Prelaunch
Mission Operation Report
No. M-932-70-13

TO: A/Administrator

31 March 1970

FROM: MA/Apollo Program Director

SUBJECT: Apollo 13 Mission (AS-508)

On 11 April 1970, we plan to launch Apollo 13 from Pad A of Launch Complex 39 at the Kennedy Space Center. This will be the third manned lunar landing mission and is targeted to a preselected point in the Fra Mauro Formation.

Primary objectives of this mission include selenological inspection, survey, and sampling of the ejecta blanket thought to have been deposited during the formation of the Imbrium basin; deployment and activation of an Apollo Lunar Surface Experiments Package; continuing the development of man's capability to work in the lunar environment; and obtaining photographs of candidate lunar exploration sites. Photographic records will be obtained and the extravehicular activities will be televised.

The 10-day mission will be completed with landing in the Pacific Ocean. Recovery and transport of the crew, spacecraft, and lunar samples to the Lunar Receiving Laboratory at the Manned Spacecraft Center will be conducted under quarantine procedures that provide for biological isolation.

Rocco A. Petrone

APPROVAL:

Dale D. Myers
Associate Administrator for
Manned Space Flight

REPORT NO. M-932-70-13

NORTH

SSION OPERATION REPORT

APOLLO 13 (AS-508)

OFFICE OF MANNED SPACE FLIGHT
PREPARED BY: APOLLO PROGRAM OFFICE-MAO

FOREWORD

MISSION OPERATION REPORTS are published expressly for the use of NASA Senior Management, as required by the Administrator in NASA Instruction 6-2-10, dated 15 August 1963. The purpose of these reports is to provide NASA Senior Management with timely, complete, and definitive information on flight mission plans, and to establish official mission objectives which provide the basis for assessment of mission accomplishment.

Initial reports are prepared and issued for each flight project just prior to launch. Following launch, updating reports for each mission are issued to keep General Management currently informed of definitive mission results as provided in NASA Instruction 6-2-10

Primary distribution of these reports is intended for personnel having program/project management responsibilities which sometimes results in a highly technical orientation. The Office of Public Affairs publishes a comprehensive series of pre-launch and post-launch reports on NASA flight missions which are available for dissemination to the Press.

APOLLO MISSION OPERATION REPORTS are published in two volumes: the MISSION OPERATION REPORT (MOR); and the MISSION OPERATION REPORT, APOLLO SUPPLEMENT. This format was designed to provide a mission-oriented document in the MOR, with supporting equipment and facility description in the MOR, APOLLO SUPPLEMENT. The MOR, APOLLO SUPPLEMENT is a program-oriented reference document with a broad technical description of the space vehicle and associated equipment, the launch complex, and mission control and support facilities.

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Mission	Launch Date	Launch Vehicle	Payload	Description
AS-201	2/26/66	SA-201	CSM-009	Launch vehicle and CSM development. Test of CSM subsystems and of the space vehicle. Demonstration of reentry adequacy of the CM at earth orbital conditions.
AS-203	7/5/66	SA-203	LH_2 in S-IVB	Launch vehicle development. Demonstration of control of LH_2 by continuous venting in orbit.
AS-202	8/25/66	SA-202	CSM-011	Launch vehicle and CSM development. Test of CSM subsystems and of the structural integrity and compatibility of the space vehicle. Demonstration of propulsion and entry control by G&N system. Demonstration of entry at 28,500 fps.
APOLLO 4	11/9/67	SA-501	CSM-017 LTA-10R	Launch vehicle and spacecraft development. Demonstration of Saturn V Launch Vehicle performance and of CM entry at lunar return velocity.
APOLLO 5	1/22/68	SA-204	LM-1 SLA-7	LM development. Verified operation of LM subsystems: ascent and descent propulsion systems (including restart) and structures. Evaluation of LM staging. Evaluation of S-IVB/IU orbital performance.
APOLLO 6	4/4/68	SA-502	CM-020 SM-014 LTA-2R SLA-9	Launch vehicle and spacecraft development. Demonstration of Saturn V Launch Vehicle performance.
APOLLO 7	10/11/68	SA-205	CM-101 SM-101 SLA-5	Manned CSM operations. Duration 10 days 20 hours.
APOLLO 8	12/21/68	SA-503	CM-103 SM-103 LTA-B SLA-11	Lunar orbital mission. Ten lunar orbits. Mission duration 6 days 3 hours. Manned CSM operations.
APOLLO 9	3/3/69	SA-504	CM-104 SM-104 LM-3 SLA-12	Earth orbital mission. Manned CSM/LM operations. Duration 10 days 1 hour.
APOLLO 10	5/18/69	SA-505	CM-106 SM-106 LM-4 SLA-13	Lunar orbital mission. Manned CSM/LM operations. Evaluation of LM performance in cislunar and lunar environment, following lunar landing profile. Mission duration 8 days.
APOLLO 11	7/16/69	SA-506	CM-107 SM-107 LM-5 SLA-14	First manned lunar landing mission. Lunar surface stay time 21.6 hours. Mission duration 8 days 3 hours.
APOLLO 12	11/14/69	SA-507	CM-108 SM-108 LM-6 SLA-15	Second manned lunar landing mission. Demonstration of point landing capability. Deployment of ALSEP I. Surveyor III investigation. Lunar Surface stay time 31.5 hours. Two dual EVA's (15.5 manhours). 89 hours in lunar orbit (45 orbits). Mission duration 10 days 4.6 hours.

NASA OMSF PRIMARY MISSION OBJECTIVES FOR APOLLO 13

PRIMARY OBJECTIVES

- Perform selenological inspection, survey, and sampling of materials in a preselected region of the Fra Mauro Formation.
- Deploy and activate an Apollo Lunar Surface Experiments Package (ALSEP).
- Develop man's capability to work in the lunar environment.
- Obtain photographs of candidate exploration sites.

Rocco A. Petrone
Apollo Program Director

Date: 24 March 1970

Dale D. Myers
Associate Administrator for
Manned Space Flight

Date: MAR 28, 1970

DETAILED OBJECTIVES AND EXPERIMENTS

SPACECRAFT DETAILED OBJECTIVES AND EXPERIMENTS

- Contingency Sample Collection.
- Apollo Lunar Surface Experiments Package (ALSEP III) Deployment.
- Selected Sample Collection.
- Lunar Field Geology (S-059).
- Photographs of Candidate Exploration Sites.
- Evaluation of Landing Accuracy Techniques.
- Television Coverage.
- EVA Communication System Performance.
- Lunar Soil Mechanics.
- Selenodetic Reference Point Update.
- Lunar Surface Close-Up Photography (S-184).
- Thermal Coating Degradation.
- CSM Orbital Science Photography.
- Transearth Lunar Photography.
- Solar Wind Composition (S-080).
- Extravehicular Mobility Unit Water Consumption Measurement.
- Gegenschein From Lunar Orbit (S-178).
- Dim Light Photography.
- CSM S-band Transponder (S-164).
- Downlink Bistatic Radar (VHF Only) (S-170).

LAUNCH VEHICLE DETAILED OBJECTIVES

- Impact the expended S-IVB/IU on the lunar surface to excite ALSEP I.
- Determine actual S-IVB/IU point of impact.

LAUNCH COUNTDOWN AND TURNAROUND CAPABILITY, AS-508

COUNTDOWN

Countdown for launch of the AS-508 Space Vehicle for the Apollo 13 Mission will begin with a precount starting at T-94 hours during which launch vehicle and spacecraft countdown activities will be conducted independently. Official coordinated spacecraft and launch vehicle countdown will begin at T-28 hours.

SCRUB/TURNAROUND

A scrub is a termination of the countdown. Turnaround is the time required to recycle and count down to launch (T-0) in a subsequent launch window assuming no serial repair activities are required. The scrub/turnaround plan will be placed in effect immediately following a scrub during the countdown.

For a hold that results in a scrub prior to T-22 minutes, turnaround procedures are initiated from the point of hold. Should a hold occur from T-22 minutes (S-II start bottle chilldown) to T-16.2 seconds (S-IC forward umbilical disconnect), then a recycle to T-22 minutes, a hold, or a scrub is possible under conditions stated in the Launch Mission Rules. A hold between T-16.2 seconds and T-8.9 seconds (ignition) could result in either a recycle or a scrub depending upon the circumstances. An automatic or manual cutoff after T-8.9 seconds will result in a scrub.

30-DAY SCRUB/TURNAROUND

A 30-day turnaround capability exists in the event that a scrub occurs and there is no launch window available within the 24 or 48-hour turnaround capability.

In the event of a 30-day scrub/turnaround a new countdown will be started at the beginning of precount. The Flight Readiness Test (FRT) and Countdown Demonstration Test (CDDT) will not be rerun.

48-HOUR SCRUB/TURNAROUND

The maximum scrub/turnaround time from any point in the launch countdown up to T-8.9 seconds is 48 hours. This maximum time assumes no serial repair activities are required and it provides for reservicing all space vehicle cryogenics.

24-HOUR SCRUB/TURNAROUND

A 24-hour turnaround capability exists as late in the countdown as T-8.9 seconds. This capability depends upon having sufficient spacecraft consumables margins above redline quantities stated in the Launch Mission Rules for the period remaining to the next launch window. Only one 24-hour scrub/turnaround can be accomplished.

FLIGHT MISSION DESCRIPTION

LANDING SITE

The landing site of the Apollo 13 Mission is a point 3°40'S latitude, 17°29'W longitude in the Fra Mauro Formation. The Fra Mauro Formation, an extensive geologic unit covering large portions of the lunar surface around Mare Imbrium, has been interpreted as the ejecta blanket deposited during the formation of the Imbrium basin. Sampling of the Fra Mauro Formation may provide information on ejecta blanket formation and modification, and yield samples of deep-seated crustal material giving information on the composition of the lunar interior and the processes active in its formation. Age dating the returned samples should establish the age of premare deep-seated material and the age of the formation of the Imbrium basin and provide important points on the geologic time scale leading to an understanding of the early history of the moon.

LAUNCH WINDOWS

The launch windows for Fra Mauro are shown in Table 1.

TABLE 1

LAUNCH DATE	APOLLO 13 LAUNCH WINDOWS OPEN	CLOSE	SUN ELEVATION ANGLE*
April 11, 1970	14:13	17:37	9.9°
**May 9, 1970 (T-24)	13:25	16:43	7.8°
**May 10, 1970 (T-0)	13:35	16:44	7.8°
**May 11, 1970 (T+24)	13:32	16:38	18.5°

NOTE: Only one scrub/turnaround is feasible for May. April times are EST; all others are EDT.

* These values are subject to possible refinement.

** The addition of the T-24 hour and T+24 hour windows to the optimum T-0 window provides increased flexibility in that all three opportunities are available for choice.

LAUNCH OPPORTUNITIES

The three opportunities established for May--in case the launch is postponed from 11 April--provide, in effect, the flexibility of a choice of two launch attempts. The optimum May launch window occurs on 10 May. The 3-day window permits a choice of attempting a launch 24 hours earlier than the optimum window and, if necessary, a further choice of a 24-hour or 48-hour recycle. It also permits a choice of making the first launch attempt on the optimum day with a 24-hour recycle capability. The 9 May window (T-24 hrs.) requires an additional 24 hours in lunar orbit before initiating powered descent to arrive at the landing site at the same time and hence have the same sun angle for landing as on 10 May. Should the 9 May window launch attempt be scrubbed, a decision will be made at that time, based on the reason for the scrub, status of spacecraft cryogenics and weather predictions, whether to recycle for 10 May (T-0 hrs.) or 11 May (T+24 hrs.) If launched on 11 May, the flight plan will be similar for the 10 May mission but the sun elevation angle at lunar landing will be 18.5° instead of 7.8°

HYBRID TRAJECTORY

The Apollo 13 Mission will use a hybrid trajectory that retains most of the safety features of the free-return trajectory but without the performance limitations. From earth orbit the spacecraft will be initially injected into a highly eccentric elliptical orbit (pericynthion of approximately 210 nautical miles (NM), which has a free-return characteristic, i.e., the spacecraft can return to the earth entry corridor without any further maneuvers. The spacecraft will not depart from the free-return ellipse until after the Lunar Module (LM) has been extracted from the launch vehicle and can provide a propulsion system backup to the Service Propulsion System (SPS). Approximately 28 hours after translunar injection (TLI), a midcourse maneuver will be performed by the SPS to place the spacecraft on a lunar approach trajectory (non-free-return) having a pericynthion of 60 NM.

The use of a hybrid trajectory will permit:

> Daylight launch/Pacific injection. This allows the crew to acquire the horizon as a backup attitude reference during high altitude abort, provides launch abort recovery visibility, and improves launch photographic coverage.
>
> Desired lunar landing site sun elevation. The hybrid profile facilitates adjustment of translunar transit time which can be used to control sun angles on the landing site during lunar orbit and at landing.

Increased spacecraft performance. The energy of the spacecraft on a hybrid lunar approach trajectory is relatively low compared to what it would be on a full free-return trajectory, thus reducing the differential velocity ($\triangle V$) required to achieve lunar orbit insertion.

Improved communication flexibility. This permits adjustment of the time of powered descent initiation (PDI) to occur within view of a 210-foot ground antenna.

LIGHTNING PRECAUTIONS

During the Apollo 12 Mission, the space vehicle was subjected to two distinct electrical discharge events. However, no serious damage occurred and the mission proceeded to a successful conclusion. Intensive investigation led to the conclusion that no hardware changes were necessary to protect the space vehicle from similar events. For Apollo 13 the Mission Rules have been revised to reduce the probability that the space vehicle will be launched into cloud formations that contain conditions conducive to initiating similar electrical discharges although flight into all clouds is not precluded.

FLIGHT PROFILE

Launch Through Earth Parking Orbit

The AS-508 Space Vehicle for the Apollo 13 Mission is planned to be launched at 14:13 EST on 11 April 1970 from Launch Complex 39A at the Kennedy Space Center Florida, on a flight azimuth of 72°. The Saturn V Launch Vehicle (LV) will insert the S-IVB/Instrument Unit (IU)/LM/CSM into a 103-NM, circular orbit. The S-IVB/IU and spacecraft checkout will be accomplished during the orbital coast phase. Figure 1 and Tables 2 through 4 summarize the flight profile events and space vehicle weight.

Translunar Injection

Approximately 2.6 hours after liftoff, the launch vehicle S-IVB stage will be reignited during the second parking orbit to perform the translunar injection (TLI) maneuver, placing the space vehicle on a free-return trajectory having a pericynthion of approximately 210 NM.

Translunar Coast

The CSM will separate from the S-IVB/IU/LM approximately 4 hours Ground Elapsed Time (GET), transpose, dock, and initiate ejection of the LM/CSM from the S-IVB/IU. During these maneuvers, the LM and S-IVB/IU will be photographed to provide engineering data.

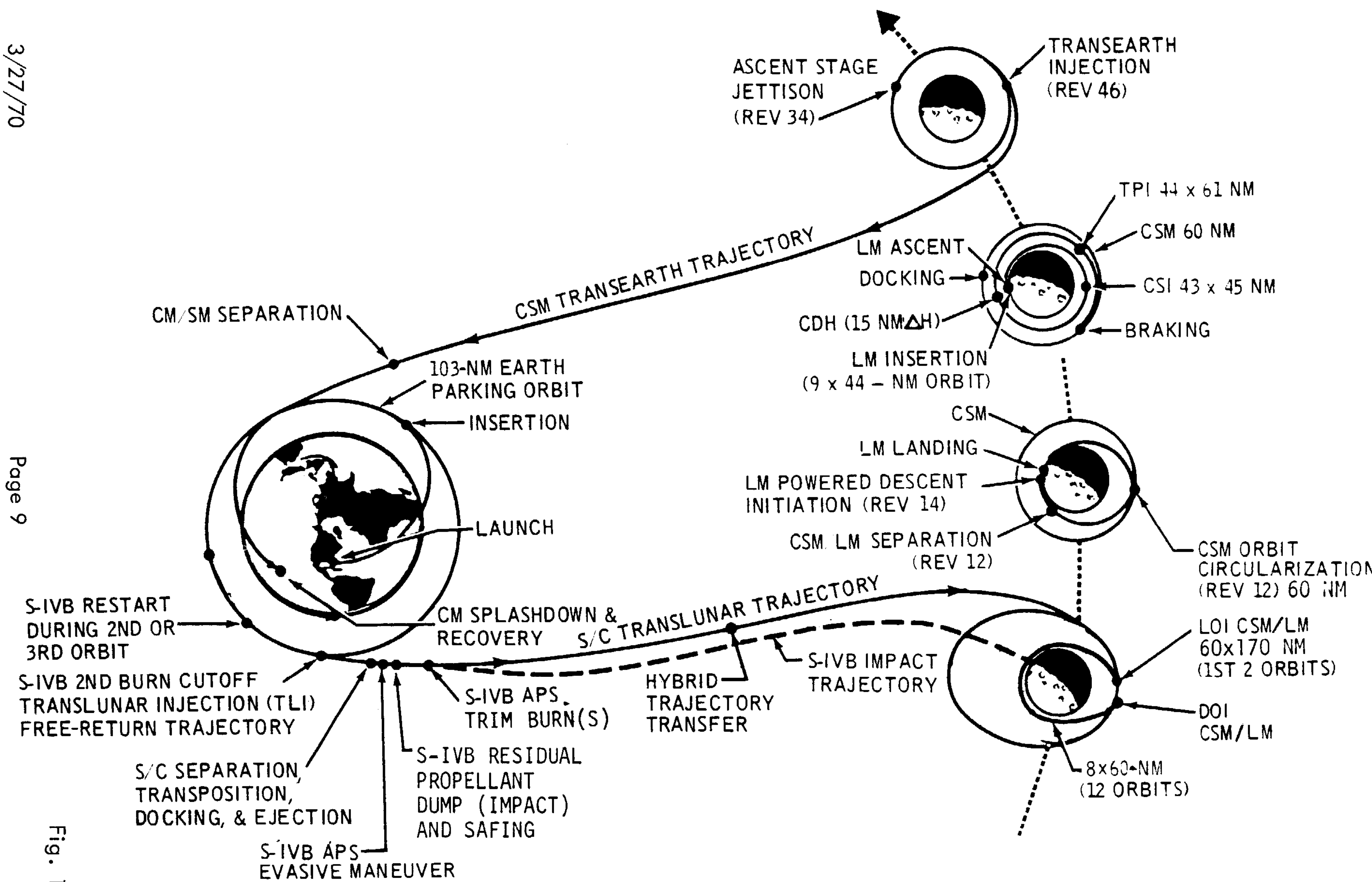


Fig. 1

APOLLO 13 FLIGHT PROFILE

M-932-70-13

TABLE 2

APOLLO 13 SEQUENCE OF MAJOR EVENTS

EVENT	GET HR:MIN	BURN DURATION ~SEC. (SYSTEM)	REMARKS
LAUNCH	00:00		PAD 39A, 4/11/70, 14:13 EST
TLI	2:35	358 (S-IVB)	PACIFIC INJECTION
MIDCOURSE CORRECTION-1	11:41	AS REQ'D	NOMINALLY ZERO
MIDCOURSE CORRECTION-2	30:41	2 (SPS)	HYBRID TRANSFER
MIDCOURSE CORRECTIONS (AS REQ'D)			74.9-HR. TRANSLUNAR COAST
LUNAR ORBIT INSERTION (LOI)	77:25	357 (SPS)	60 x 170-NM ORBIT
DESCENT ORBIT INSERTION	81:45	23 (SPS)	8 x 60-NM ORBIT (CSM/LM)
CSM/LM UNDOCKING & SEPARATION	99:16	6 (SM RCS)	SOFT UNDOCKING
CSM ORBIT CIRCULARIZATION	100:35	4 (SPS)	53 x 62-NM ORBIT (REV. 12)
POWERED DESCENT INITIATION (PDI)	103:31	687 (DPS)	LANDING POINT UPDATE
LANDING FRA MAURO	103:42		SEA = 7.1°, 4/15, 21:55 EST
EVA-1	108:00		4 HR. PLANNED
EVA-2	127:45		4 HR. PLANNED
ASCENT (LM LIFTOFF)	137:09	528 (APS)	4/17, 7:22 EST
DOCKING	140:45		CSM-ACTIVE
LM IMPACT BURN	144:32	75 (LM RCS)	ASCENT STAGE IMPACT AT 145:00
TRANSEARTH INJECTION (TEI)	167:29	135 (SPS)	73.6-HR. TRANSEARTH COAST
ENTRY INTERFACE	240:50		VELOCITY 36, 129 FPS
LANDING	241:03		PACIFIC, 4/21, 15:16 EST

TABLE 3

APOLLO 13 TV SCHEDULE

DAY	DATE	EST	GET	DURATION	ACTIVITY/SUBJECT	VEH	STA
SATURDAY	APRIL 11	15:49	01:36	05 MIN	COLOR PHOTOS OF EARTH	CSM	KSC
SATURDAY	APRIL 11	17:28	03:15	1 HR 08 MIN	TRANSPOSITION & DOCKING	CSM	GDS
SUNDAY	APRIL 12	20:28	30:15	30 MIN	SPACECRAFT INTERIOR (MCC-2)	CSM	GDS
TUESDAY	APRIL 14	00:13	58:00	30 MIN	INTERIOR & IVT TO LM	CSM	GDS
WEDNESDAY	APRIL 15	14:03	95:50	15 MIN	FRA MAURO	CSM	MAD
THURSDAY	APRIL 16	02:23	108:10	3 HR 52 MIN	LUNAR SURFACE (EVA-1)	LM	GDS/HSK
THURSDAY	APRIL 16	22:03	127:50	6 HR 35 MIN	LUNAR SURFACE (EVA-2)	LM	GDS
FRIDAY	APRIL 17	10:36	140:23	12 MIN	DOCKING	CSM	MAD
SATURDAY	APRIL 18	12:23	166:10	40 MIN	LUNAR SURFACE	CSM	MAD*
SATURDAY	APRIL 18	14:13	168:00	25 MIN	LUNAR SURFACE (POST TEI)	CSM	MAD*
MONDAY	APRIL 20	19:58	221:45	15 MIN	EARTH & SPACECRAFT INTERIOR	CSM	GDS

* RECORDED ONLY

TABLE 4

APOLLO 13 WEIGHT SUMMARY

(Weight in Pounds)

STAGE/MODULE	INERT WEIGHT	TOTAL EXPENDABLES	TOTAL WEIGHT	FINAL SEPARATION WEIGHT
S-IC	288,000	4,746,870	5,034,870	363,403
S-IC/S-II Interstage	11,464	---	11,464	---
S-II Stage	78,050	996,960	1,075,010	92,523
S-II/S-IVB Interstage	8,100	---	8,100	---
S-IVB Stage	25,050	236,671	261,721	35,526
Instrument Unit	4,482	---	4,482	---
Launch Vehicle at Ignition			6,395,647	
Spacecraft-LM Adapter	4,044	---	4,044	---
Lunar Module	9,915	23,568	33,483	*33,941
Service Module	10,532	40,567	51,099	**14,076
Command Module	12,572	---	12,572	**11,269 (Landing)
Launch Escape System	9,012	---	9,012	---
Spacecraft at Ignition			110,210	
Space Vehicle at Ignition			6,505,857	
S-IC Thrust Buildup			(-)84,598	
Space Vehicle at Liftoff			6,421,259	
Space Vehicle at Orbit Insertion			299,998	

* CSM/LM Separation

** CM/SM Separation

At 4.2 hours GET the S-IVB/IU will begin a series of programmed and ground-commanded operations which will alter the LV trajectory so that the S-IVB/IU will impact the lunar surface at the desired point providing a known energy source for the Apollo 12 ALSEP seismology equipment. The first is a programmed Auxiliary Propulsion System (APS) ullage motor retrograde burn evasive maneuver to provide initial launch vehicle/spacecraft separation to prevent recontact of the two vehicles. Second, by a combination of programmed liquid oxygen (LOX) dumping the S-IVB/IU will be placed on a lunar impact trajectory. A second APS ullage motor burn will be ground commanded at approximately 6.0 hours GET. The burn duration and attitude will be determined in real-time based on trajectory data. This burn is intended to place the S-IVB/IU on the trajectory for lunar impact at the desired point. A third APS ullage motor burn, also ground commanded, will be performed if necessary to refine the S-IVB/IU trajectory. This burn will occur approximately 9.0 hours GET. The desired impact will be within 350 kilometers of the target point, 3°S. latitude, 30°W. longitude. The impact will occur while the CSM/LM is on the backside of the moon. Later, the crew will photograph the S-IVB/IU target impact area. It is desired that postflight determination of actual impact be within 5 kilometers in distance and 1 second in time.

The spacecraft will be placed on a hybrid trajectory by performing a Service Propulsion System (SPS) maneuver at the time scheduled for the second Midcourse Correction (MCC), approximately 30.6 hours GET. The CSM/LM combination will be targeted for a pericynthion altitude of 60 NM and, as a result of the SPS maneuver, will be placed on a non-free-return trajectory. The spacecraft will remain within the LM Descent Propulsion System (DPS) as well as the SPS return capability.

Earth weather will be photographed for a 3 to 4-hour period beginning at approximately 7 hours GET. Lunar photgraphy may be performed, at the crew's option, at 56 and 75 hours GET. MCC's will be made as required, using the Manned Space Flight Network (MSFN) for navigation.

Lunar Orbit Insertion

The SPS will insert the spacecraft into an initial lunar orbit (approximately 60 x 170 NM) at 77.6 hours GET (Figure 2). The spacecraft will remain in a 60 x 170-NM orbit for approximately two revolutions.

Descent Orbit Insertion

After two revolutions in lunar orbit, the SPS will be used to insert the spacecraft in a 60 x 8-NM descent orbit. During the 4th revolution, the Command Module Pilot (CMP) will photograph the candidate exploration site Censorinus from the CSM at low altitude while the Commander (CDR) and Lunar Module Pilot (LMP) enter the LM for checkout and housekeeping. The crew will use approximately six revolutions for eat and rest periods, and then will prepare the LM for separation and powered descent.

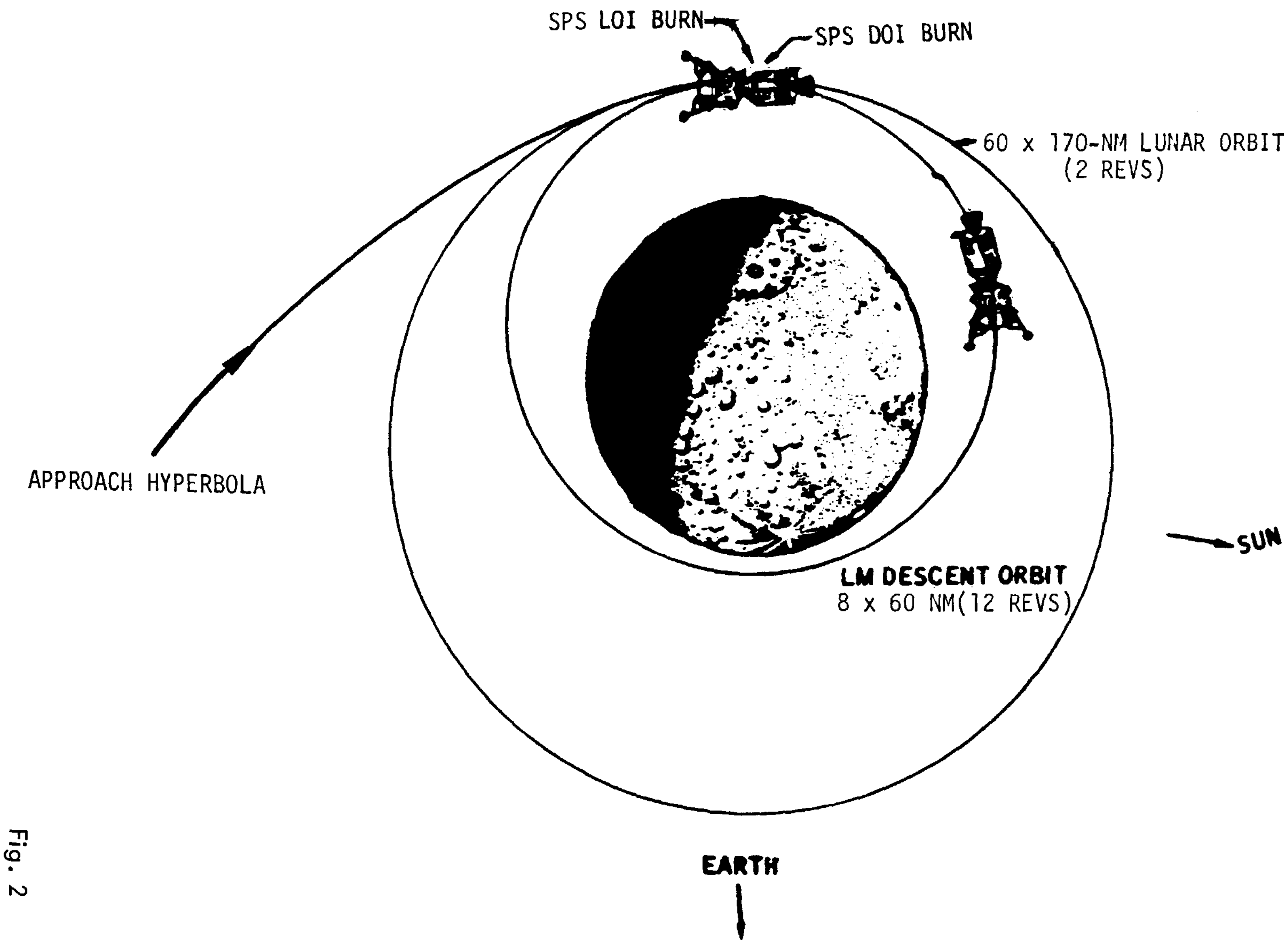


Fig. 2

LUNAR ORBIT INSERTION AND DESCENT ORBIT INSERTION GEOMETRY

A soft undocking will be made during the 12th revolution. Spacecraft separation will be executed by the Service Module Reaction Control System (SM RCS) with the CSM radially below the LM (Figure 3).

LM DESCENT ORBITAL EVENTS

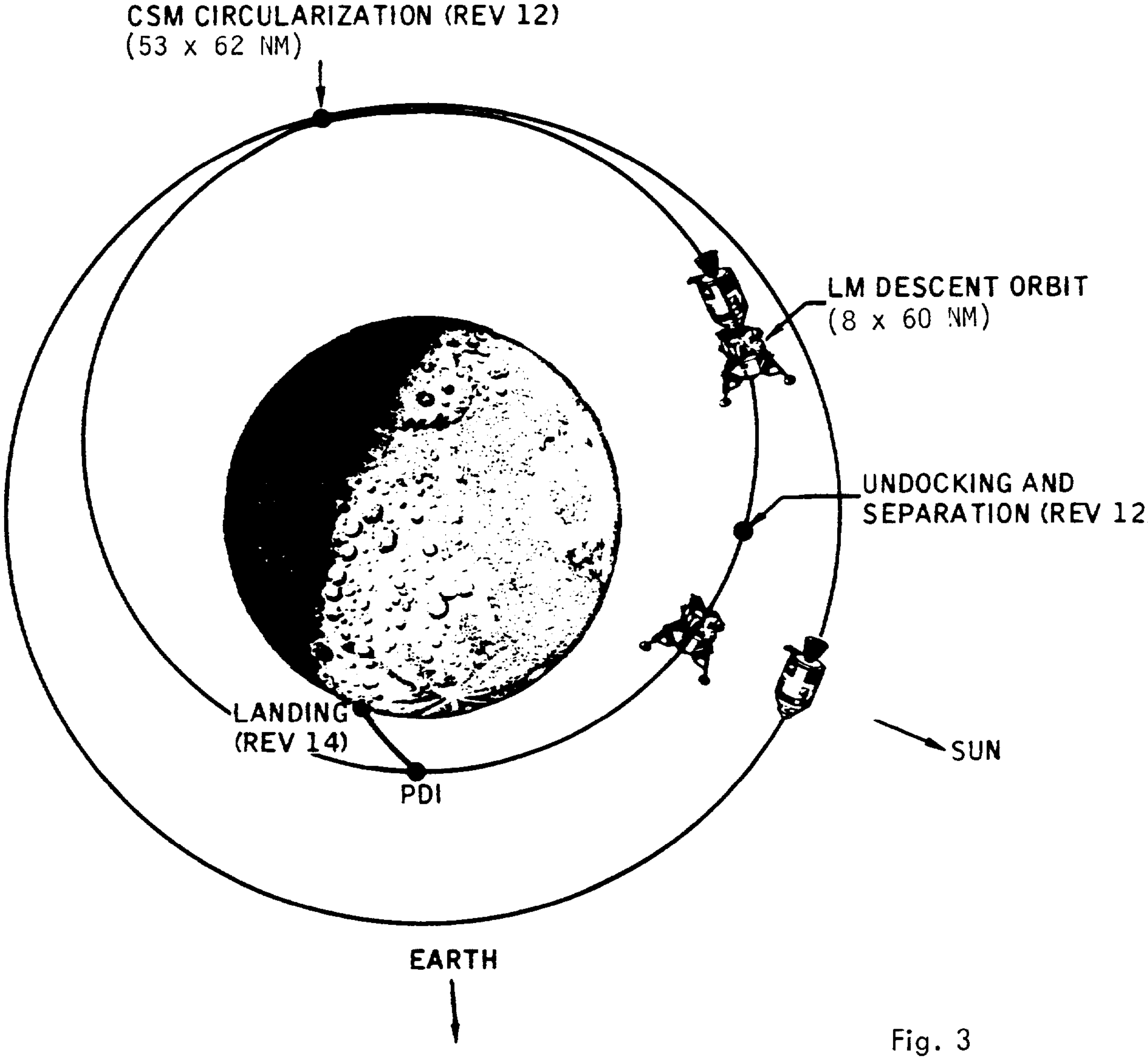


Fig. 3

CSM Lunar Solo (Pre-Rendezvous)

During the 12th revolution (after undocking) the CSM will perform a circularization maneuver to a near-circular 60-NM orbit. The CSM will photograph selected sites that will include the candidate exploration site Censorinus. Lunar orbital science photography and dim light photography of zodiacal light, solar corona, and gegenschein will be performed.

Lunar Module Descent

During the 14th revolution the DPS will be used for the powered descent maneuver, which will start approximately at pericynthion. The vertical descent portion of an automatic landing during the landing phase will start at an altitude of about 100 feet and will be terminated at touchdown on the lunar surface (Figure 3). The crew may elect to take over manually at an altitude of about 500 feet or below. Return to automatic control is a newly added capability of the LM guidance computer.

During descent, the lunar surface will be photographed from the LMP's window to record LM movement and surface disturbances and to aid in determining the landed LM location.

Lunar Surface Operations

A summary of the lunar surface activities is shown in Figure 4.

Postlanding

Immediately upon landing, the LM crew will execute the lunar contact checklist and reach a stay/no-stay decision. After reaching a decision to stay, the Inertial Measurement Unit (IMU) will be aligned, the Abort Guidance System (AGS) gyro will be calibrated and aligned, and the lunar surface will be photographed through the LM window. Following a crew eat period all loose items not required for extravehicular activity (EVA) will be stowed.

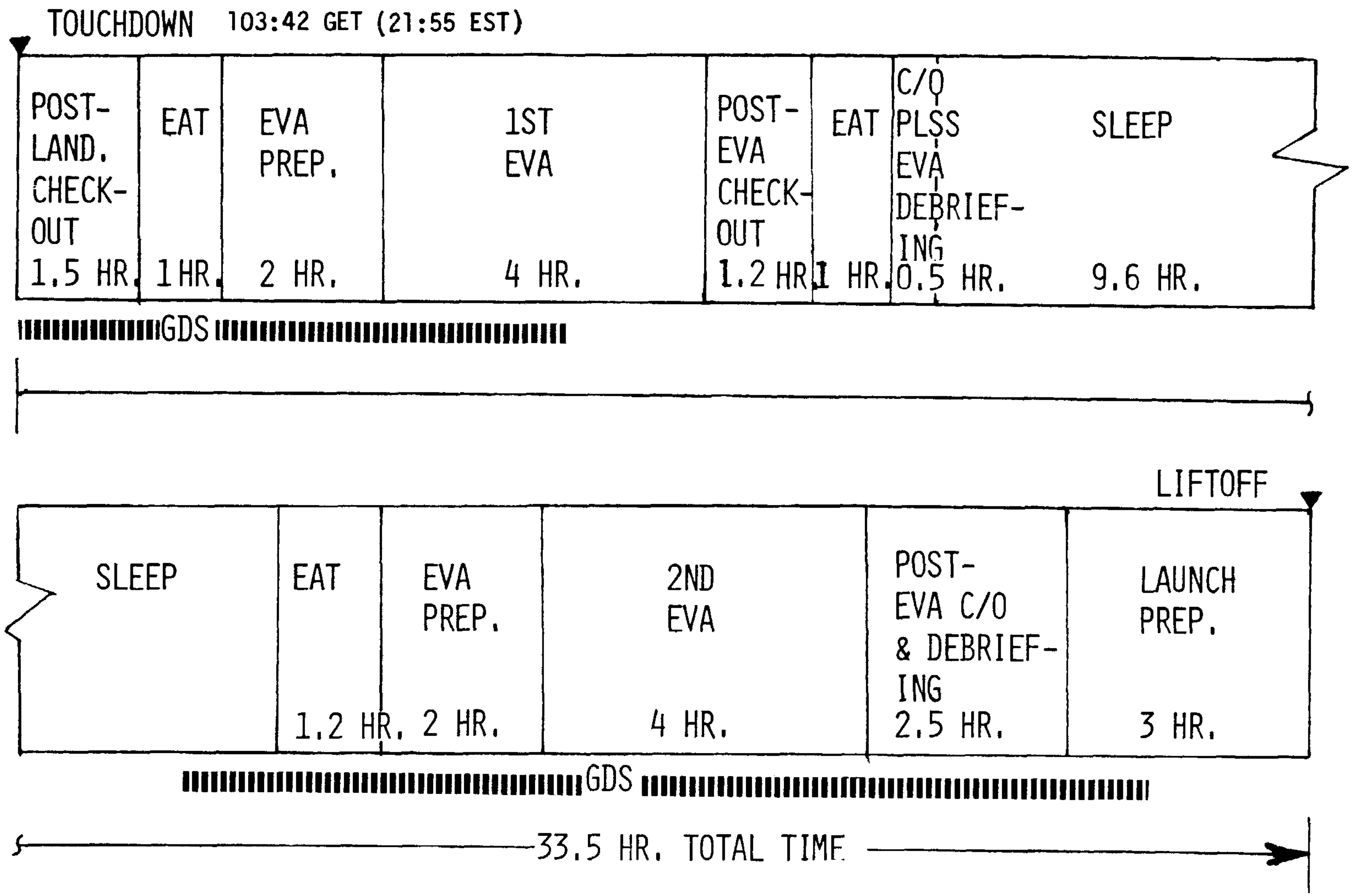
EVA-1

The activity timeline for EVA-1 is shown in Figure 5. Both crew members will don helmets, gloves, Portable Life Support Systems (PLSS), and Oxygen Purge Systems (OPS) and the cabin will be depressurized. The CDR will move through the hatch, deploy the Lunar Equipment Conveyor (LEC), and move to the ladder where he will deploy the Modularized Equipment Stowage Assembly (MESA), Figure 6, which initiates television coverage from the MESA. He will then descend the ladder to the lunar surface. The LMP will monitor and photograph the CDR using a still camera (70mm Hasselblad Electric Camera) and the lunar geologic exploration sequence camera (16mm Data Acquisition Camera).

Environmental Familiarization/Contingency Sample Collection - After stepping to the surface and checking his mobility, stability, and the Extravehicular Mobility Unit (EMU), the CDR will collect a contingency sample. This will make it possible to assess the nature of the lunar surface material at the Apollo 13 landing site in the event the EVA were terminated at this point. The sample will be collected by quickly scooping up a loose sample of the

APOLLO 13

LUNAR SURFACE ACTIVITIES SUMMARY



EVA EXTENDABLE TO 5 HOURS BASED ON A REALTIME ASSESSMENT OF REMAINING CONSUMABLES.

Fig. 4

M-932-70-13

APOLLO 13 EVA-1 TIMELINE

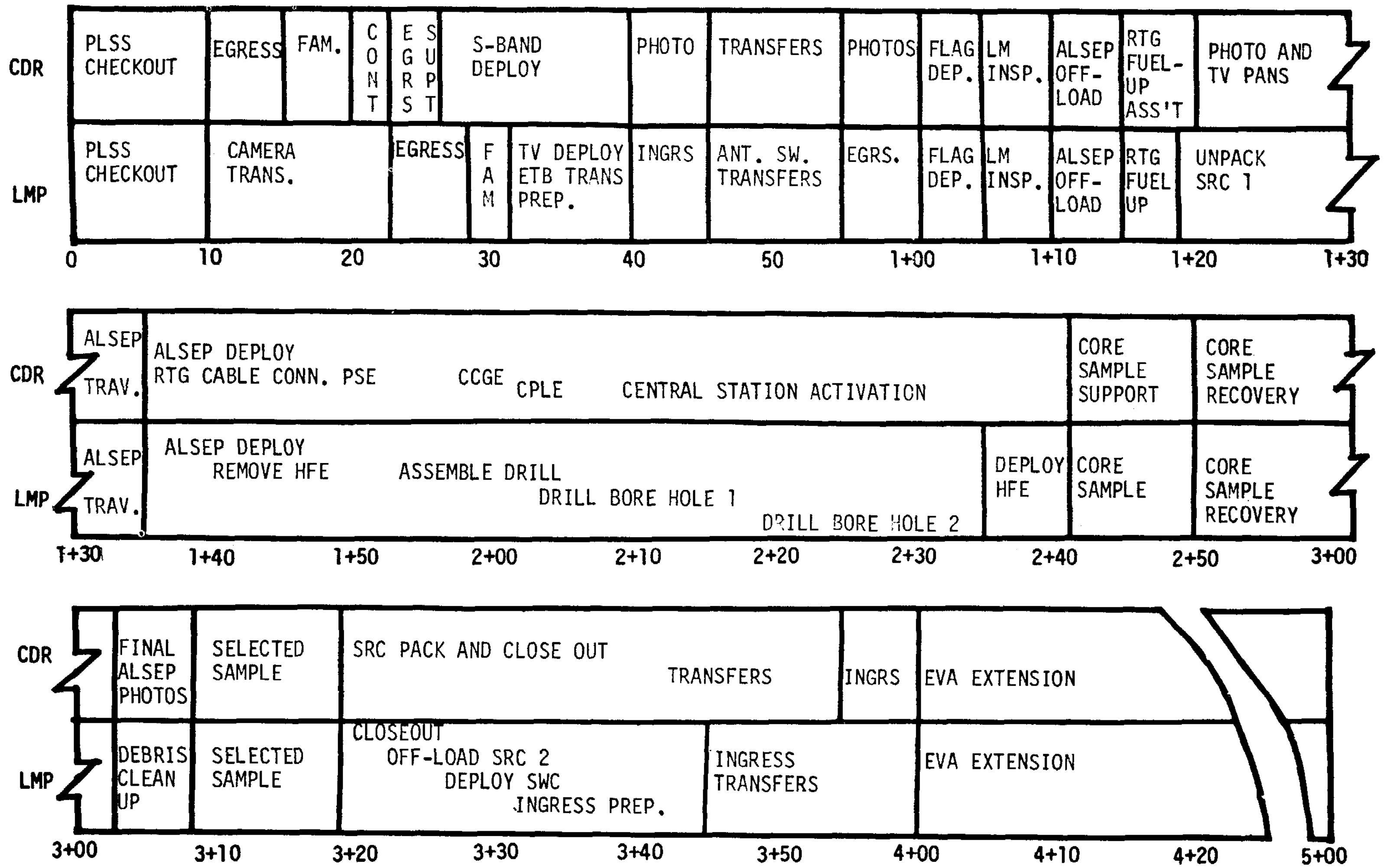


Fig. 5

DEPLOYED MODULARIZED EQUIPMENT STOWAGE ASSEMBLY

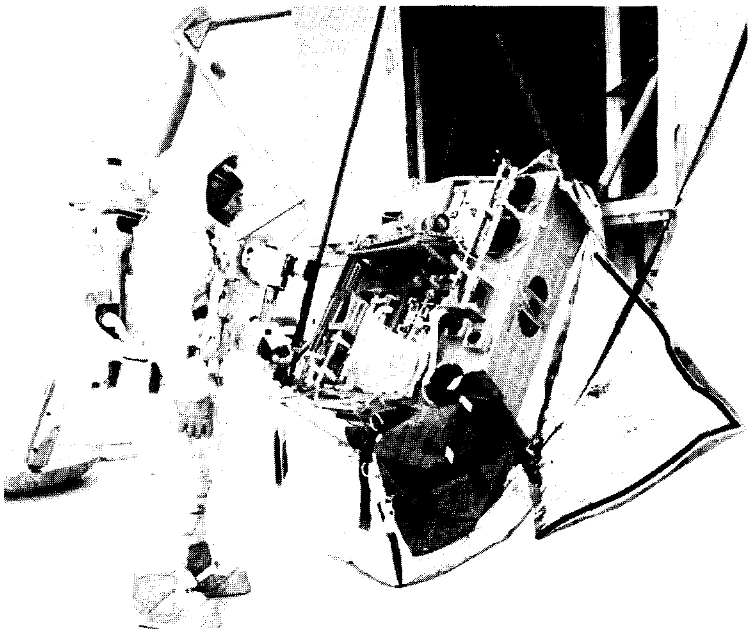


Fig. 6

lunar material (approximately 2 pounds), sealing it in a Contingency Sample Container, and placing the sample in the Equipment Transfer Bag (ETB), along with the lithium hydroxide (LiOH) canisters and PLSS batteries for later transfer into the LM using the LEC. The LMP will transfer the 70mm cameras to the surface with the LEC. The LMP will then descend to the surface.

S-band Antenna Deployment - The S-band antenna will be removed from the LM and carried to the site where the CDR will erect it, as shown in Figure 7, connect the antenna cable to the LM, and perform the required alignment.

DEPLOYED S-BAND ANTENNA

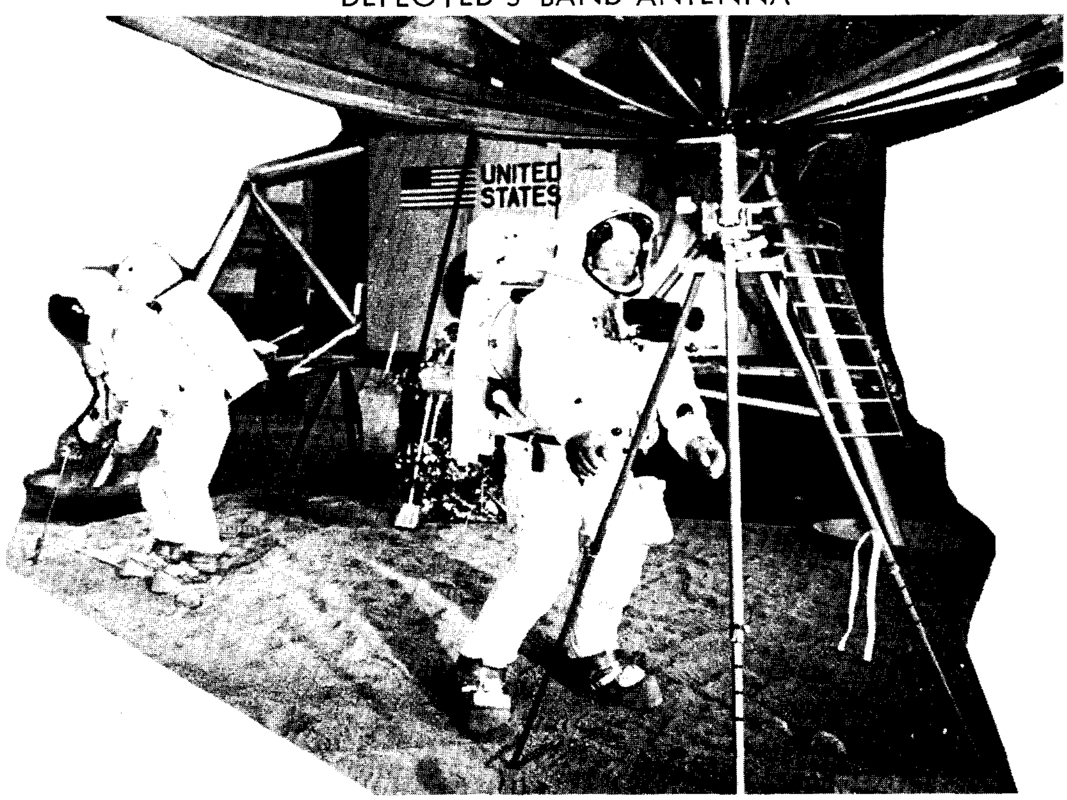


Fig. 7

Lunar TV Camera (Color) Deployment - While the CDR deploys the S-band antenna, the LMP will unstow the TV camera and deploy it on the tripod approximately 50 feet from the LM. The LMP will then ingress the LM to activate and verify TV transmission with the Mission Control Center.

The contingency sample and other equipment will be transferred into the LM and the 16mm lunar geologic exploration camera transferred to the surface. The LMP will egress again, leaving the hatch slightly ajar, and descend to the surface. The CDR will photograph the contingency sample area and the LMP egress. Following this, the American flag will be deployed.

LM Inspection - After repositioning the TV to view the scientific equipment bay area, the LMP will inspect and photograph the LM footpads and quadrants I, II, III, and IV with an EMU-mounted 70mm camera. Concurrently the CDR will also inspect and photograph the LM. The Apollo Lunar Surface Close-Up Camera (ALSCC) will be removed from the MESA and placed down sun.

ALSEP Deployment - After offloading ALSEP from the LM, the Radioisotope Thermoelectric Generator (RTG) will be fueled (Figure 8), the ALSEP packages will be attached to a one-man carry bar for traverse in a barbell mode, and the TV will be positioned to view the ALSEP site. The hand tools will be loaded on the hand tool carrier. While the CDR obtains TV and photographic panoramic views from the site, the LMP will unload Sample Return Container number 1 (SRC 1) and remove the ALSCC. The CDR and LMP will then carry the ALSEP packages, hand tool carrier, and Apollo Lunar Surface Drill (ALSD) to the deployment site approximately 500 feet from the LM. The crew will survey the site and determine the desired location for the experiments. The following individual experiment packages will then be separated, assembled, and deployed to respective sites in the arrangement shown in Figure 9.

APOLLO 13 ALSEP
RADIOISOTOPE THERMOELECTRIC
GENERATOR (UNFUELED)

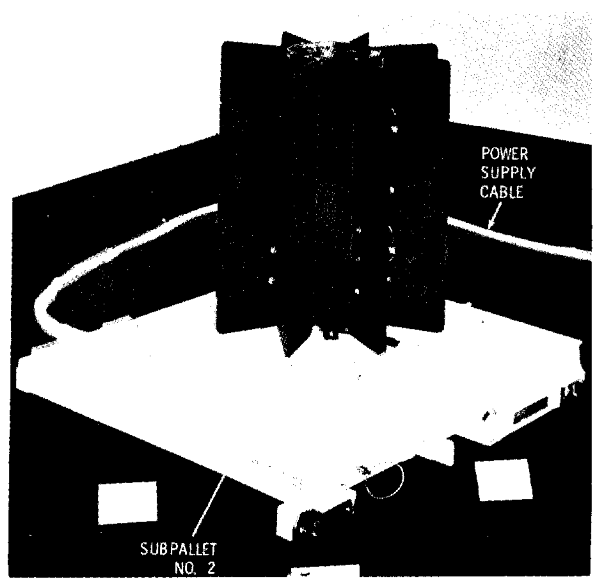
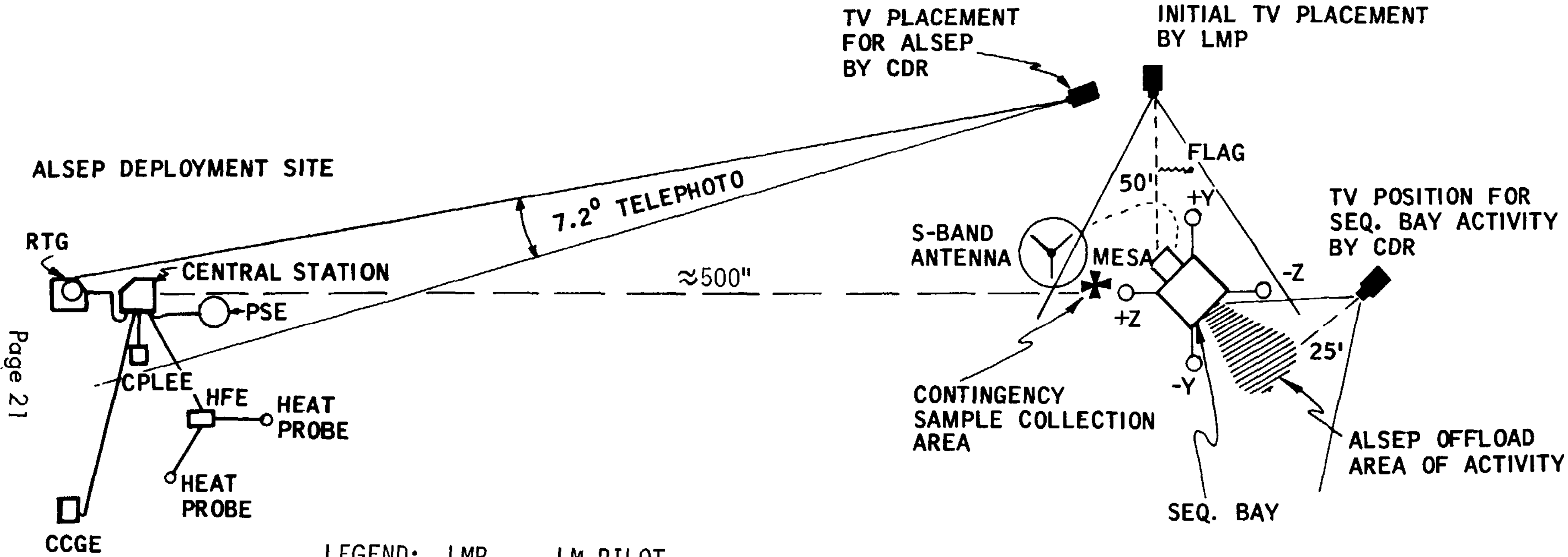


Fig. 8

EVA-1 EQUIPMENT DEPLOYMENT



LEGEND:

LMP	-	LM PILOT
CDR	-	COMMANDER
ALSEP	-	APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE
SEQ	-	SCIENTIFIC EQUIPMENT
PSE	-	PASSIVE SEISMIC EXPERIMENT
HFE	-	HEAT FLOW EXPERIMENT
CPLEE	-	CHARGED PARTICLE LUNAR ENVIRONMENT EXPERIMENT
CCGE	-	COLD CATHODE GAUGE EXPERIMENT
RTG	-	RADIOISOTOPIC THERMOELECTRIC GENERATOR

Fig. 9

Passive Seismic Experiment (S-031) - The CDR will deploy and set up the Passive Seismic Experiment package with its thermal cover.

Charged Particle Lunar Environment Experiment (S-038) - The CDR will deploy and orient the Charged Particle Lunar Environment Experiment package while the LMP is assembling the ALSD and drilling the first hole for the heat flow experiment.

Cold Cathode Ion Gauge (S-058) - The CDR will deploy and orient the Cold Cathode Ion Gauge.

Heat Flow Experiment (S-037) - The LMP will assemble the battery-powered ALSD and will drill two three-meter deep holes using hollow-center bore stems. Each bore stem will be left in place as an encasement into which the heat flow probes are inserted.

ALSEP Central Station - The CDR will level and align the central station which includes deployment of the sun shield. At this time the LMP will be drilling the second hole for the Heat Flow Experiment. The CDR will then assemble and align the ALSEP antenna. The CDR will activate the central station and photograph the ALSEP layout while the LMP is implanting the Heat Flow Experiment probes.

Core Sampling - The CDR will assist the LMP in modifying the ALSD, collecting core samples and photographing the operation.

Selected Sample Collection - The crew will begin the return traverse and initiate collection of the selected samples. At the return to the LM, samples will be weighed and, with the core stems, stowed in SRC 1 and the SRC will be sealed. SRC 2 will be offloaded and SRC 1 will be transferred into the LM.

Solar Wind Composition Experiment (S-080) - The four-square-foot panel of aluminum foil will be deployed by the LMP.

EMU cleaning and ingress into the LM will be accomplished by the LMP and the CDR. EVA-1 will terminate when the LM cabin is repressurized.

Post-EVA 1 Operations

After configuring the LM systems for Post-EVA-1 operations, the PLSS's will be recharged. This includes filling the oxygen system to a minimum pressure of 875 pounds per square inch, filling the water reservoir, and replacing the battery and LiOH canister. A one-hour eating period is scheduled between the beginning and end of the PLSS recharge operations. The PLSS's and OPS's will be stowed, followed by a 9-1/2-hour rest period and another eat period.

EVA-2

The LM will be configured for EVA activities and the CDR will egress. The LMP will again monitor and photograph the CDR and then transfer camera equipment in the ETB to the CDR with the LEC. The LMP will descend to the lunar surface leaving the LM hatch slightly ajar. A summary of EVA-2 activities is shown in Figure 10.

Sample Collection and Camera Calibration - The crew will collect a thermal sample and a sieve sample from near the LM and a contaminated sample from under the LM. They will calibrate their cameras by photographing a special contrast chart on the hand tool carrier and then will position the TV camera for the field geology traverse.

Lunar Field Geology (S-059) Traverse - Both crewmen will conduct the field geology traverse, which is planned in detail prior to launch. Additional support and real-time planning will be provided from the ground based on features of the landing site obtained from crew descriptions and TV. Traversing outbound from the LM, the crew will obtain Close-Up Stereo Camera photos of selected areas. They will take panoramic photographs of the lunar surface and will use a special polarizing filter to photograph selected features. They will obtain subsurface samples, core camples, and surface samples. Special gas analysis, environmental, and magnetic lunar surface samples will be collected. Approximately 1/2 mile from the LM the CDR will dig a two-foot-deep trench for lunar soil mechanics evaluation. The LMP will collect a core sample and a special environmental sample from the trench and obtain photographic data of the boot prints in the trench material. Gas analysis and magnetic samples will also be obtained in the vicinity of the trench.

The crew will begin traversing inbound to the LM by a different route to obtain additional documented samples as performed on the outbound traverse. A typical documented sample procedure will include locating the gnomon up sun of the sample site, photography of the site and the sample, description of the sample, and stowage of the lunar surface material in a sample bag. The typical core sampling will consist of placing the gnomon up sun and photography of the sample site cross sun, driving the core tube into the surface, recovery and capping the sample within the tube.

Upon return to the LM, the CDR will offload the samples into SRC 2. The LMP will reposition the TV, collect a soil mechanics sample, and then take down and roll up the Solar Wind Composition experiment and place it and the Close-Up Stereo Camera magazine in the SRC. He will then close and seal the SRC. The LMP will clean his EMU, ingress into the LM, and hook up the LEC. The CDR and LMP will utilize the LEC to transfer samples and equipment into the LM. The CDR will clean his EMU, ascend into the LM, jettison the LEC and ingress. The LM will be repressurized, terminating EVA-2. Equipment and samples will be stowed and preparations made for equipment jettison. The LM will be depressurized, equipment jettisoned, and the LM repressurized.

APOLLO 13 EVA-2 TIMELINE

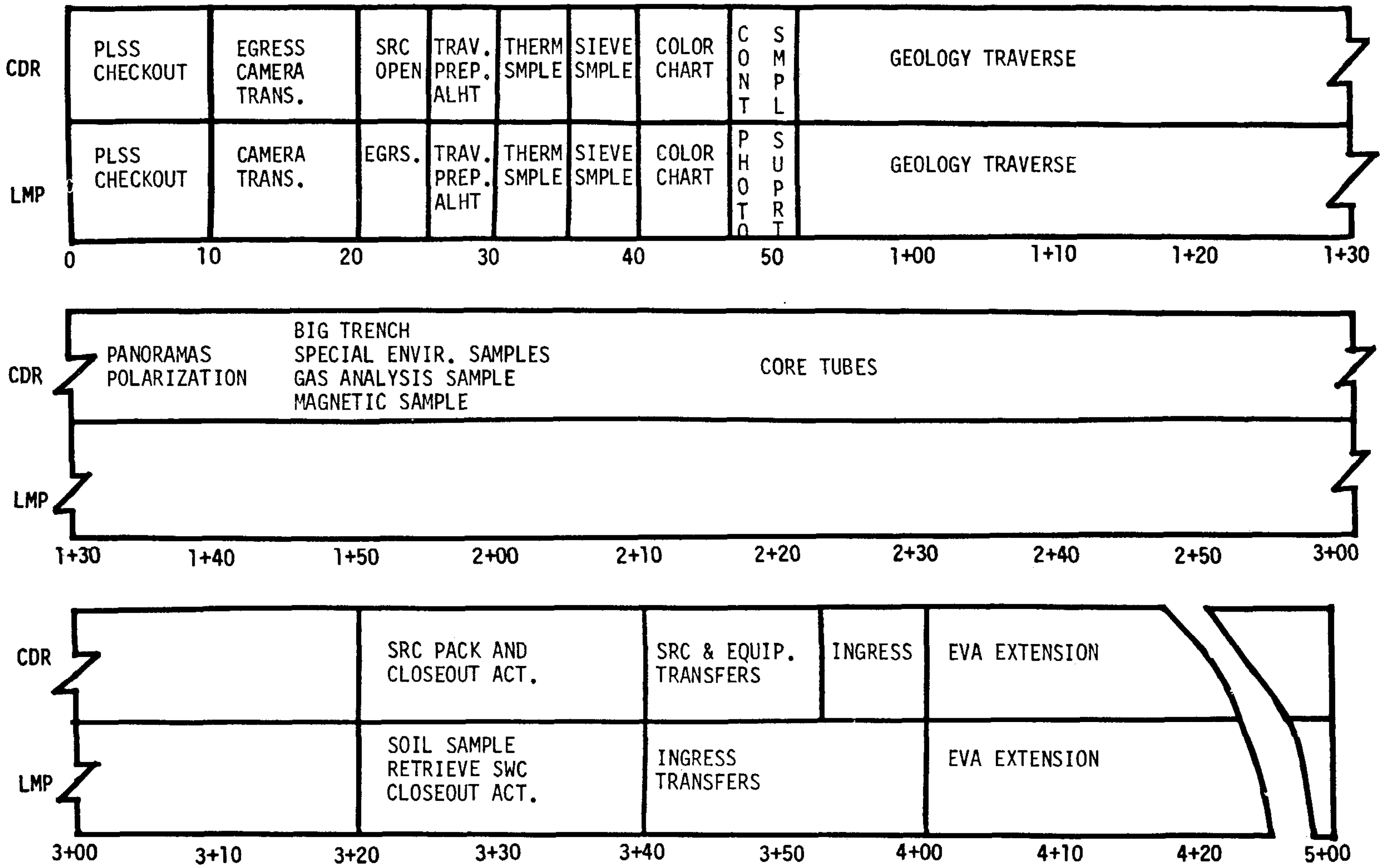
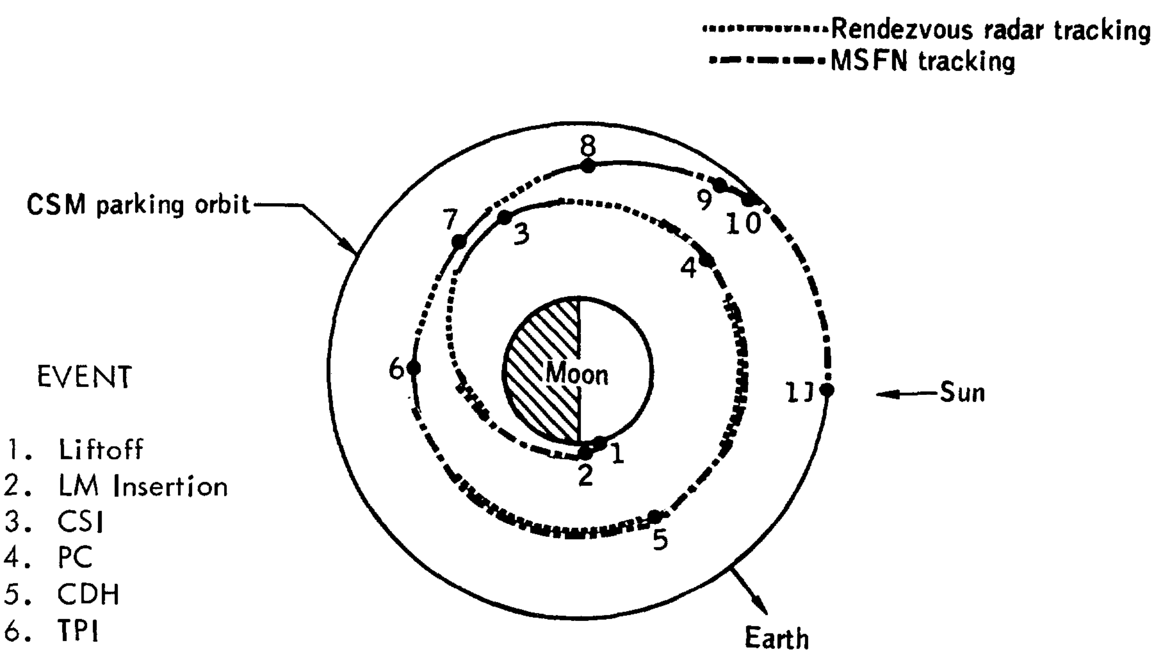


Fig. 10

Lunar Module Ascent

The LM ascent (Figure 11) will begin after a lunar stay of approximately 33.5 hours. The Ascent Propulsion System (APS) powered ascent is divided into two phases. The first phase is a vertical rise, which is required to achieve terrain clearance, and the second phase is orbit insertion. After orbit insertion the LM will execute the coelliptic rendezvous sequence which nominally consists of four major maneuvers: concentric sequence initiation (CSI), constant delta height (CDH), terminal phase initiation (TPI), and terminal phase finalization (TPF). A nominally zero plane change (PC) maneuver will be scheduled between CSI and CDH, and two nominally zero midcourse correction maneuvers will be scheduled between TPI and TPF; the TPF maneuver is actually divided into several braking maneuvers. All maneuvers after orbit insertion will be performed with the LM RCS. Once docked to the CSM, the two crewmen will transfer to the CSM with equipment, lunar samples, and exposed film. Decontamination operations will be performed, jettisonable items will be placed in the Interim Stowage Assembly and transferred to the LM, and the LM will be configured for deorbit and lunar impact.

LM ASCENT THROUGH DOCKING



EVENT

1. Liftoff
2. LM Insertion
3. CSI
4. PC
5. CDH
6. TPI
7. MC-1
8. MC-2
9. Begin Braking
10. Begin Stationkeeping
11. Docking

Fig. 11

LM Ascent Stage Deorbit

The ascent stage will be deorbited (Figure 12), during the 35th revolution, for lunar surface impact between the ALSEP I of Apollo 12 and the newly deployed ALSEP III, to provide a known energy source to produce signals for recording by the seismic experiments. The CSM will be separated radially from the ascent stage with a SM RCS retrograde burn approximately 2 hours after docking to the CSM. Following the LM jettison maneuver, the CSM will perform a pitchdown maneuver. The LM deorbit maneuver will be a retrograde RCS burn initiated by ground control and the LM will be targeted to impact the lunar surface approximately 36.5 NM west northwest of the Apollo 13 landing site. The ascent stage jettison, ignition, and impacted lunar surface area will be photographed from the CSM.

LM ASCENT STAGE DEORBIT

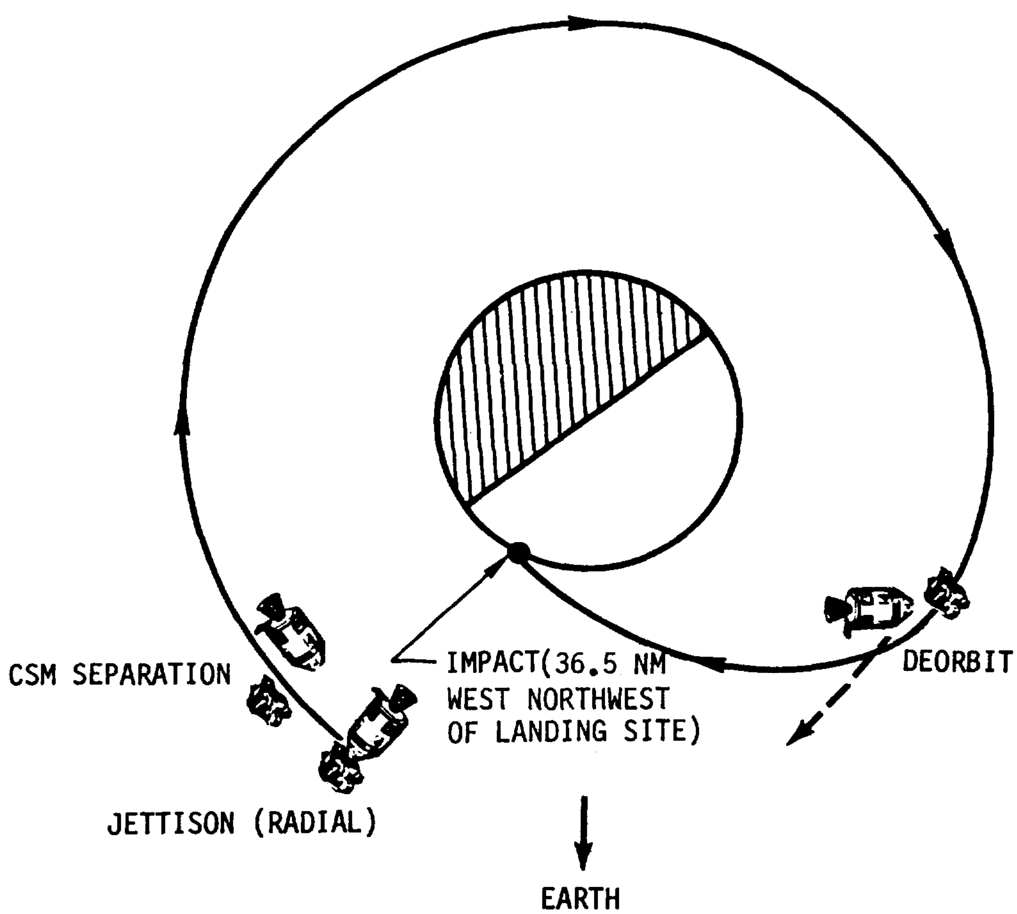


Fig. 12

CSM Lunar Orbit Operations

The CSM will execute an orbital plane change, soon after MSFN acquisition of signal in the 35th revolution, for approximately 9 hours of lunar reconnaissance photography. High resolution vertical and oblique topographic photography, stereo strip photography, science photography and landmark tracking will be performed. The Censorinus, Descartes, and Davy Rille sites are of special photographic interest as candidate future landing sites.

Transearth Injection and Coast

At the end of the 46th revolution, and approximately 10 minutes prior to MSFN acquisition of signal, the SPS will be used to inject the CSM onto the transearth trajectory. The return flight duration will be approximately 73 hours (based on an 11 April launch) and the return inclination (to the earth's equator) will not exceed 40 degrees. Midcourse corrections will be made as required, using the MSFN for navigation.

Entry and Landing

Prior to atmospheric entry, the CSM will maneuver to a heads-up attitude, the Command Module (CM) will jettison the SM and orient to the entry attitude. The nominal range from entry interface (EI) at 400,000 feet altitude to landing will be approximately 1250 NM. Earth landing will nominally be in the Pacific Ocean at 1°34'S latitude and 157°30'W longitude (based on an 11 April launch) approximately 241 hours after liftoff.

Crew Recovery and Quarantine

Following landing, the Apollo 13 crew will don the flight suits and face masks passed in to them through the spacecraft hatch by a recovery swimmer wearing standard scuba gear. Integral Biological Isolation Garments (BIG's) will be available for use in case of an unexplained crew illness. The swimmer will swab the hatch and adjacent areas with a liquid decontamination agent. The crew will then be carried by helicopter to the recovery ship where they will enter a Mobile Quarantine Facility (MQF) and all subsequent crew quarantine procedures will be the same as for the Apollo 11 and 12 Missions.

CM and Data Retrieval Operations

After flight crew pickup by the helicopter, the CM will be retrieved and placed on a dolly aboard the recovery ship. The CM will be mated to the MQF, and the lunar samples, film, flight logs, etc., will be retrieved and passed out through a decontamination lock for shipment to the Lunar Receiving Laboratory (LRL). The spacecraft will be offloaded from the ship at Pearl Harbor and transported to an area where deactivation of the CM pyrotechnics and propellant system will be accomplished. This operation will be confined to the exterior of the spacecraft. The spacecraft will then be flown to the LRL and placed in a special room for storage. Contingency plans call for sterilization and early release of the spacecraft if the situation so requires.

CONTINGENCY OPERATIONS

GENERAL

If an anomaly occurs after liftoff that would prevent the space vehicle from following its nominal flight plan, an abort or an alternate mission will be initiated. Aborts will provide for an acceptable flight crew and Command Module (CM) recovery while alternate missions will attempt to maximize the accomplishment of mission objectives as well as provide for an acceptable flight crew and CM recovery.

ABORTS

The following sections present the abort procedures and descriptions in order of the mission phase in which they could occur.

Launch

There are six launch abort modes. The first three abort modes would result in termination of the launch sequence and a CM landing in the launch abort area. The remaining three abort modes are essentially alternate launch procedures and result in insertion of the Command/Service Module (CSM) into earth orbit. All of the launch abort modes are the same as those for the Apollo 11 Mission.

Earth Parking Orbit

A return to earth abort from earth parking orbit (EPO) will be performed by separating the CSM from the remainder of the space vehicle and performing a retrograde Service Propulsion System (SPS) burn to effect entry. Should the SPS be inoperable, the Service Module Reaction Control System (SM RCS) will be used to perform the deorbit burn. After CM/SM separation and entry, the crew will fly a guided entry to a pre-selected target point, if available.

Translunar Injection

Translunar injection (TLI) will be continued to nominal cutoff, whenever possible, in order for the crew to perform malfunction analysis and determine the necessity of an abort.

Translunar Coast

If ground control and the spacecraft crew determine that an abort situation exists, differential velocity (ΔV) targeting will be voiced to the crew or an onboard abort program will be used as required. In most cases, the Lunar Module (LM) will be jettisoned prior to the abort maneuver if a direct return is required. An SPS burn will be initiated to achieve a direct return to a landing area. However, a real-time decision capability will be exploited as necessary for a direct return or circumlunar trajectory by use of the several CSM/LM propulsion systems in a docked configuration.

Lunar Orbit Insertion

In the event of an early shutdown of the SPS during lunar orbit insertion (LOI), contingency action will depend on the condition which caused the shutdown. If the shutdown was inadvertent, and if specified SPS limits have not been exceeded, an immediate restart will be attempted. Upon completion of the LOI burn a real-time decision will be made on possible alternate missions. If, during the LOI burn, the SPS limits are exceeded, a manual shutdown will be made. The LM Descent Propulsion System (DPS) will serve as a backup propulsion system.

Descent Orbit Insertion

In the event of a descent orbit insertion (DOI) overburn where, despite trim corrections, the pericynthion remains lower than desired, a so-called "bail-out" SPS burn will be performed to raise the pericynthion. Based on Mission Rules criteria, this situation could lead to a continuation of the nominal landing mission, selection of an alternate mission, or early mission termination.

Transearth Injection

An SPS shutdown during transearth injection (TEI) may occur as the result of an inadvertent automatic shutdown. Manual shutdowns are not recommended. If an automatic shutdown occurs, an immediate restart will be initiated.

ALTERNATE MISSION SUMMARY

The two general categories of alternate missions that can be performed during the Apollo 13 Mission are (1) earth orbital and (2) lunar. Both of these categories have several variations which depend upon the nature of the anomaly leading to the alternate mission and the resulting systems status of the LM and CSM. A brief description of these alternate missions is contained in the following paragraphs.

Earth Orbit

The CSM will dock with the LM, and the photographic equipment will be retrieved from the LM. Following this, the LM will be deorbited into the Pacific Ocean area to eliminate debris problems. The CSM will perform SPS plane change maneuvers to achieve an orbital inclination of 40° with daylight coverage of all US passes. Earth orbital photography will then be conducted.

Lunar Orbit

CSM and LM

The nominal mission bootstrap photographic objectives will be accomplished. These objectives include photographs of Censorinus, Descartes, and Davy Rille. The LM will normally be jettisoned prior to accomplishing photographic objectives to avoid CM window blockage.

CSM Alone

The hybrid transfer will be deleted in this case. If the hybrid transfer has been performed, the CSM will be placed back on a free return trajectory. A two-burn LOI sequence, as on Apollo 8, 11, and 12 will be used to place the vehicle in a 60-NM circular orbit. The LOI burn will also establish an orbit to pass over Censorinus and Mosting C for photography and landmark tracking.

MISSION SUPPORT

GENERAL

Mission Support is provided by the Launch Control Center, the Mission Control Center, the Manned Space Flight Network, and the recovery forces. A comprehensive description of the mission support elements is in the MOR Supplement.

CONTROL CENTERS

The Launch Control Center (LCC), located at Kennedy Space Center, Florida, is the focal point for overall direction, control and monitoring of prelaunch checkout, countdown and launch of Apollo/Saturn V Space Vehicles.

The Mission Control Center (MCC), located at the Manned Spacecraft Center in Houston, Texas, provides centralized mission control from the time the space vehicle clears the launch tower through astronaut and spacecraft recovery. The MCC functions within the framework of a Communications, Command, and Telemetry System (CCATS); Real-Time Computer Complex (RTCC); Voice Communications System; Display Control System; and a Mission Operations Control Room (MOCR) supported by Staff Support Rooms (SSR's). These systems allow the flight control personnel to remain in contact with the space vehicle, receive telemetry and operational data which can be processed by the CCATS and RTCC for verification of a safe mission, or compute alternatives. The MOCR and SSR's are staffed with specialists in all aspects of the mission who provide the Flight Director and Mission Director with real-time evaluation of mission progress.

MANNED SPACE FLIGHT NETWORK

The Manned Space Flight Network (MSFN) is a worldwide communications and tracking network that is controlled by the MCC during Apollo missions. The network is composed of fixed stations supplemented by mobile stations. The functions of these stations are to provide tracking, telemetry, updata, and voice communications between the spacecraft and the MCC. Connection between these many MSFN stations and the MCC is provided by the NASA Communications Network.

Figure 13 depicts communications during lunar surface operations.

Figure 14 shows the MSFN configuration for Apollo 13.

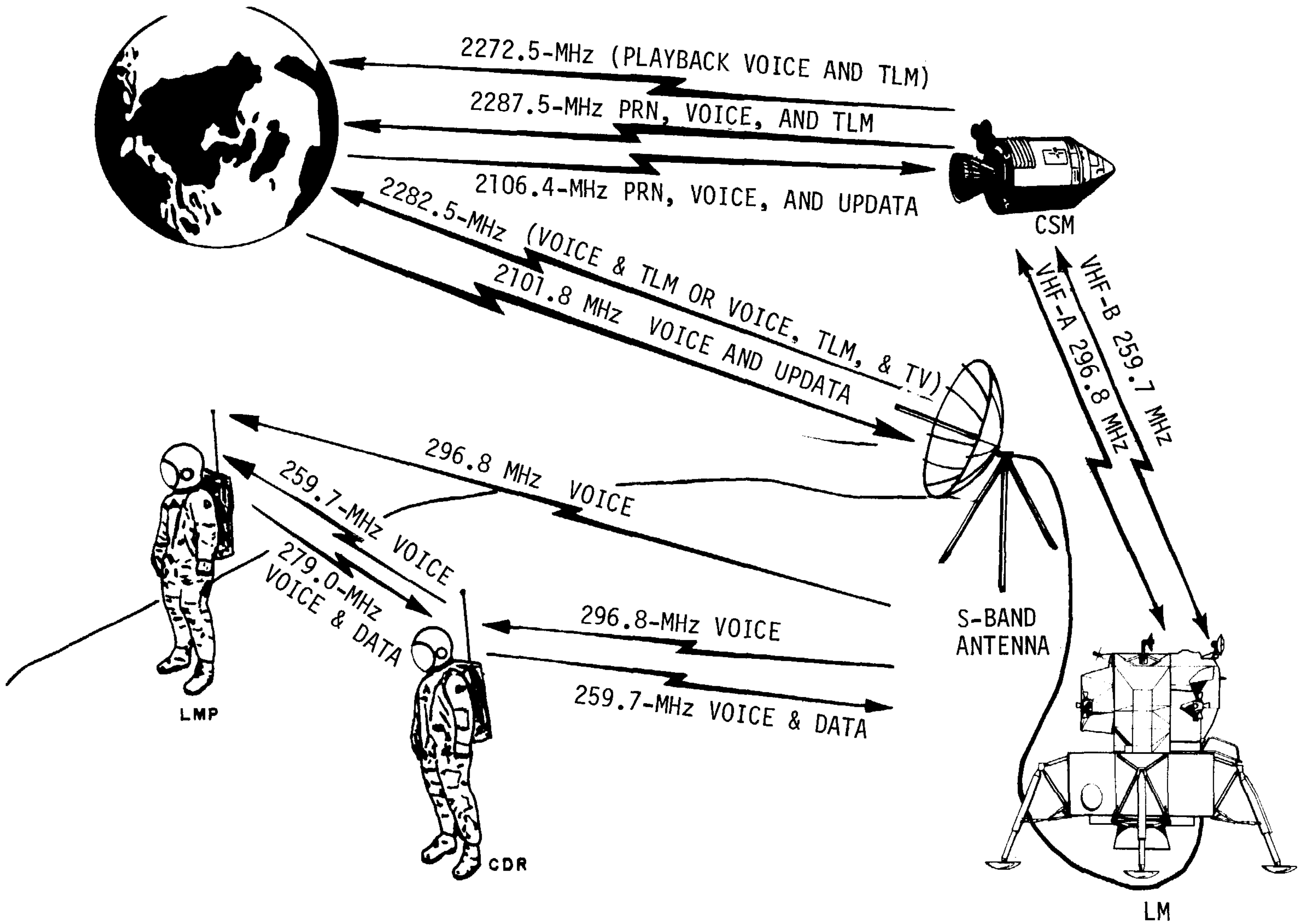
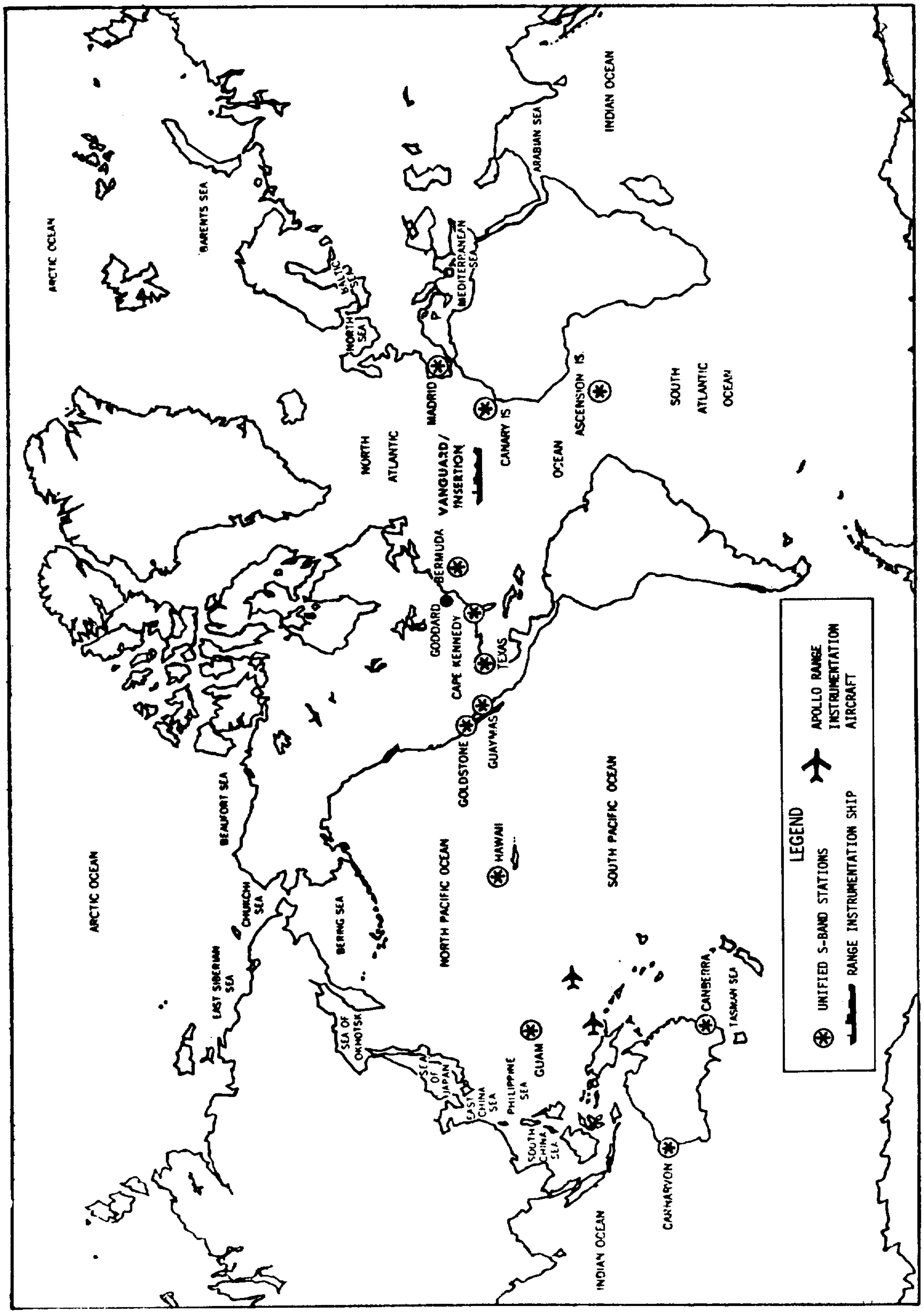


Fig. 13

LUNAR SURFACE COMMUNICATIONS NETWORK

M-932-70-13



MANNED SPACE FLIGHT NETWORK (APOLLO 13)

Fig. 14

RECOVERY SUPPORT

General

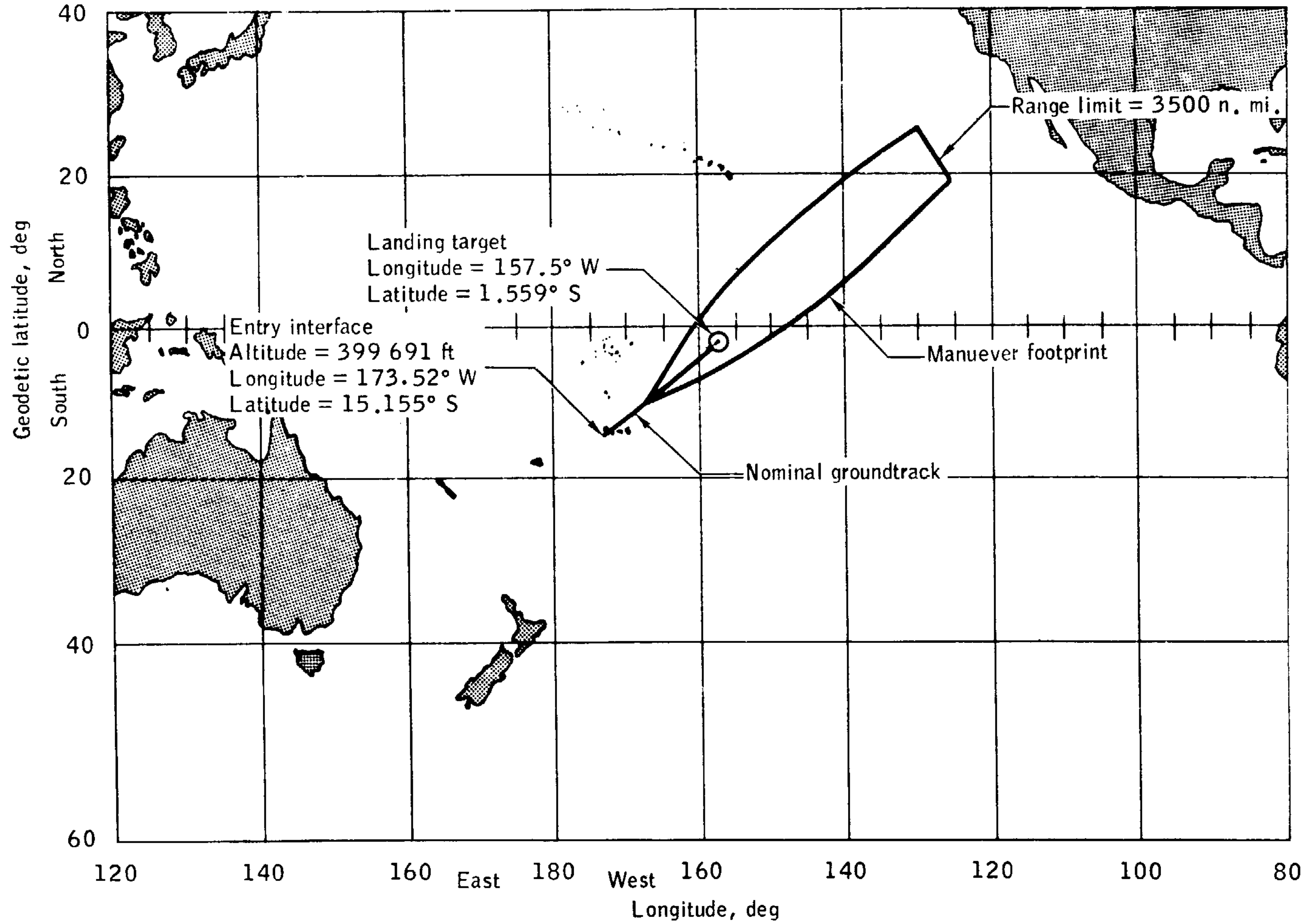
The Apollo 13 flight crew and Command Module (CM) will be recovered as soon as possible after landing, while observing the constraints required to maintain biological isolation of the flight crew, CM, and materials removed from the CM. After locating the CM, first consideration will be given to determining the condition of the astronauts and to providing first-level medical aid if required. The second consideration will be recovery of the astronauts and CM. Retrieval of the CM main parachutes, apex cover, and drogue parachutes, in that order, is highly desirable if feasible and practical. Special clothing, procedures, and the Mobile Quarantine Facility (MQF) will be used to provide biological isolation of the astronauts and CM. The lunar soil and rock samples will also be isolated for return to the Manned Spacecraft Center.

Primary Landing Area

The primary landing area, shown in Figure 15, is that area in which the CM will land following circumlunar or lunar orbital trajectories that are targeted to the mid-Pacific Ocean. The target point will normally be 1250 nautical miles (NM) downrange of the entry point (400,000 feet altitude). If the entry range is increased to avoid bad weather, the area moves along with the target point and contains all the high probability landing points as long as the entry range does not exceed 3500 NM.

Figures 16 and 17 show the primary landing area and worldwide recovery forces deployment. Recovery equipment and procedures changes for Apollo 13 are as follows:

- Recovery beacon CM antennas switched
- Sea dye inside CM deployed on request
- Navy type "Mae West" astronaut egress lifejacket
- New design recovery liferaft



APOLLO 13 PRIMARY LANDING AREA

Fig. 15

ABBREVIATIONS:

R RECOVERY
P PHOTO
S-1 SWIM 1
ST-1 SWIM TEAM 1
S-2 SWIM 2
ST-2 SWIM TEAM 2
HAW RES HAWAII RESCUE

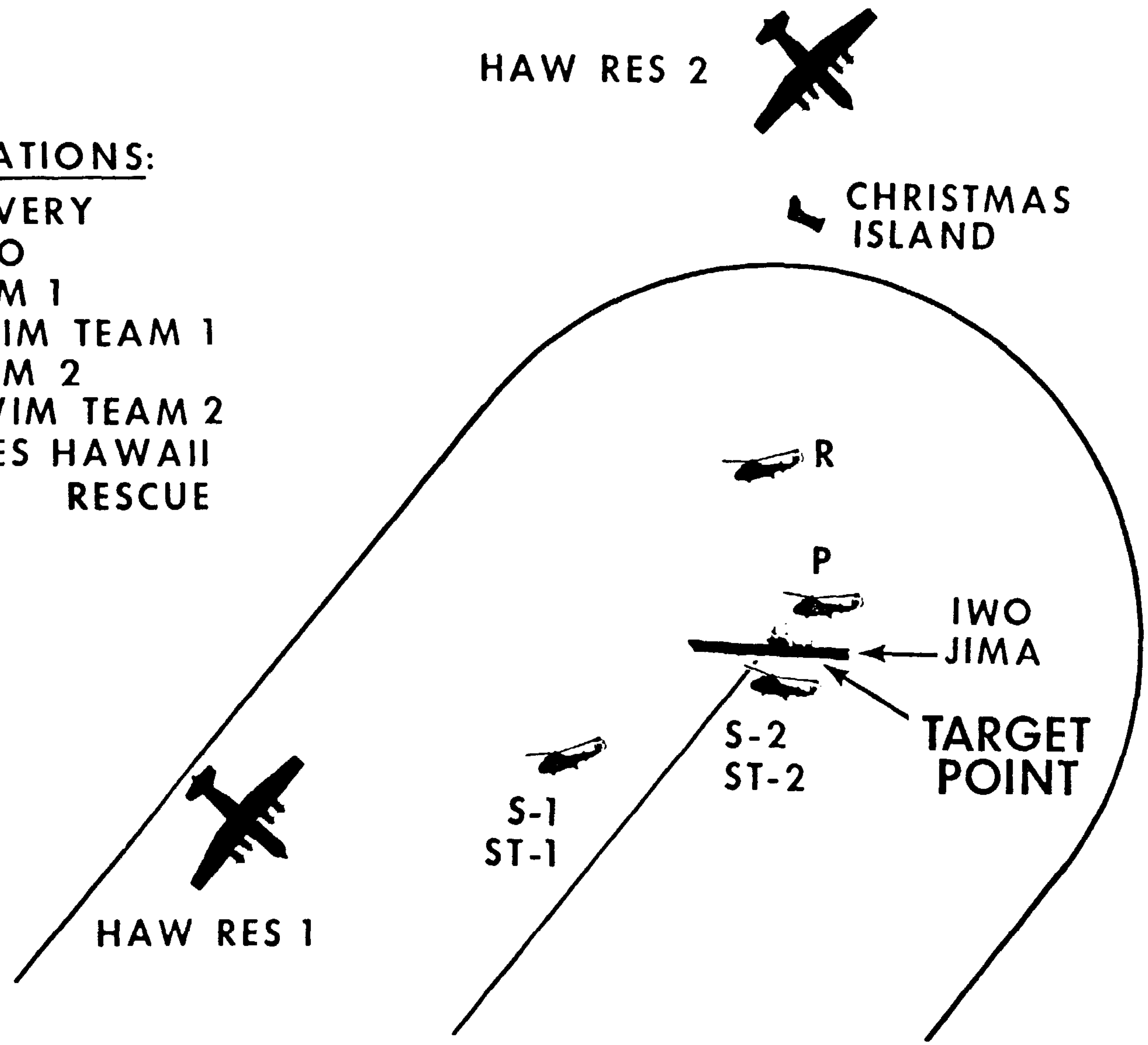


Fig. 16

PRIMARY LANDING AREA
RECOVERY FORCE VOICE CALLS

RECOVERY FORCE SUPPORT

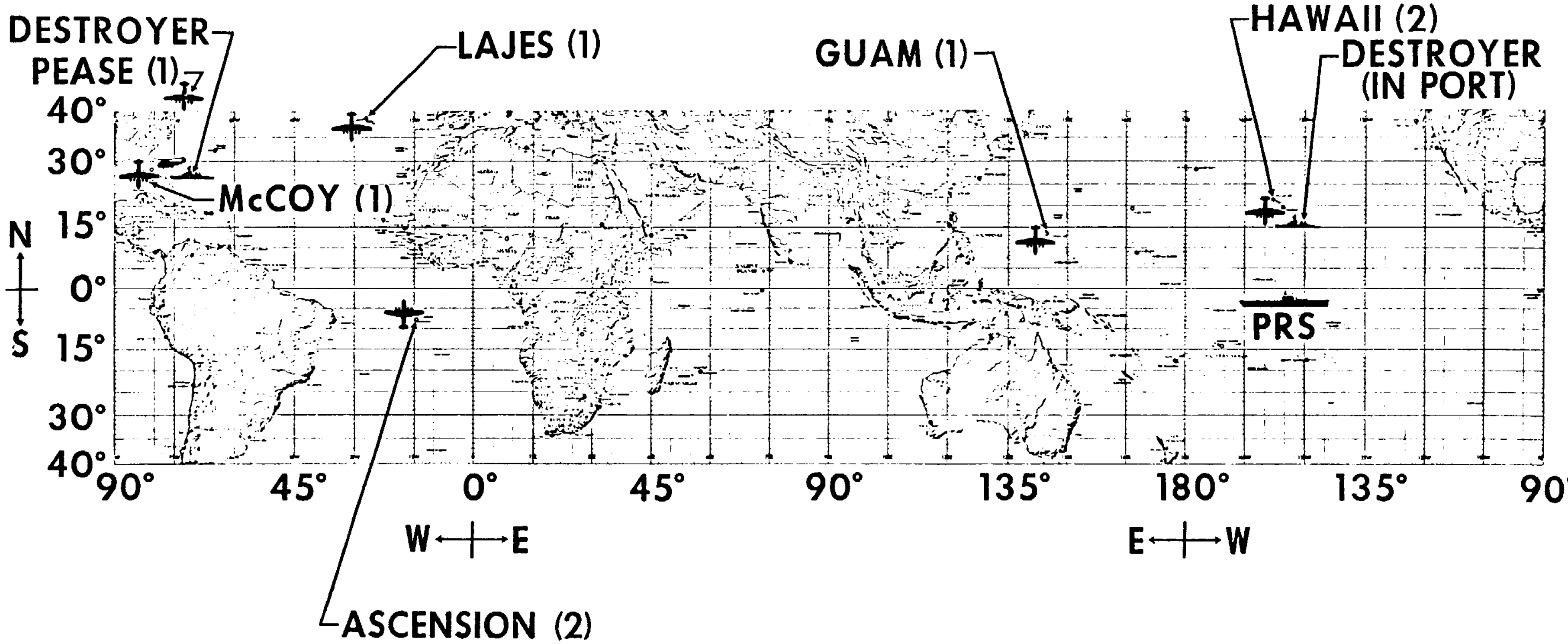


Fig. 17

CONFIGURATION DIFFERENCES

SPACE VEHICLE	REMARKS
Command/Service Module (CSM-109)	
• Changed Service Module Jettison Controller (SMJC) timers.	Allows additional SM movement away from CM prior to RCS termination during separation. Provides decreased probability of CM/SM recontact during earth entry.
• Added Lunar Topographic Camera system.	Provides for high resolution lunar topographic photography with image motion compensation.
• Added cabin fan filter.	Removes lunar dust.
Lunar Module (LM-7) (Ascent Stage)	
• Added "auto" and "attitude hold" modes in P66 and eliminated P65 and P67 software programs.	Aids crew during lunar landing in obscured visibility.
• Incorporated a non-clogging flow limiter in primary Environmental Control System lithium hydroxide canister.	Improves crew comfort by eliminating water in suit loop.
Lunar Module (LM-7) (Descent Stage)	
• Installed heat exchanger bypass line on descent stage fuel line.	Facilitates planned depressurization of fuel tanks after landing.
Spacecraft-LM Adapter (SLA-16)	
• (No significant differences.)	

LAUNCH VEHICLE

Instrument Unit (S-IU-508)

- Added fourth battery to IU. — Extends Command Communications System tracking to assist S-IVB/IU lunar impact trajectory corrections.

- Relocated and added telemetry measurements for vibration investigation of ST-124 inertial platform. — Provides data for analysis if a flight anomaly occurs on ST-124.

- Added four wires to IU Emergency Detection System distributor. — Provides automatic vehicle ground command capability at spacecraft separation in event of a contingency separation.

S-IVB Stage (S-IVB-508)

- (No significant differences.)

S-II Stage (S-II-8)

- Installed all spray foam insulation. — Reduces weight of the stage.

S-IC Stage (S-IC-8)

- (No significant differences.)

FLIGHT CREW

FLIGHT CREW ASSIGNMENTS

Prime Crew (Figure 18)

Commander (CDR) - James A. Lovell, Jr. (Captain, USN)
Command Module Pilot (CMP) - Thomas K. Mattingly, II
(Lieutenant Commander, USN)
Lunar Module Pilot (LMP) - Fred W. Haise, Jr. (Civilian)

Backup Crew

Commander (CDR) - John W. Young (Commander, USN)
Command Module Pilot (CMP) - John L. Swigert, Jr. (Civilian)
Lunar Module Pilot (LMP) - Charles M. Duke, Jr. (Major, USAF)

The backup crew follows closely the training schedule for the prime crew and functions in three significant categories. One, they receive nearly complete mission training which becomes a valuable foundation for later assignments as a prime crew. Two, should the prime crew become unavailable, the backup crew is prepared to fly as prime crew up until the last few weeks prior to launch. Three, they are fully informed assistants who help the prime crew organize the mission and check out the hardware.

During the final weeks before launch, the flight hardware and software, ground hardware and software, and flight crew and ground crews work as an integrated team to perform ground simulations and other tests of the upcoming mission. It is necessary that the flight crew that will conduct the mission take part in these activities, which are not repeated for the benefit of the backup crew. To do so would add an additional costly and time consuming period to the prelaunch schedule, which for a lunar mission would require rescheduling for a later lunar launch window.

PRIME CREW DATA

Commander

NAME: James A. Lovell, Jr. (Captain, USN)

SPACE FLIGHT EXPERIENCE: Captain Lovell was selected as an astronaut by NASA in September 1962. He has since served as backup pilot for the Gemini 4 flight and backup command pilot for the Gemini 9 flight.

PRIME CREW OF SEVENTH MANNED APOLLO MISSION

JAMES A. LOVELL, JR.   THOMAS K. MATTINGLY, II   FRED W. HAISE, JR.

Fig. 18

On 4 December 1965, he and command pilot Frank Borman were launched on the Gemini 7 Mission. The flight lasted 330 hours, 35 minutes and included the first rendezvous of two manned maneuverable spacecraft as Gemini 7 was joined in orbit by Gemini 6.

As command pilot, Lovell flew the 4-day, 59-revolution, Gemini 12 Mission in November 1966. This flight, which included a third-revolution rendezvous with a previously launched Agena, marked the successful completion of the Gemini Program.

Lovell served as Command Module Pilot on the 6-day Apollo 8 (21-27 December 1968) first manned flight to the moon. Apollo 8 performed 10 revolutions in lunar orbit and returned to an earth landing after a total flight time of 147 hours.

Captain Lovel has since served as the backup spacecraft Commander for Apollo 11, the first manned lunar landing. He has logged a total of 572 hours, 10 minutes of space flight in three missions.

Command Module Pilot

NAME: Thomas K. Mattingly, II (Lieutenant Commander, USN)

SPACE FLIGHT EXPERIENCE: Lieutenant Commander Mattingly was selected as an astronaut by NASA in April 1966. He has served as a member of the astronaut support crews for the Apollo 8 and 11 Missions.

Lunar Module Pilot

NAME: Fred W. Haise, Jr. (Civilian)

SPACE FLIGHT EXPERIENCE: Mr. Haise was selected as an astronaut by NASA in April 1966. He has served as a member of the astronaut backup crews for the Apollo 8 and 11 Missions.

BACKUP CREW DATA

Commander

NAME: John. W. Young (Commander, USN)

SPACE FLIGHT EXPERIENCE: Commander Young was selected as an astronaut by NASA in September 1962. He served as pilot on the first manned Gemini flight - a 3-orbit mission launched on 23 March 1965. Following that assignment he was backup pilot for Gemini 6.

On 18 July 1966, Young was the command pilot on the Gemini 10 Mission which made two successful rendezvous' and dockings with Agena target vehicles. Gemini 10 was a 3-day, 44-revolution earth orbital flight.

He was subsequently assigned as the backup Command Module Pilot for Apollo 7.

Commander Young flew as the Command Module Pilot on the Apollo 10 lunar orbital mission which performed all but the final minutes of an actual lunar landing.

Command Module Pilot

NAME: John L. Swigert, Jr. (Civilian)

SPACE FLIGHT EXPERIENCE: Mr. Swigert was selected as an astronaut by NASA in April 1966.

Lunar Module Pilot

NAME: Charles M. Duke, Jr. (Major, USAF)

SPACE FLIGHT EXPERIENCE: Major Duke was selected as an astronaut by NASA in April 1966.

MISSION MANAGEMENT RESPONSIBILITY

Title	Name	Organization
Director, Apollo Program	Dr. Rocco A. Petrone	NASA/OMSF
Mission Director	Capt. Chester M. Lee (Ret)	NASA/OMSF
Assistant Mission Director	Col. Thomas H. McMullen	NASA/OMSF
Director, Mission Operations	Maj. Gen. John D. Stevenson (Ret)	NASA/OMSF
Saturn Program Manager	Mr. Roy E. Godfrey	NASA/MSFC
Mission Operations Manager	Dr. Fridtjof A. Speer	NASA/MSFC
Apollo Spacecraft Program Manager	Col. James A. McDivitt	NASA/MSC
Director of Flight Operations	Mr. Sigurd A. Sjoberg	NASA/MSC
Flight Directors	Mr. Milton Windler Mr. Gerald D. Griffin Mr. Eugene F. Kranz Mr. Glynn S. Lunney	NASA/MSC
Spacecraft Commander (Prime)	Capt. James A. Lovell	NASA/MSC
Spacecraft Commander (Backup)	Cdr. John W. Young	NASA/MSC
Apollo Program Manager KSC	Mr. Edward R. Mathews	NASA/KSC
Director of Launch Operations	Mr. Walter J. Kapryan	NASA/KSC
Launch Operations Manager	Mr. Paul C. Donnelly	NASA/KSC

ABBREVIATIONS AND ACRONYMS

AGS	Abort Guidance System
ALSEP	Apollo Lunar Surface Experiments Package
AOS	Acquisition of Signal
APS	Ascent Propulsion System (LM)
APS	Auxiliary Propulsion System (S-IVB)
ARIA	Apollo Range Instrumentation Aircraft
AS	Apollo/Saturn
BIG	Biological Isolation Garment
CCATS	Communications, Command, and Telemetry System
CCGE	Cold Cathode Gauge Experiment
CDH	Constant Delta Height
CDR	Commander
CPLEE	Charged Particle Lunar Environment Experiment
CM	Command Module
CMP	Command Module Pilot
CSC	Close-up Stereo Camera
CSI	Concentric Sequence Initiation
CSM	Command/Service Module
DAC	Data Acquisition Camera
DDAS	Digital Data Acquisition System
DOD	Department of Defense
DOI	Descent Orbit Insertion
DPS	Descent Propulsion System
DSKY	Display and Keyboard Assembly
ECS	Environmental Control System
EI	Entry Interface
EMU	Extravehicular Mobility Unit
EPO	Earth Parking Orbit
EST	Eastern Standard Time
ETB	Equipment Transfer Bag
EVA	Extravehicular Activity
FM	Frequency Modulation
fps	Feet Per Second
FDAI	Flight Director Attitude Indicator
FTP	Fixed Throttle Position
GET	Ground Elapsed Time
GNCS	Guidance, Navigation, and Control System (CSM)
GSFC	Goddard Space Flight Center
HBR	High Bit Rate
HFE	Heat Flow Experiment
HTC	Hand Tool Carrier
IMU	Inertial Measurement Unit
IU	Instrument Unit
IVT	Intravehicular Transfer
KSC	Kennedy Space Center
LBR	Low Bit Rate
LCC	Launch Control Center
LDMK	Landmark
LEC	Lunar Equipment Conveyor
LES	Launch Escape System
LET	Launch Escape Tower
LH_2	Liquid Hydrogen
LiOH	Lithium Hydroxide
LM	Lunar Module
LMP	Lunar Module Pilot
LOI	Lunar Orbit Insertion
LOS	Loss of Signal
LOX	Liquid Oxygen
LPO	Lunar Parking Orbit
LR	Landing Radar
LRL	Lunar Receiving Laboratory
LRRR	Laser Ranging Retro-Reflector
LSM	Lunar Surface Magnetometer
LV	Launch Vehicle
MCC	Midcourse Correction
MCC	Mission Control Center
MESA	Modularized Equipment Stowage Assembly
MHz	Megahertz
MOCR	Mission Operations Control Room
MOR	Mission Operations Report
MPL	Mid-Pacific Line
MQF	Mobile Quarantine Facility
MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network
NASCOM	NASA Communications Network
NM	Nautical Mile
OMSF	Office of Manned Space Flight
OPS	Oxygen Purge System
ORDEAL	Orbital Rate Display Earth and Lunar
PCM	Pulse Code Modulation
PDI	Powered Descent Initiation
PGA	Pressure Garment Assembly
PGNCS	Primary Guidance, Navigation, and Control System (LM)
PLSS	Portable Life Support System
PSE	Passive Seismic Experiment
PTC	Passive Thermal Control
QUAD	Quadrant
RCS	Reaction Control System
RR	Rendezvous Radar
RLS	Radius Landing Site
RTCC	Real-Time Computer Complex
RTG	Radioisotope Thermoelectric Generator
S/C	Spacecraft
SEA	Sun Elevation Angle
S-IC	Saturn V First Stage
S-II	Saturn V Second Stage
S-IVB	Saturn V Third Stage
SIDE	Suprathermal Ion Detector Experiment
SLA	Spacecraft-LM Adapter
SM	Service Module
SPAN	Solar Particle Alert Network
SPS	Service Propulsion System
SRC	Sample Return Container
SSB	Single Side Band
SSR	Staff Support Room
SV	Space Vehicle
SWC	Solar Wind Composition Experiment
TD&E	Transposition, Docking and LM Ejection
TEC	Transearth Coast
TEI	Transearth Injection
TFI	Time From Ignition
TLC	Translunar Coast
TLI	Translunar Injection
TLM	Telemetry
TPF	Terminal Phase Finalization
TPI	Terminal Phase Initiation
T-time	Countdown Time (referenced to liftoff time)
TV	Television
USB	Unified S-Band
USN	United States Navy
USAF	United States Air Force
VAN	Vanguard
VHF	Very High Frequency
ΔV	Differential Velocity

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