, "Antares," to a landing in the hilly upland Fra Mauro region of the Moon, Shepard and Mitchell subsequently deployed and activated various scientific equipment and experiments and collected almost 100 pounds of lunar samples for return to Earth. Other Apollo 14 achievements include: first use of Mobile Equipment Transporter (MET); largest payload placed in lunar orbit; longest distance traversed on the lunar surface; largest payload returned from the lunar surface; longest lunar surface stay time (33 hours); longest lunar surface EVA (9 hours and 17 minutes); first use of shortened lunar orbit rendezvous techniques; first use of colored TV with new vidicon tube on lunar surface; and first extensive orbital science period conducted during CSM solo operations.

In completing his first space flight, Mitchell logged a total of 216 hours and 42 minutes.

He was designated as backup lunar module pilot for Apollo 16 on March 3, 1971.

- end -

March 1972

Spaceflight Tracking and Data Support Network

NASA's worldwide Spaceflight Tracking and Data Network (STDN) will provide communication with the Apollo astronauts, their launch vehicle and spacecraft. It will also maintain the communications link between Earth and the Apollo experiments left on the lunar surface and track the particles and fields subsatellite injected into lunar orbit during Apollo 16.

The STDN is linked together by the NASA Communication Network (NASCOM) which provides for all information and data flow.

In support of Apollo 16, the STDN will employ 11 ground tracking stations equipped with 9.1-meter (30-foot) and 25.9-meter (85-foot) antennas, an instrumented tracking ship, and four instrumented aircraft. This portion of the STDN was known formerly as the Manned Space Flight Network. For Apollo 16, the network will be augmented by the 64-meter (210-foot) antenna system at Goldstone, California (a unit of NASA's Deep Space Network).

The STDN is maintained and operated by the NASA Goddard Space Flight Center, Greenbelt, Md., under the direction of NASA's Office of Tracking and Data Acquisition. Goddard will become an emergency control center if the Houston Mission Control Center is impaired for an extended time.

NASA Communications Network (NASCOM). The tracking network is linked together by the NASA Communications Network. All information flows to and from MCC Houston and the Apollo spacecraft over this communications system.

The NASCOM consists of more than 3.2 million circuit kilometers (1.7 million nm), using satellites, submarine cables, land lines, microwave systems, and high frequency radio facilities. NASCOM control center is located at Goddard. Regional communication switching centers are in Madrid; Canberra, Australia; Honolulu; and Guam.

Intelsat communications satellites will be used for Apollo 16. One satellite over the Atlantic will link Goddard with Ascension Island and the Vanguard tracking ship. Another Atlantic satellite will provide a direct link between Madrid and Goddard for TV signals received from the spacecraft. One satellite positioned over the mid-Pacific will link Carnarvon,

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Canberra, Guam and Hawaii with Goddard through the Jamesburg, California ground station. An alternate route of communications between Spain and Australia is available through another Intelsat satellite positioned over the Indian Ocean if required.

Mission Operations: Prelaunch tests, liftoff, and Earth orbital flight of the Apollo 16 are supported by the Apollo subnet station at Merritt Island Fla., 6.4 km (3.5 nm) from the launch pad.

During the critical period of launch and insertion of the Apollo 16 into Earth orbit, the USNS Vanguard provides tracking, telemetry, and communications functions. This single sea-going station of the Apollo subnet will be stationed about 1610 km (870 nm) southeast of Bermuda.

When the Apollo 16 conducts the TLI maneuver to leave Earth orbit for the Moon, two Apollo range instrumentation aircraft (ARIA) will record telemetry data from Apollo and relay voice communications between the astronauts and the Mission Control Center at Houston. These aircraft will be airborne between Australia and Hawaii.

Approximately one hour after the spacecraft has been injected into a translunar trajectory, three prime MSFN stations will take over tracking and communication with Apollo. These stations are equipped with 25.9 meter (85-foot) antennas.

Each of the prime stations, located at Goldstone, Madrid, and Honeysuckle is equipped with dual systems for tracking the command module in lunar orbit and the lunar module in separate flight paths or at rest on the Moon.

For reentry, two ARIA (Apollo Range Instrumented Aircraft) will be deployed to the landing area to relay communications between Apollo and Mission Control at Houston. These aircraft also will provide position information on the Apollo after the blackout phase of reentry has passed.

An applications technology satellite (ATS) terminal has been placed aboard the recovery ship USS Ticonderoga to relay command control communications of the recovery forces, via NASA's ATS satellite. Communications will be relayed from the deck mounted terminal to the NASA tracking stations at Mojave, California and Rosman, N.C. through Goddard to the recovery control centers located in Hawaii and Houston.

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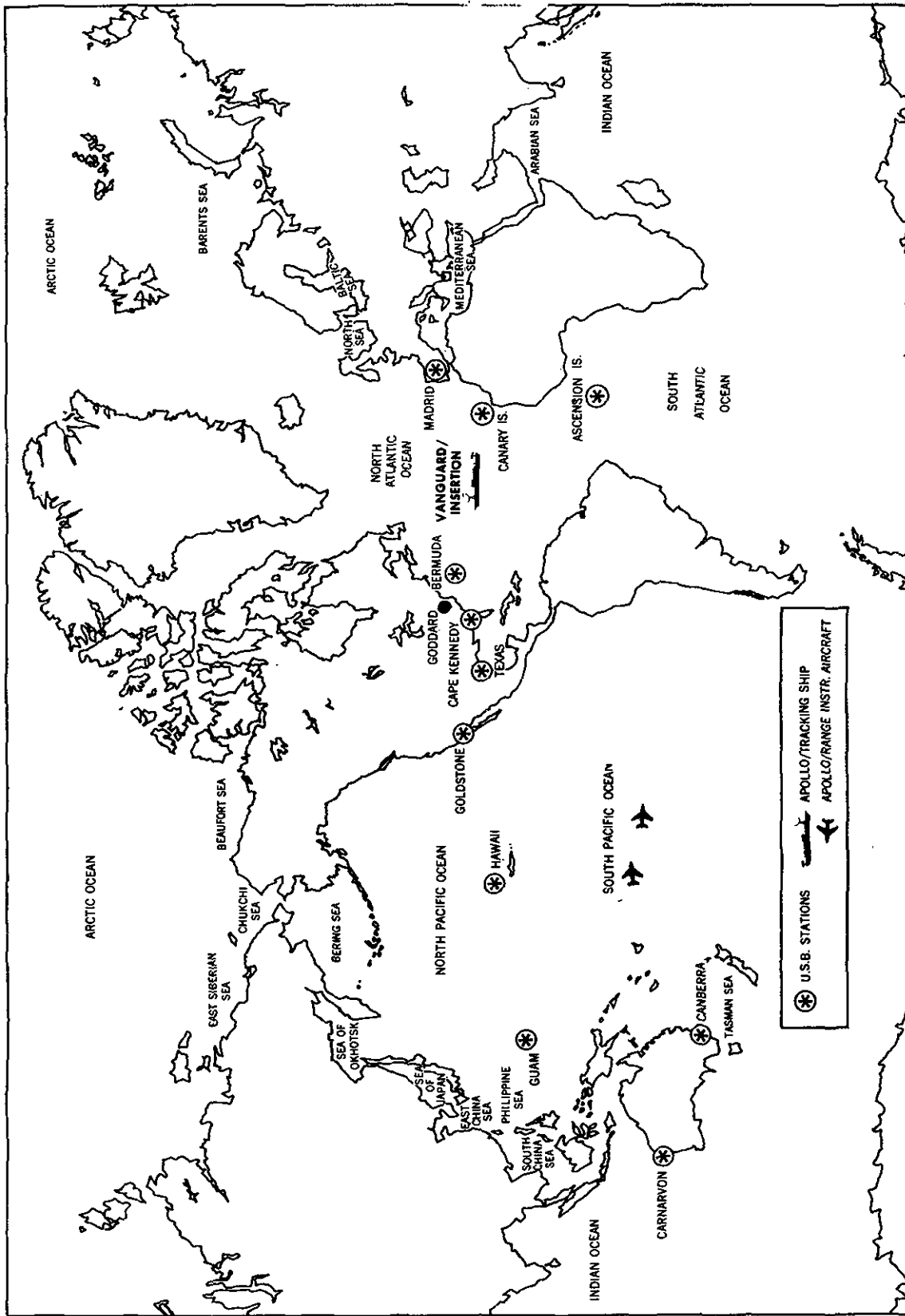


Prior to recovery, the astronauts aeromedical records are transmitted via the ATS satellite to the recovery ship for comparison with the physical data obtained in the post-flight examination performed aboard the recovery ship.

Television Transmissions: Television from the Apollo spacecraft during the journey to and from the Moon and on the lunar surface will be received by the three prime stations, augmented by the 64-meter (210-foot) antennas at Goldstone and Parkes. The color TV signal must be converted at the MSC Houston. A black and white version of the color signal can be released locally from the stations in Spain and Australia.

Before the lunar surface TV camera is mounted on the LRV TV signals originating from the Moon will be transmitted to the MSFN stations via the lunar module. While the camera is mounted on the LRV, the TV signals will be transmitted directly to tracking stations as the astronauts explore the Moon.

Once the LRV has been parked near the lunar module, its batteries will have about 80 hours of operating life. This will allow ground controllers to position the camera for viewing the lunar module liftoff, post lift-off geology, and other scenes.



**MANNED SPACE FLIGHT TRACKING NETWORK**

ENVIRONMENTAL IMPACT OF APOLLO/SATURN V MISSION

Studies of NASA space mission operations have concluded that Apollo does not significantly effect the human environment in the areas of air, water, noise or nuclear radiation.

During the launch of the Apollo/Saturn V space vehicle, products exhausted from Saturn first stage engines in all cases are within an ample margin of safety. At lower altitudes, where toxicity is of concern, the carbon monoxide is oxidized to carbon dioxide upon exposure at its high temperature to the surrounding air. The quantities released are two or more orders of magnitude below the recognized levels for concern in regard to significant modification of the environment. The second and third stage main propulsion systems generate only water and a small amount of hydrogen. Solid propellant ullage and retro rocket products are released and rapidly dispersed in the upper atmosphere at altitudes above 70 kilometers (43.5 miles). This material will effectively never reach sea level and, consequently, poses no toxicity hazard.

Should an abort after launch be necessary, some RP-1 fuel (kerosene) could reach the ocean. However, toxicity of RP-1 is slight and impact on marine life and waterfowl are considered negligible due to its dispersive characteristics. Calculations of dumping an aborted S-IC stage into the ocean showed that spreading and evaporating of the fuel occurred in one to four hours.

There are only two times during a nominal Apollo mission when above normal overall sound pressure levels are encountered. These two times are during vehicle boost from the launch pad and the sonic boom experienced when the spacecraft enters the Earth's atmosphere. Sonic boom is not a significant nuisance since it occurs over the mid-Pacific Ocean.

NASA and the Department of Defense have made a comprehensive study of noise levels and other hazards to be encountered for launching vehicles of the Saturn V magnitude. For uncontrolled areas the overall sound pressure levels are well below those which cause damage or discomfort. Saturn launches have had no deleterious effects on wildlife which has actually increased in the NASA-protected areas of Merritt Island.

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A source of potential radiation hazard but highly unlikely, is the fuel capsule of the radioisotope thermoelectric generator supplied by the Atomic Energy Commission which provides electric power for Apollo lunar surface experiments. The fuel cask is designed to contain the nuclear fuel during normal operations and in the event of aborts so that the possibility of radiation contamination is negligible. Extensive safety analyses and tests have been conducted which demonstrated that the fuel would be safely contained under almost all credible accident conditions.

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PROGRAM MANAGEMENT

The Apollo Program is the responsibility of the Office of Manned Space Flight (OMSF), National Aeronautics and Space Administration, Washington, D. C. Dale D. Myers is Associate Administrator for Manned Space Flight.

NASA Manned Spacecraft Center (MSC), Houston, is responsible for development of the Apollo spacecraft, flight crew training, and flight control. Dr. Christopher C. Kraft, Jr. is Center Director.

NASA Marshall Space Flight Center (MSFC), Huntsville, Ala., is responsible for development of the Saturn launch vehicles. Dr. Eberhard F. M. Rees is Center Director.

NASA John F. Kennedy Space Center (KSC), Fla., is responsible for Apollo/Saturn launch operations. Dr. Kurt H. Debus is Center Director.

The NASA Office of Tracking and Data Acquisition (OTDA) directs the program of tracking and data flow on Apollo. Gerald M. Truszynski is Associate Administrator for Tracking and Data Acquisition.

NASA Goddard Space Flight Center (GSFC), Greenbelt, Md., manages the Manned Space Flight Network and Communications Network. Dr. John F. Clark is Center Director.

The Department of Defense is supporting NASA during launch, tracking, and recovery operations. The Air Force Eastern Test Range is responsible for range activities during launch and down-range tracking. Recovery operations include the use of recovery ships and Navy and Air Force aircraft.

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Apollo/Saturn Officials

NASA Headquarters

Dr. Rocco A. Petrone	Apollo Program Director, OMSF
Chester M. Lee (Capt., USN, Ret.)	Apollo Mission Director, OMSF
John K. Holcomb (Capt., USN, Ret.)	Director of Apollo Operations, OMSF
William T. O'Bryant (Capt., USN, Ret.)	Director of Apollo Lunar Exploration, OMSF

Kennedy Space Center

Miles J. Ross	Deputy Center Director
Walter J. Kapryan	Director of Launch Operations
Raymond L. Clark	Director of Technical Support
Robert C. Hock	Apollo/Skylab Program Manager
Dr. Robert H. Gray	Deputy Director, Launch Operations
Dr. Hans F. Gruene	Director, Launch Vehicle Operations
John J. Williams	Director, Spacecraft Operations
Paul C. Donnelly	Associate Director Launch Operations
Isom A. Rigell	Deputy Director for Engineering

Manned Spacecraft Center

Sigurd A. Sjoberg	Deputy Center Director, and Acting Director, Flight Operations
Brig. General James A. McDivitt (USAF)	Manager, Apollo Spacecraft Program
Donald K. Slayton	Director, Flight Crew Operations
Pete Frank	Flight Director
Phil Shaffer	Flight Director
Gerald D. Griffin	Flight Director
Eugene F. Kranz	Flight Director
Donald Puddy	Flight Director
Richard S. Johnston	Director, Medical Research and Operations (Acting)

Marshall Space Flight Center

Dr. Eberhard Rees	Director
Dr. William R. Lucas	Deputy Center Director, Technical
Richard W. Cook	Deputy Center Director, Management
James T. Shepherd	Director, Program Management

Herman F. Kurtz	Manager, Mission Operations Office
Richard G. Smith	Manager, Saturn Program Office
John C. Rains	Manager, S-IC Stage Project, Saturn Program Office
William F. LaHatte	Manager, S-II S-IVB Stages Project, Saturn Program Office
Frederich Duerr	Manager, Instrument Unit/GSE Project, Saturn Program Office
William D. Brown	Manager, Engine Program Office
James M. Sisson	Manager, LRV Project, Saturn Program Office

Goddard Space Flight Center

Ozro M. Covington	Director, Networks
William P. Varson	Chief, Network Computing & Analysis Division
H. William Wood	Chief, Network Operations Division
Robert Owen	Chief, Network Engineering Division
L. R. Stelter	Chief, NASA Communications Division

Department of Defense

Maj. Gen. David M. Jones, USAF	DOD Manager for Manned Space Flight Support Operations
Col. Alan R. Vette, USAF	Deputy DOD Manager for Manned Space Flight Support Operations, and Director, DOD Manned Space Flight Support Office
Rear Adm. Henry S. Morgan, Jr., USN	Commander, Task Force 130, Pacific Recovery Area
Rear Adm. Roy G. Anderson, USN	Commander Task Force 140, Atlantic Recovery Area
Capt. E. A. Boyd, USN	Commanding Officer, USS Ticonderoga, CVS-14
Brig. Gen. Frank K. Everest, Jr., USAF	Primary Recovery Ship Commander Aerospace Rescue and Recovery Service

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CONVERSION TABLE

	<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
<u>Distance:</u>	inches	2.54	centimeters
	feet	0.3048	meters
	meters	3.281	feet
	kilometers	3281	feet
	kilometers	0.6214	statute miles
	statute miles	1.609	kilometers
	nautical miles	1.852	kilometers
	nautical miles	1.1508	statute miles
	statute miles	0.8689	nautical miles
	statute miles	1760	yards
<u>Velocity:</u>	feet/sec	0.3048	meters/sec
	meters/sec	3.281	feet/sec
	meters/sec	2.237	statute mph
	feet/sec	0.6818	statute miles/hr
	feet/sec	0.5925	nautical miles/hr
	statute miles/hr	1.609	km/hr
	nautical miles/hr (knots)	1.852	km/hr
	km/hr	0.6214	statute miles/hr
<u>Liquid measure, weight:</u>	gallons	3.785	liters
	liters	0.2642	gallons
	pounds	0.4536	kilograms
	kilograms	2.205	pounds
	metric ton	1000	kilograms
	short ton	907.2	kilograms
<u>Volume:</u>	cubic feet	0.02832	cubic meters
<u>Pressure:</u>	pounds/sq. inch	70.31	grams/sq. cm
<u>Thrust:</u>	pounds	4.448	newtons
	newtons	0.225	pounds
<u>Temperature:</u>	Centigrade	1.8; add 32	Fahrenheit