PreLaunch
Mission Operation Report
No. M-932-69-10

MEMORANDUM

MAY 9 1969

To: A/Administrator

From: MA/Apollo Program Director

Subject: Apollo 10 Mission (AS-505)

No earlier than 18 May 1969, we plan to launch the next Apollo/Saturn V mission, Apollo 10. This will be the third manned Saturn V flight, the fourth flight of a manned Apollo Command/Service Module, and the second flight of a manned Lunar Module.

The Apollo 10 Mission will be a manned lunar mission development flight. It will demonstrate crew/space vehicle/mission support facilities performance during a manned lunar mission with the Command/Service Module and Lunar Module, and will evaluate Lunar Module performance in the cislunar and lunar environment. The mission will be about eight days in duration and will use the operational configuration of the Saturn V Launch Vehicle and Apollo Spacecraft.

Apollo 10 will be the first Saturn V flight launched from Pad B of Launch Complex 39 at the Kennedy Space Center. Five daily launch windows per month have been selected for May, June, and July. The first three days of each monthly window provide favorable lunar lighting conditions for the primary Apollo 11 Mission landing sites. The last two days of each monthly window provide slightly degraded lunar lighting conditions. Lunar operations will simulate the Apollo 11 Mission timeline as closely as possible. Recovery will be in the Pacific Ocean at 165 degrees west longitude and at southern latitudes for the first two days of each monthly window and at 175 degrees west longitude and northern latitudes thereafter.

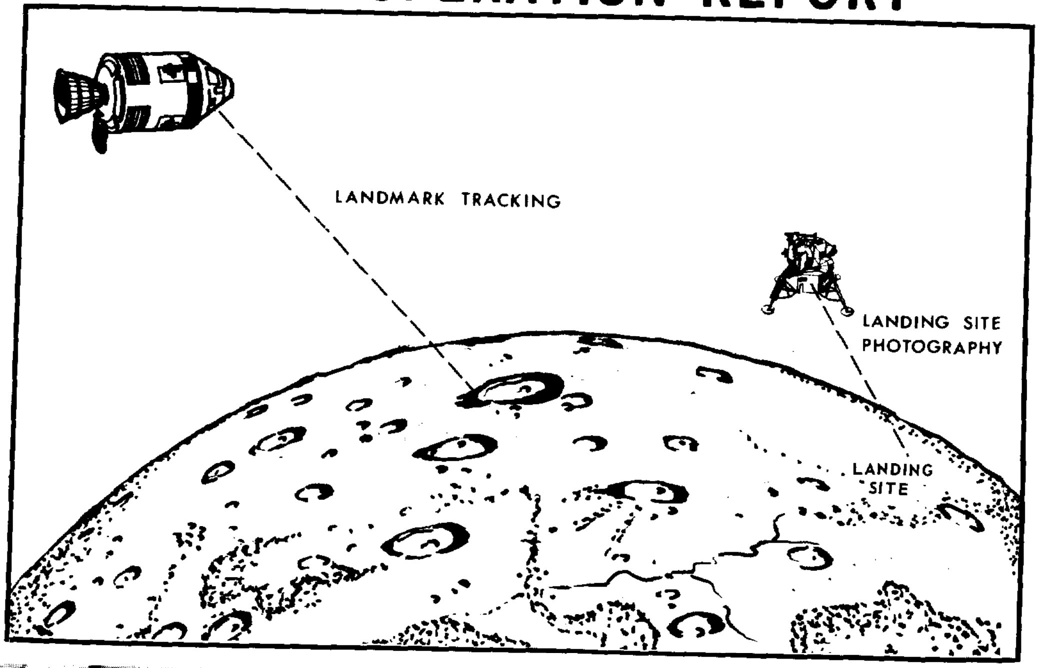
Sam C. Phillips
Lt. General, USAF
Apollo Program Director

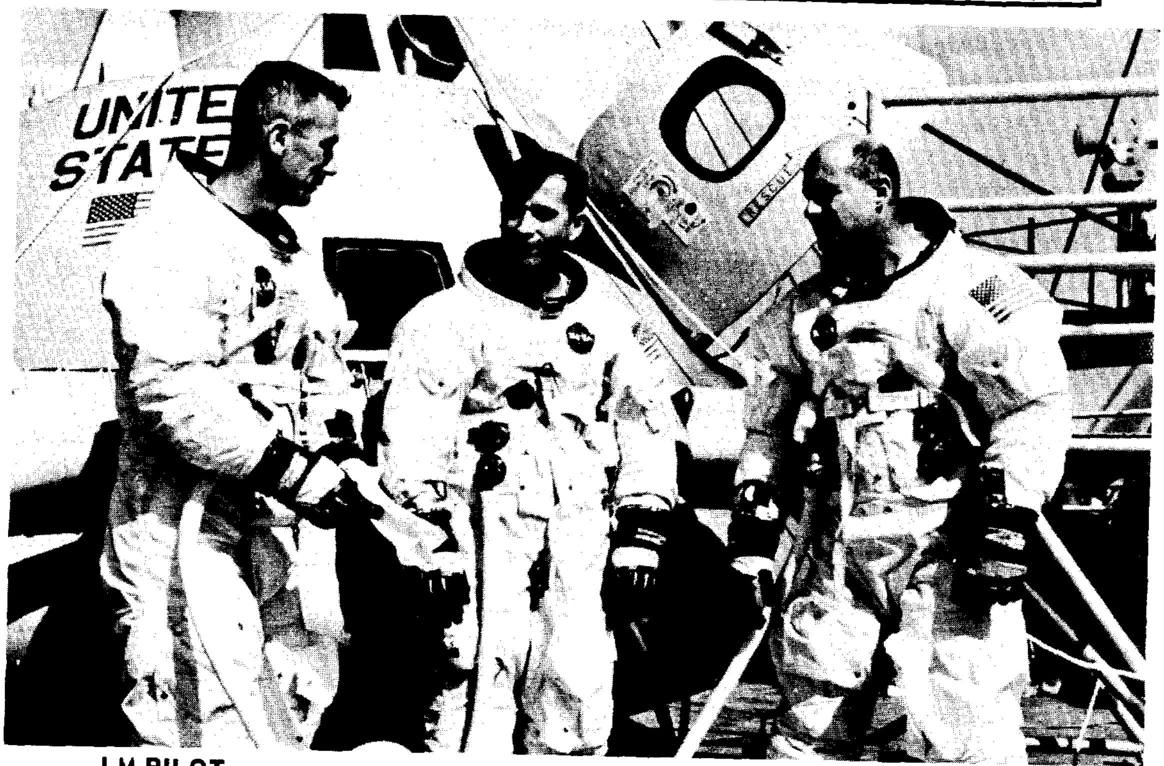
APPROVAL:

George E. Mueller
Associate Administrator for
Manned Space Flight

Report No.

MISSION OPERATION REPORT





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APOLLO 10 (AS-505) MISSION

OFFICE OF MANNED SPACE FLIGHT
Prepared by: Apollo Program Office-MAO

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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 August 15, 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.

Because of their sometimes highly technical orientation, distribution of these reports is limited to personnel having program-project management responsibilities. The Office of Public Affairs publishes a comprehensive series of pre-launch and post-launch reports on NASA flight missions, which are available for general distribution.

The Apollo 10 Mission Operation Report is published in two volumes: the Mission Operation Report (MOR); and the Mission Operation Report Supplement. This format was designed to provide a mission-oriented document in the MOR with only a very brief description of the space vehicle and support facilities. The MOR Supplement is a program-oriented reference document with a more comprehensive description of the space vehicle, launch complex, and mission monitoring, support, and control facilities. The MOR Supplement was issued on 25 February 1969 for the previous mission, Apollo 9, and will not be reissued for this mission.

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THE APOLLO 10 MISSION

The Apollo 10 Mission will be a manned lunar mission development flight. It will demonstrate crew/space vehicle/mission support facilities performance during a manned lunar mission with the Command/Service Module (CSM) and Lunar Module (LM), and will evaluate LM performance in the cislunar and lunar environment. In addition, more knowledge of the lunar gravitational effect, additional refinement of Manned Space Flight Network tracking techniques, and landmark tracking will be obtained. The mission will be about eight days in duration and will use the operational configuration of the Saturn V Launch Vehicle and Apollo Spacecraft with the LM Ascent Propulsion System (APS) propellant tanks loaded to half capacity.

The mission profile through descent orbit insertion will be similar to the first lunar landing mission including targeting for specific lunar landing sites. During the LM-active phase, the manned LM will perform a minimum energy descent to approximately 50,000 feet above the lunar surface. The LM will then perform a phasing revolution to make the required adjustment in the CSM lead angle prior to orbit insertion. The rendezvous maneuvers will be performed as on a lunar landing mission. Prior to phasing, the lunar surface will be photographed from the LM. After the LM-active phase, an unmanned LM APS burn to propellant depletion will be performed. Between the APS depletion burn and the transearth injection burn, lunar surface photography and lunar landmark tracking from the CSM will be accomplished.

Earth touchdown will be in the Pacific Ocean at 165°W longitude within ±35° latitude and will nominally occur eight days from launch. The recovery line shifts westward starting at 0° latitude until it reaches 175°W longitude at 15°N latitude and then continues north to 35°N latitude.

The Apollo 10 Mission will provide the following first-time in-flight opportunities:

- Lunar orbit rendezvous.
- Docked lunar landmark tracking.
- LM steerable antenna operation at distances greater than those of low earth orbit enabling its evaluation under conditions for which it was designed.
- Descent Propulsion System engine burn in the lunar landing mission configuration and environment.
- Lunar landing mission profile simulation (except for powered descent, lunar surface activity, and ascent).
- Low level (50,000 feet) evaluation of lunar visibility.

- Docked CSM/LM thermal control in the absence of earth albedo and during long periods of sunlight.
- LM omnidirectional antenna operation at lunar distance.
- Abort Guidance System operation during an APS burn over the range of inertias for a lunar mission.
- VHF ranging during a rendezvous.
- Landing radar operation near lunar environment where the reflected energy from the lunar surface will be detected.
- Transposition, docking, and LM ejection in daylight after the S-IVB burn when the S-IVB is in inertial hold attitude and while the spacecraft is moving away from the earth.
- Translunar midcourse correction with a docked CSM/LM.
- LM Digital Uplink Assembly first flight (replaces Digital Command Assembly used on LM-3).

PROGRAM DEVELOPMENT

The first Saturn vehicle was successfully flown on 27 October 1961 to initiate operations of the Saturn I Program. A total of 10 Saturn I vehicles (SA-1 to SA-10) was successfully flight tested to provide information on the integration of launch vehicle and spacecraft and to provide operational experience with large multiengined booster stages (S-I, S-IV).

The next generation of vehicles, developed under the Saturn IB Program, featured an uprated first stage (S-IB) and a more powerful new second stage (S-IVB). The first Saturn IB was launched on 26 February 1966. The first three Saturn IB missions (AS-201, AS-203, and AS-202) successfully tested the performance of the launch vehicle and spacecraft combination, separation of the stages, behavior of liquid hydrogen in a weightless environment, performance of the Command Module heat shield at low earth orbital entry conditions, and recovery operations.

The planned fourth Saturn IB mission (AS-204) scheduled for early 1967 was intended to be the first manned Apollo flight. This mission was not flown because of a spacecraft fire, during a manned prelaunch test, that took the lives of the prime flight crew and severely damaged the spacecraft. The SA-204 Launch Vehicle was later assigned to the Apollo 5 Mission.

The Apollo 4 Mission was successfully executed on 9 November 1967. This mission initiated the use of the Saturn V Launch Vehicle (SA-501) and required an orbital restart of the S-IVB third stage. The spacecraft for this mission consisted of an unmanned Command/Service Module (CSM) and a Lunar Module test article (LTA). The CSM Service Propulsion System (SPS) was exercised, including restart, and the Command Module Block II heat shield was subjected to the combination of high heat load, high heat rate, and aerodynamic loads representative of lunar return entry. All primary mission objectives were successfully accomplished.

The Apollo 5 Mission was successfully launched and completed on 22 January 1968. This was the fourth mission utilizing Saturn IB vehicles (SA-204). This flight provided for unmanned orbital testing of the Lunar Module (LM-1). The LM structure, staging, and proper operation of the Lunar Module Ascent Propulsion System (APS) and Descent Propulsion System (DPS), including restart, were verified. Satisfactory performance of the S-IVB/Instrument Unit (IU) in orbit was also demonstrated. All primary objectives were achieved.

The Apollo 6 Mission (second unmanned Saturn V) was successfully launched on 4 April 1968. Some flight anomalies encountered included oscillation reflecting propulsion-structural longitudinal coupling, an imperfection in the Spacecraft LM Adapter (SLA) structural integrity, and certain malfunctions of the J-2 engines in the S-II and S-IVB stages. The spacecraft flew the planned trajectory, but preplanned high velocity re-entry conditions were not achieved. A majority of the mission objectives for Apollo 6 were accomplished.

The Apollo 7 Mission (first manned Apollo) was successfully launched on 11 October 1968. This was the fifth and last planned Apollo mission utilizing a Saturn IB Launch Vehicle (SA-205). The 11-day mission provided the first orbital tests of the Block II Command/Service Module. All primary mission objectives were successfully accomplished. In addition, all planned detailed test objectives, plus three that were not originally scheduled, were satisfactorily accomplished.

The Apollo 8 Mission was successfully launched on 21 December and completed on 27 December 1968. This was the first manned flight of the Saturn V Launch Vehicle and the first manned flight to the vicinity of the moon. All primary mission objectives were successfully accomplished. In addition, all detailed test objectives plus four that were not originally scheduled, were successfully accomplished. Ten orbits of the moon were successfully performed with the last eight circular at an altitude of 60 NM. TV and photographic coverage was successfully carried out, with telecasts to the public being made in real time.

The Apollo 9 Mission was successfully launched on 3 March and completed on 13 March 1969. This was the second manned Saturn V flight, the third flight of a manned Apollo Command/Service Module, and the first flight of a manned Lunar Module. This flight provided the first manned LM systems performance demonstration. All primary mission objectives were successfully accomplished. All detailed test objectives were accomplished except two associated with S-band and VHF communications which were partially accomplished. The S-IVB second orbital restart, CSM transposition and docking, and LM rendezvous and docking were also successfully demonstrated.

NASA OMSF PRIMARY MISSION OBJECTIVES

FOR APOLLO 10

PRIMARY OBJECTIVES

- Demonstrate crew/space vehicle/mission support facilities performance during a manned lunar mission with CSM and LM.

- Evaluate LM performance in the cislunar and lunar environment.

Sam C. Phillips
Lt. General, USAF
Apollo Program Director

Date: 6 May 1969

George E. Mueller
Associate Administrator for
Manned Space Flight

Date: MAY 8 1969

DETAILED TEST OBJECTIVES

The Detailed Test Objectives (DTO's) listed below have been assigned to the Apollo 10 Mission. Principal DTO's are planned for accomplishment on the Apollo 10 Mission in order to demonstrate a lunar landing capability. Secondary DTO's are not prerequisites to a lunar landing mission, but will provide significant data or experience. No mandatory DTO's will be performaned on this mission.

LAUNCH VEHICLE*

Secondary DTO's

- Verify J-2 engine modifications.
- Confirm J-2 engine environment in S-II and S-IVB stages.
- Confirm launch vehicle longitudinal oscillation environment during S-IC stage burn period.
- Verify that modifications incorporated in the S-IC stage suppress low frequency longitudinal oscillations.
- Confirm launch vehicle longitudinal oscillation environment during S-II stage burn period.
- Demonstrate that early center engine cutoff for S-II stage suppresses low frequency longitudinal oscillations.

SPACECRAFT

Principal DTO's

- Demonstrate CSM/LM rendezvous capability for a lunar landing mission (20.78).
- Perform manual and automatic acquisition, tracking, and communications with MSFN using the steerable S-band antenna at lunar distance (16.10).
- Perform lunar landmark tracking from the CSM while in lunar orbit (20.121).
- Perform lunar landmark tracking in lunar orbit from the CSM with the LM attached (20.91).

*No principal DTO's have been assigned.

- Operate the landing radar at the closest approach to the moon and during DPS burns (16.14).
- Obtain data on the CM and LM crew procedures and timeline for the lunar orbit phase of a lunar landing mission (20.66).
- Perform PGNCS/DPS undocked Descent Orbit Insertion (DOI) and a high thrust maneuver (11.15).

Secondary DTO's

- Demonstrate LM/CSM/MSFN communications at lunar distance (16.17).
- Communicate with MSFN using the LM S-band omniantennas at lunar distance (16.12).
- Obtain data on the rendezvous radar performance and capability near maximum range (16.15).
- Obtain supercritical helium system pressure data while in standby conditions and during all DPS engine firings (13.14).
- Perform an unmanned AGS-controlled APS burn (12.9).
- Obtain data on the operational capability of VHF ranging during a LM-active rendezvous (20.77).
- Obtain data on the effects of lunar illumination and contrast conditions on crew visual perception while in lunar orbit (20.86).
- Obtain data on the Passive Thermal Control (PTC) system during a lunar orbit mission (7.26).
- Demonstrate CSM/LM passive thermal control modes during a lunar orbit mission (20.79).
- Demonstrate RCS translation and attitude control of the staged LM using automatic and manual AGS/CES control (12.8).
- Evaluate the ability of the AGS to perform a LM-active rendezvous (12.10).
- Monitor PGNCS/AGS performance during lunar orbit operations (20.82).
- Demonstrate operational support for a CSM/LM lunar orbit mission (20.80).

- Perform a long duration unmanned APS burn (13.13).
- Perform lunar orbit insertion using SPS GNCS-controlled burns with a docked CSM/LM (20.117).
- Obtain data to verify IMU performance in the flight environment (11.17).
- Perform a reflectivity test using the CSM S-band high-gain antenna while docked (6.9).
- Perform CSM transposition, docking, and CSM/LM ejection after the S-IVB TLI burn (20.46).
- Perform translunar midcourse corrections (20.95).
- Obtain AGS performance data in the flight environment (12.6).
- Perform star-lunar landmark sightings during the transearth phase (1.39).
- Obtain data on LM consumables for a simulated lunar landing mission, in lunar orbit, to determine lunar landing mission consumables (20.83).

LAUNCH COUNTDOWN AND TURNAROUND CAPABILITY, AS-505

COUNTDOWN

Countdown for the Apollo 10 Mission will begin with a precount period starting at T-93 hours during which Launch Vehicle (LV) and Spacecraft (SC) countdown activities will be independently conducted. Coordinated SC and LV launch countdown will contain only a single built-in hold (6 hours at T-9). It is anticipated that additional holds (assuming slack time is available) will be inserted at advantageous times after the Count Down Demonstration Test has been completed. Figure 1 shows the significant launch countdown events.

SCRUB/TURNAROUND

The space vehicle turnaround will begin immediately following a scrub during the countdown. Turnaround is the time required to recycle and countdown to launch (T-0). A 3-day scrub turnaround is planned for AS-505. Activity times are considered to be minimal and do not account for serial time which may be required for repair and retest of any system which may have caused the scrub.

Six primary cases can be identified to implement the required turnaround activities in preparation for a subsequent launch attempt following a countdown scrub prior to ignition. These cases identify the turnaround activities necessary to maintain the same confidence for subsequent launch attempts as for the original attempt. The six cases are:

Case 1. Scrub/turnaround at post-LV cryogenic loading - CSM/LM cryogenic reservicing (65 hours 45 minutes).

Case 2. Scrub/turnaround at post-LV cryogenic loading - LM cryogenic reservicing (39 hours 15 minutes).

Case 3. Scrub/turnaround at post-LV cryogenic loading - LM cryogenic reservicing (23 hours 15 minutes).

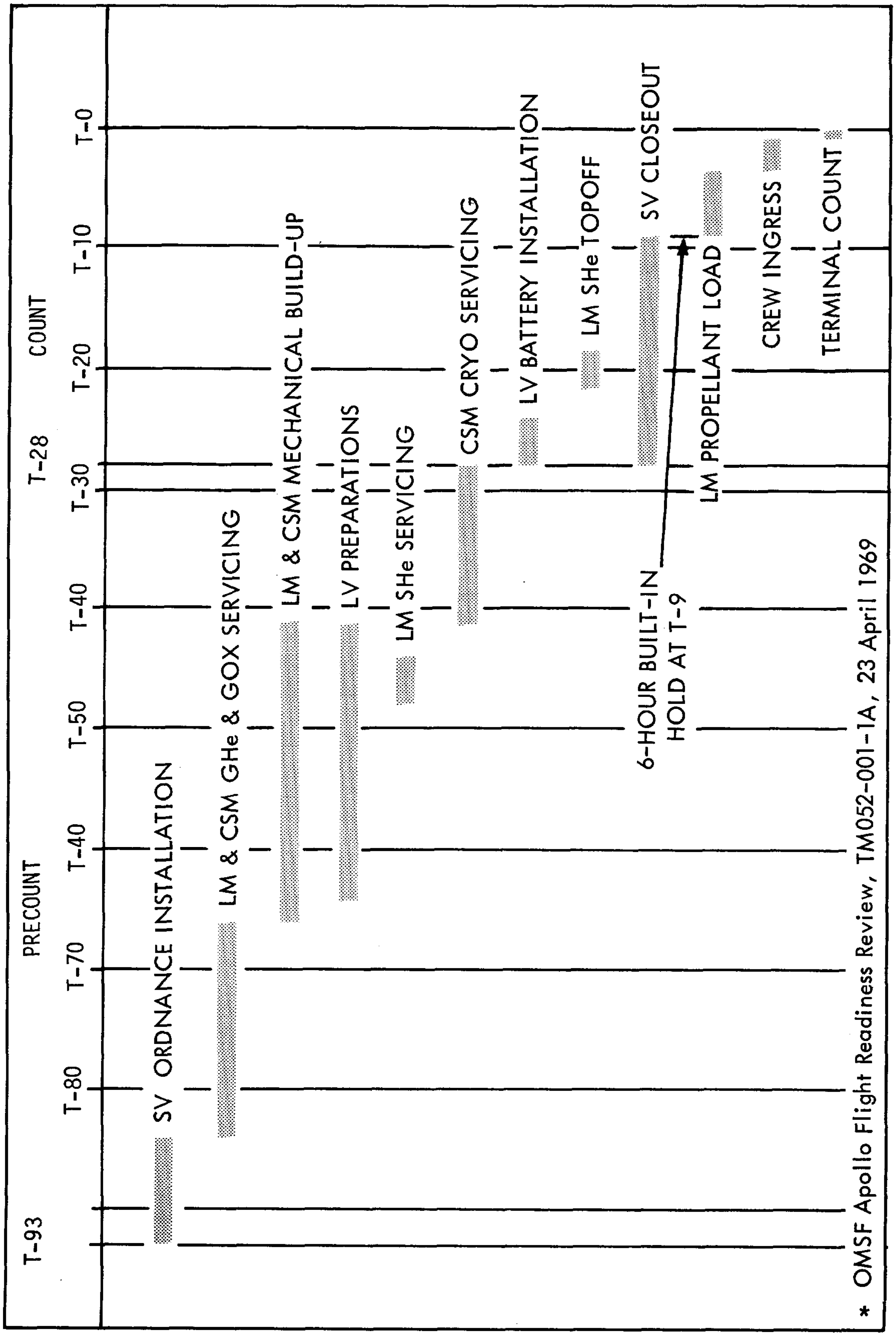
Case 4. Scrub/turnaround at pre-LV cryogenic loading - CSM/LM cryogenic reservicing (55 hours 30 minutes).

Case 5. Scrub/turnaround at pre-LV cryogenic loading - LM cryogenic reservicing (32 hours 00 minutes).

Case 6. Scrub/turnaround at pre-LV cryogenic loading - No CSM/LM cryogenic reservicing (hold for next launch window).

A second scrub/turnaround would result in a combination of cases and each combination presents special considerations.

*LAUNCH COUNTDOWN, AS-505



* OMSF Apollo Flight Readiness Review, TM052-001-1A, 23 April 1969

DETAILED FLIGHT MISSION DESCRIPTION

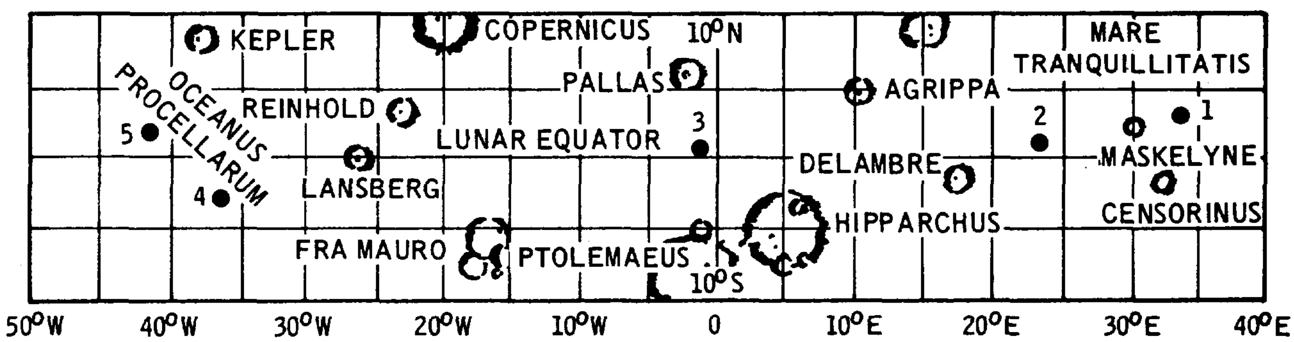
LAUNCH WINDOWS

Launch windows are based on range safety flight azimuth limits of 72° to 108° (based on the earth-fixed heading of the launch vehicle at the beginning of the pitch program), on booster and spacecraft performance, on insertion tracking, and on meeting lighting constraints at the candidate lunar landing sites. The minimum operational daily window is 2-1/2 hours. Mission planning allows for launch attempts during each of three consecutive months, starting at the planning date in the Apollo launch schedule. Current guidelines call for mission plans to be based on sites (and launch windows) approved for the initial lunar landing mission.

LUNAR LANDING SITES

The following landing sites have been approved for mission planning:

SITE	LAT.	LONG.	DATE	MAY (EDT) OPEN-CLOSE	SEA
2	0°44'N	23°39'E	18	12:49-17:09	11°
3	0°22'N	1°21'W	20	13:03-17:24	10.5°
4	3°39'S	36°42'W	23	13:12-17:35	10°
5	1°46'N	41°56'W	24	13:15-17:40	17°
5	1°46'N	41°56'W	25	13:19-17:45	28°*



* HIGH SUN ELEVATION ANGLE (SEA) IS ACCEPTED AT SITE 5 TO EXTEND LAUNCH WINDOW TO FIVE OPPORTUNITIES.

NOMINAL MISSION

The launch date set for Apollo 10 is 18 May 1969 at 12:49 EDT. The launch azimuth will be 72 degrees, translunar injection will occur during the second orbit over the Pacific Ocean, and the targeted lunar landing site will be Site 2. The duration of this mission will be approximately 8 days with a lunar orbital stay time of about 61.5 hours. Transearth flight time will be approximately 53.5 hours and touchdown will occur in the Pacific Ocean at 165°W longitude, 15°S latitude.

A summary flight profile of the Apollo 10 Mission is shown in Figure 2 and the summary flight plan is shown in Figure 3.

The sequence of events for the Apollo 10 Mission is given in Table 1. Launch Vehicle (LV) Time Base (TB) notations are also included. TB's may be defined as precise initial points upon which succeeding critical preprogrammed activities or functions may be based. The TB's noted in Table 1 are for a nominal mission and presuppose nominal LV performance. However, should the launch vehicle stages produce non-nominal performance, the launch vehicle computer will recompute the subsequent TB's and associated burns to correct LV performance to mission rules.

First Period of Activity

The Saturn V Launch Vehicle will place the following vehicle combination into a 103-NM circular earth parking orbit: S-IVB stage, Instrument Unit (IU), Lunar Module (LM), Spacecraft LM Adapter (SLA) and Command/Service Module (CSM). The ascent trajectory is shown in Figure 4. The launch time and azimuth are chosen to support two translunar injection (TLI) opportunities for an optimized payload. Checkout of the S-IVB, IU, and CSM will be accomplished during this orbital coast period. The earth orbital configuration is shown in Figure 5.

The S-IVB J-2 engine will be reignited during the second parking orbit to inject the vehicle combination into a translunar trajectory. Within 2 hours after injection, the CSM will be separated from the remainder of the vehicle and will transpose, dock with the LM, and initiate ejection of the CSM/LM from the SLA/IU/S-IVB as shown in Figure 6. A pitchdown maneuver of a prescribed magnitude for this transposition, docking, and ejection (TD&E) phase is designed to place the sun over the shoulders of the crew, avoiding CSM shadow on the docking interface. The pitch maneuver also provides continuous tracking and communications during the inertial attitude hold during TD&E. A Service Propulsion System (SPS) evasive maneuver will place the docked spacecraft, as shown in Figure 7, on a free-return trajectory. A free-return to earth will be possible if the insertion into lunar parking orbit cannot be accomplished. Land landing is dictated by the free-return constraints for some opportunities, but can be avoided by a corrective maneuver at an acceptable time during the translunar coast. Any necessary spacecraft midcourse corrections (MCC) will be accomplished during translunar coast. These corrections will utilize the Manned Space Flight Network (MSFN) for navigation.

APOLLO 10 FLIGHT PROFILE

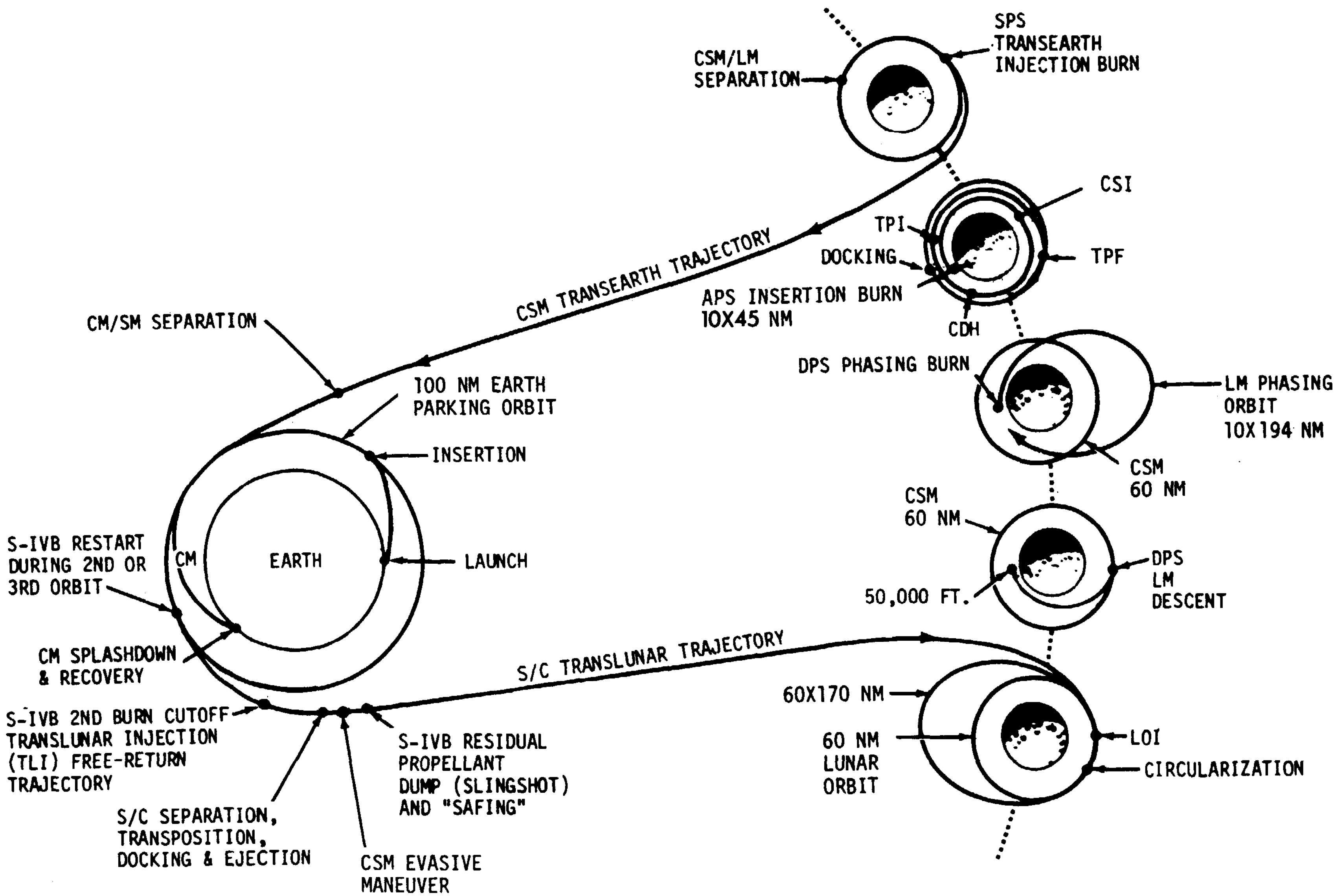


Fig. 2

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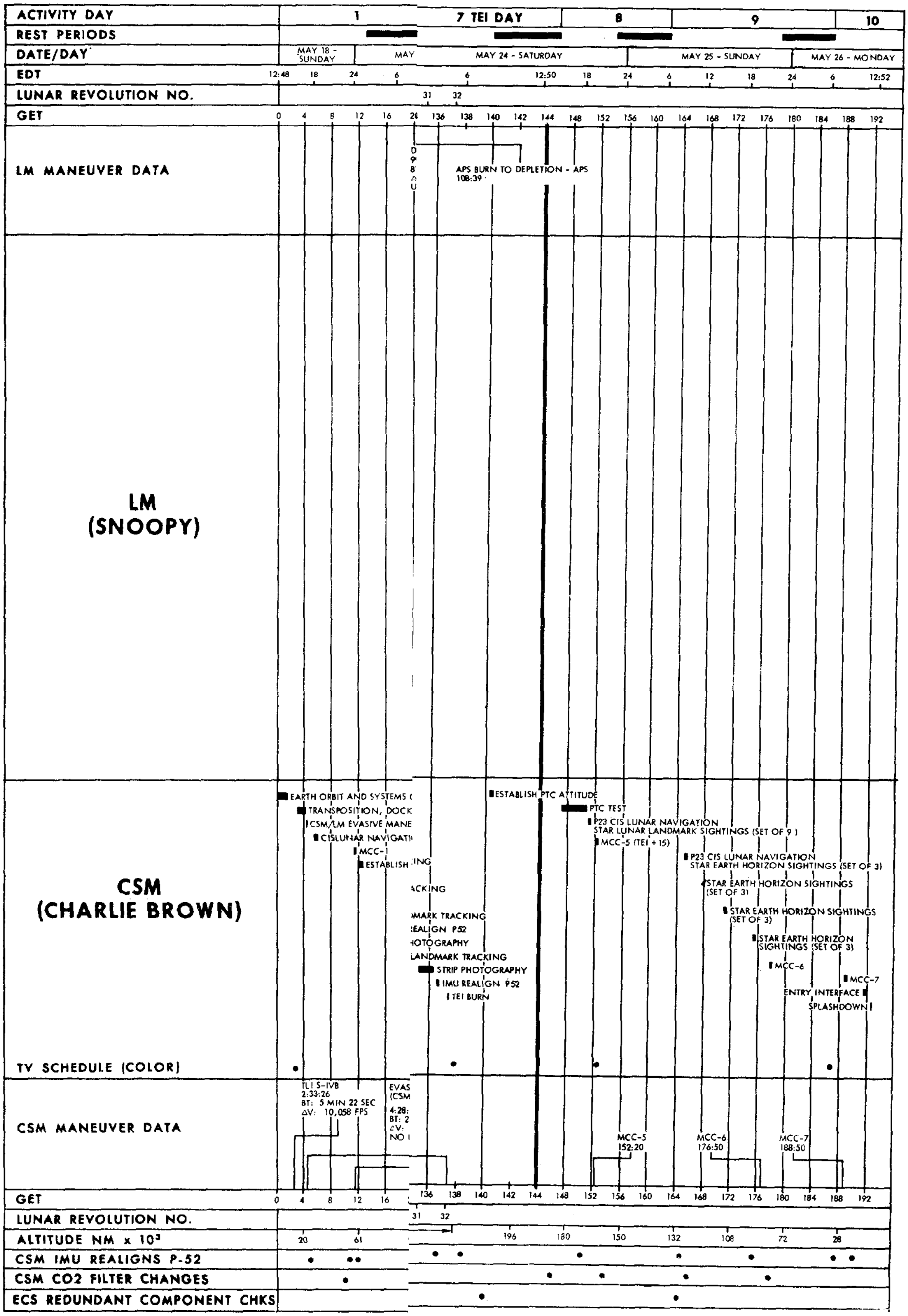

ACTIVITY DAY
1
7 TEI DAY
8
9
10
REST PERIODS
DATE/DAY
MAY 18 - SUNDAY
MAY
MAY 24 - SATURDAY
MAY 25 - SUNDAY
MAY 26 - MONDAY
EDT
LUNAR REVOLUTION NO.
31
32
GET
0 4 8 12 16 24 136 138 140 142 144 148 152 156 160 164 168 172 176 180 184 188 192
LM MANEUVER DATA
APS BURN TO DEPLETION - APS
108:39
LM
(SNOOPY)
CSM
(CHARLIE BROWN)
EARTH ORBIT AND SYSTEMS
TRANSPOSITION, DOCK
CSM/LM EVASIVE MANE
CISLUNAR NAVIGATI
MCC-1
ESTABLISH
ESTABLISH PTC ATTITUDE
PTC TEST
P23 CIS LUNAR NAVIGATION
STAR LUNAR LANDMARK SIGHTINGS (SET OF 9)
MCC-5 (TEI + 15)
P23 CIS LUNAR NAVIGATION
STAR EARTH HORIZON SIGHTINGS (SET OF 3)
STAR EARTH HORIZON SIGHTINGS (SET OF 3)
STAR EARTH HORIZON SIGHTINGS (SET OF 3)
STAR EARTH HORIZON SIGHTINGS (SET OF 3)
MCC-6
MCC-7
ENTRY INTERFACE
SPLASHDOWN
LANDMARK TRACKING
STRIP PHOTOGRAPHY
IMU REALIGN P52
TEI BURN
TV SCHEDULE (COLOR)
CSM MANEUVER DATA
TLI S-IVB
2:33:26
BT: 5 MIN 22 SEC
ΔV: 10,058 FPS
MCC-5
152:20
MCC-6
176:50
MCC-7
188:50
ALTITUDE NM x 10³
20
61
196
180
150
132
108
72
28
CSM IMU REALIGNS P-52
CSM CO2 FILTER CHANGES
ECS REDUNDANT COMPONENT CHKS

Fig. 3

TABLE 1

APOLLO 10 SEQUENCE OF EVENTS*

Ground Elapsed Time (GET) HR:MIN:SEC:	Event
00:00:00	Lift-off - Time Base (TB) - 1
00:00:30	SV Roll Complete
00:01:17	Max Q (Maximum Dynamic Pressure)
00:02:15	S-IC Inboard Engine Cutoff - TB2
00:02:40	S-IC Outboard Engine Cutoff - TB3
00:02:42	S-IC/S-II Separation
00:02:42	S-II Ignition
00:03:16	Launch Escape Tower Jettison
00:09:14	S-II Engine Cutoff - TB4
00:09:15	S-II/S-IVB Separation
00:09:18	S-IVB Ignition
00:11:43	S-IVB Cutoff - TB5
00:11:53	Earth Parking Orbit Insertion
00:13:00	S-IVB Restart Preparations - TB6
02:33:26	S-IVB Ignition (Translunar Injection)
02:38:48	S-IVB Cutoff - TB7
03:00:00	CSM/S-IVB Separation, SLA Panel Jettison
03:10:00	CSM Turnaround and Dock
04:09:00	CSM/LM Ejection from S-IVB
04:29:00	CSM/LM SPS Evasive Maneuver
04:39:00	S-IVB Slingshot Maneuver
11:33:00	Midcourse Correction - 1 (SPS)
12:55:00	Crew Rest (9 hours)
26:33:00	Midcourse Correction - 2
27:15:00	TV Transmission to Goldstone
34:00:00	Crew Rest (9 hours)
53:45:00	Midcourse Correction - 3
54:00:00	TV Transmission to Goldstone (15 minutes)
58:00:00	Crew Rest (10 hours)
70:45:00	Midcourse Correction - 4
72:20:00	TV Transmission to Goldstone (15 minutes)
75:45:00	Lunar Orbit Insertion - 1
80:10:00	Lunar Orbit Insertion - 2 (Circularization)
80:45:00	TV Transmission to Goldstone (10 minutes)
84:40:00	Crew Rest (8 hours)

* Based on MSC Revision 1 of Spacecraft Operational Trajectory for Apollo 10, 28 April 1969, and Saturn V AS-505 Apollo 10 Mission LV Operational Trajectory, 17 April 1969.

TABLE 1 (Continued)

94:25:00	Intravehicular Transfer to LM
98:10:00	LM/CSM Separation
98:13:00	TV Transmission to Goldstone (10 minutes)
99:34:00	Descent Orbit Insertion
100:20:00	Landing Radar Operation and Photography
100:46:00	Phasing Maneuver (DPS)
102:33:00	Descent Stage Jettison (LM RCS)
102:43:00	Insertion (APS)
103:34:00	Concentric Sequence Initiation
104:32:00	Constant Delta Height Maneuver
105:09:00	Terminal Phase Initiation
106:20:00	LM/CSM Docking
108:09:00	LM Jettison
108:35:00	TV Transmission to Goldstone (15 minutes)
108:39:00	LM APS Burn to Depletion
109:00:00	Crew Rest
119:30:00	Strip Photography (Revolution 23)
122:17:00	Landmark Tracking
126:20:00	TV Transmission to Goldstone (40 minutes)
128:10:00	Lunar Landing Site Photography
128:40:00	Crew Rest (3.5 hours)
137:20:00	Transearth Injection
137:45:00	TV Transmission to Honeysuckle (15 minutes) (Canberra, Australia)
140:30:00	Crew Rest (5.5 hours)
152:20:00	Midcourse Correction - 5
152:35:00	TV Transmission to Goldstone (10 minutes)
154:05:00	Crew Rest (9 hours)
176:50:00	Midcourse Correction - 6
177:30:00	Crew Rest (8 hours)
186:50:00	TV Transmission to Honeysuckle (15 minutes)
188:50:00	Midcourse Correction - 7
191:35:00	CM/SM Separation
191:50:00	Entry Interface
191:50:26	S-band Blackout
191:51:24	Peak G
191:53:26	S-band Blackout Exit
191:58:33	Drogue Parachute Deployment
191:59:22	Main Parachute Deployment
192:04:00	Touchdown

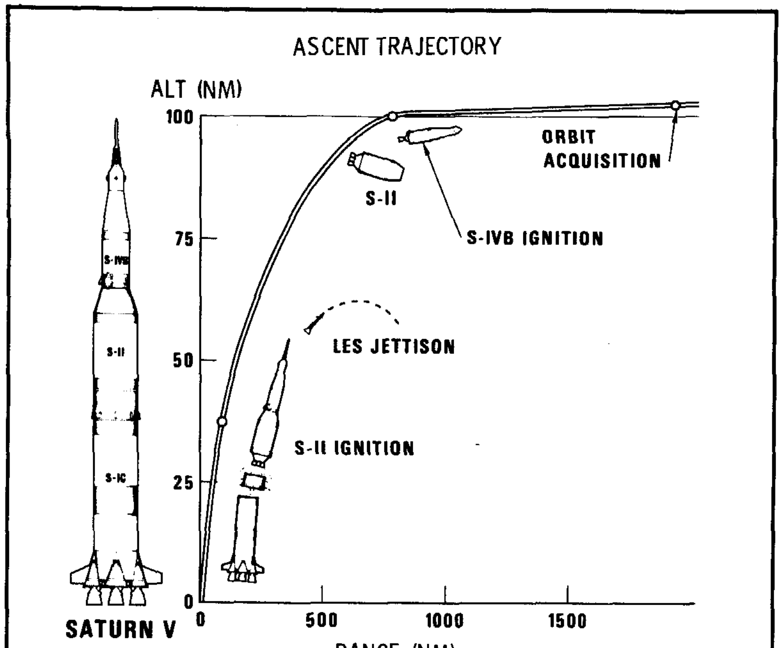


Fig. 4

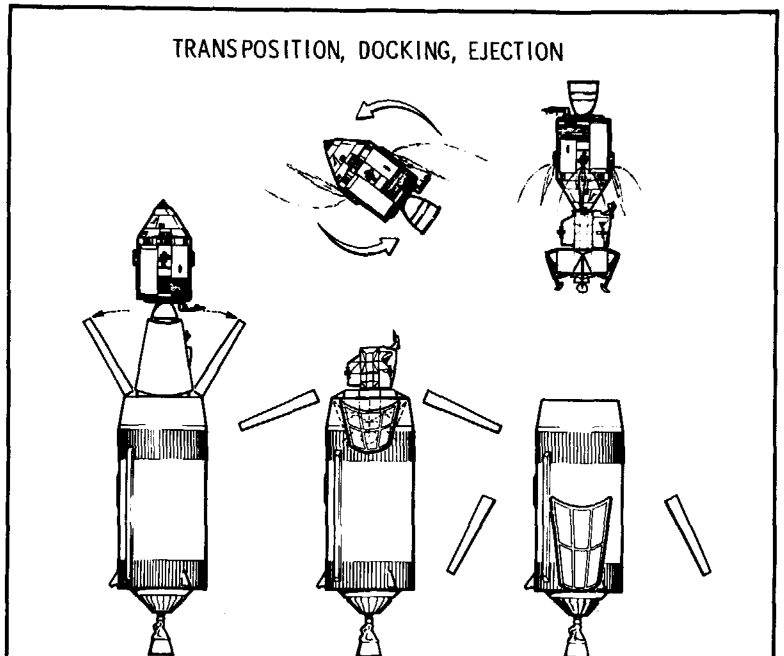


Fig. 6

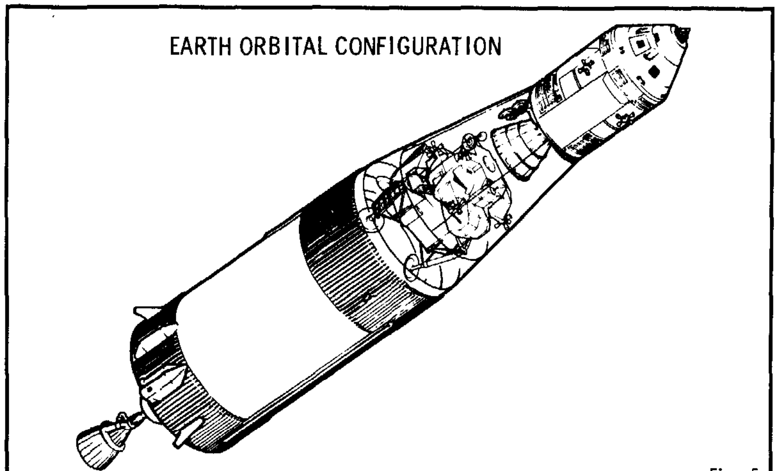


Fig. 5

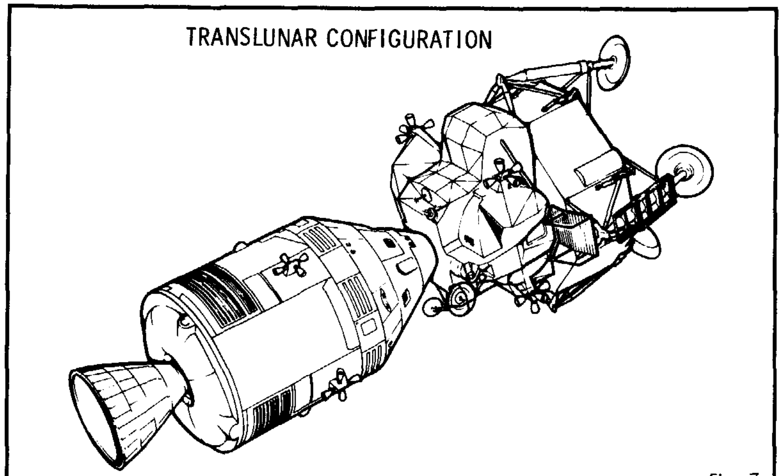


Fig. 7

Shortly after the spacecraft evasive maneuver, any available residual stage propellants and the Auxiliary Propulsion System (APS) of the S-IVB will be used to perform a retrograde maneuver to reduce the possibility of S-IVB contact with the spacecraft, earth, or moon. S-IVB stage safing will subsequently be performed.

Second Period of Activity

Passive thermal control will be initiated after the first MCC and will be maintained throughout the translunar coast phase unless interrupted by a subsequent MCC. The constraints influencing the translunar coast attitude timeline are thermal control, communications, crew rest cycle, and preferred times of MCC. The translunar coast phase will span approximately 73 hours.

The SPS will be used to insert the docked spacecraft into lunar orbit as shown in Figure 8. The lunar insertion orbit altitude will be approximately 60 x 170 NM. Following insertion, approximately two revolutions in the 60 x 170 NM orbit, and navigation update, the orbit will be circularized at 60 NM. The SPS burn will be initiated near pericynthion of the second revolution. After circularization of the lunar orbit, some LM housekeeping will be accomplished. Subsequently, a simultaneous rest and eat period of approximately 8 hours will be provided for the three astronauts prior to checkout of the LM.

Third Period of Activity

The Commander and Lunar Module Pilot will enter the LM, perform a thorough check of all systems, and undock from the Command/Service Module. The Service Module Reaction Control System (SM RCS) will be used to separate about 30 feet from the LM. Stationkeeping will be initiated at this point while the Command Module Pilot in the CSM visually inspects the LM. The SM RCS will then be used to perform a separation maneuver directed radially downward toward the moon's center. This maneuver provides a LM/CSM separation at Descent Orbit Insertion (DOI) of about 1.8 NM. The DOI will be performed by a LM Descent Propulsion System (DPS) burn (horizontal, retrograde) (see Figure 9), such that the resulting pericynthion (50,000-foot altitude) occurs about 15° prior to the landing site -- the position at which the powered descent is initiated in the Apollo 11 Mission. However, one of the major goals of the Apollo 10 Mission is to accomplish a fidelity demonstration of all phases of a lunar landing mission, except those directly involving LM-powered descent and ascent and lunar surface activities. Relative to the LM-active phase, this goal will be accomplished by incorporating, between the DOI and in-orbit ascent, approximately one phasing revolution during which the required adjustment in CSM lead angle is made (see Figure 9). Near lunar surface activities performed prior to phasing are shown in Figure 10.

LUNAR ORBIT INSERTION

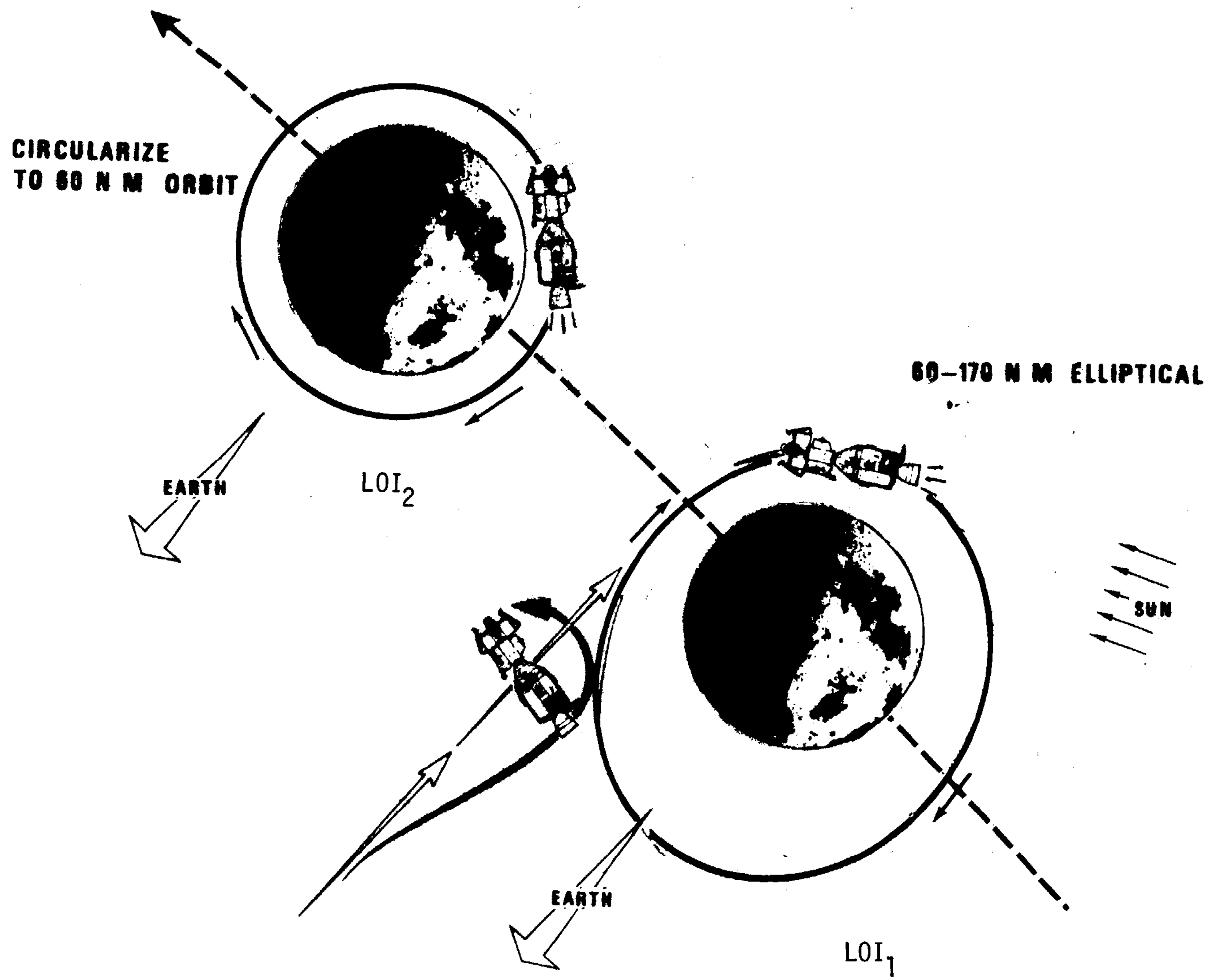


Fig. 8

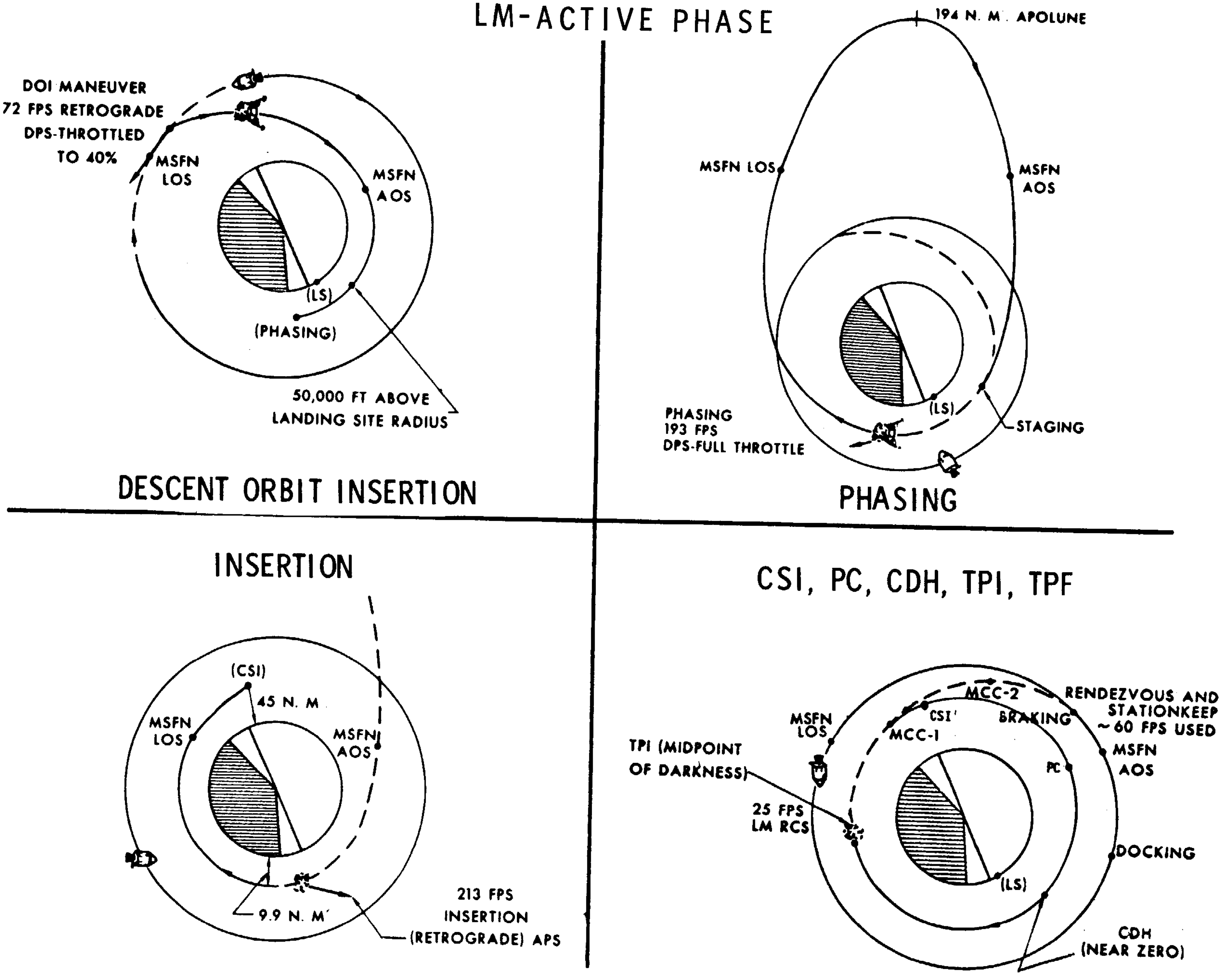


Fig. 9

M-932-69-10

NEAR LUNAR SURFACE ACTIVITY

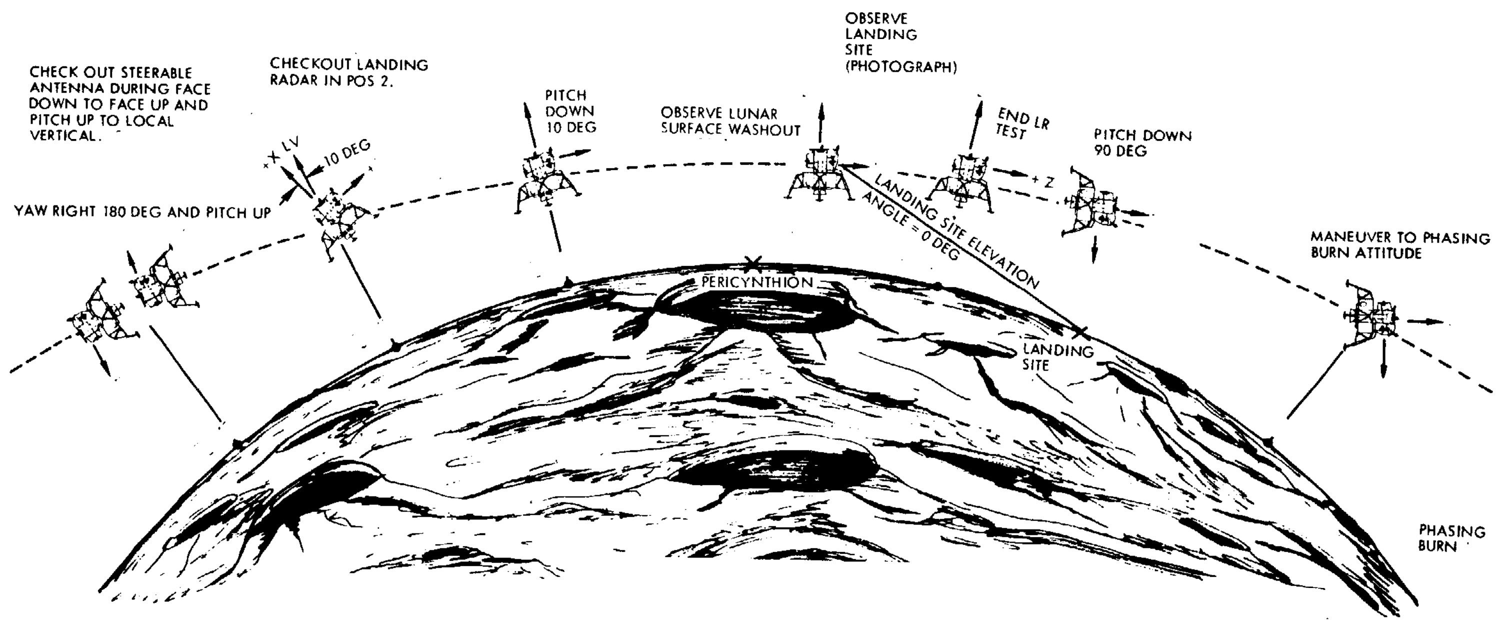


Fig. 10

M-932-69-10

This second LM maneuver will be a DPS burn (posigrade) designed to establish at the resulting LM pericynthion a CSM lead angle equivalent to that which occurs at nominal powered ascent cutoff in a lunar landing mission. This second maneuver is referred to as "phasing." The apocynthion altitude of the phasing orbit will be about 194 NM which will afford the required catch-up time between phasing and the resulting pericynthion of approximately 60,000 feet.

Just prior to this resulting pericynthion, the LM Descent Stage will be jettisoned. Then at pericynthion, a LM Ascent Propulsion System (APS) maneuver (retrograde) will be performed to establish the equivalent of the standard LM insertion orbit (10 by 45 NM) of a lunar landing mission (see Figure 9). At completion of this maneuver, referred to as "insertion," the conditions will be essentially equivalent to those at powered ascent cutoff for a lunar landing mission. The following maneuvers (see Figure 9), will occur during the rendezvous: concentric sequence initiation (CSI), plane change (PC), constant delta height (CDH), terminal phase initiation (TPI), terminal phase finalization (TPF), and docking. The PC and CDH will nominally be zero.

The LM will coast from insertion to an elliptical orbit (10 by 45 NM) for about an hour. CSI will be initiated at the apocynthion. The terminal maneuver will occur at the midpoint of the period of darkness. After the TPI maneuver and coast period, the LM-to-CSM range will be about 1 NM. Braking during the TPF will be performed manually.

During the LM-active phase discussed above, the CSM will maintain communications with the LM when line-of-sight exists and monitor CSM systems to assure a state-of-readiness if rescue of the LM is required.

Once docked to the CSM, the two LM crewmen will transfer with the exposed film packets and Hasselblad camera to the CSM. The CSM will be separated from the LM using the SM RCS.

Fourth Period of Activity

Following the manned LM activities described above, a LM APS burn to depletion will be commanded by the MSFN in conjunction with the ascent engine arming assembly. Targeting for this burn will be selected to avoid spacecraft recontact, earth return and impact, and lunar impact, respectively, in descending order of priority. Targeting will also be selected to optimize communications during and after the depletion burn.

An 8-hour rest period will ensue, followed by four revolutions to conduct strip photography of Apollo Sites 1 and 2 and to track four well-spaced lunar landmarks. (Figure 11 illustrates tracking of a typical lunar landmark.) Another 4-hour rest period will be followed by about two revolutions of landmark tracking and photography of Site 3. The SPS will be used to inject the CSM into the transearth trajectory after a total time in lunar orbit of about 61.5 hours. The transearth injection burn is currently planned for a nominal transearth return time of 53 hours. The spacecraft transearth configuration is shown in Figure 12.

CSM LUNAR LANDMARK TRACKING

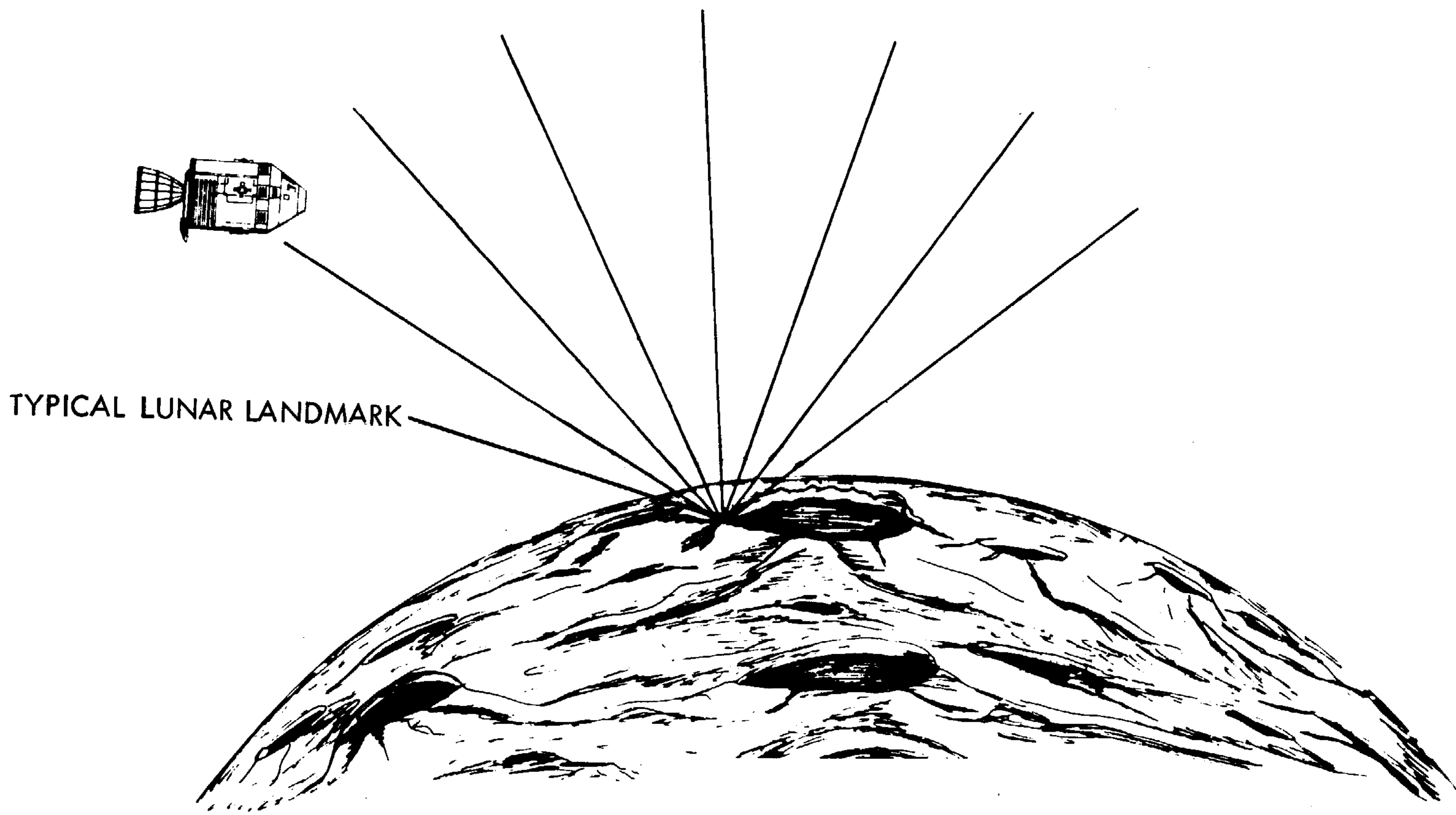


Fig. 11

TRANSEARTH CONFIGURATION

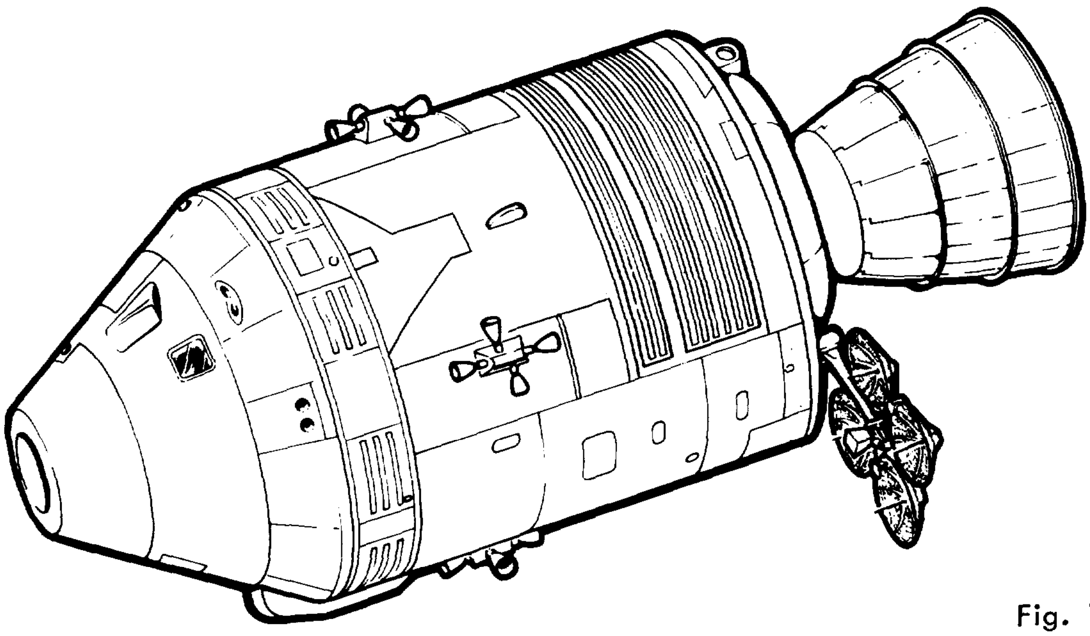


Fig. 12

Fifth Period of Activity

During transearth coast, intermediate MCC's will be made, if required, as shown in Figure 13. These corrections will utilize the MSFN for navigation. In the transearth phase there will be continuous communications coverage from the time the spacecraft appears from behind the moon until about 1 minute prior to entry. The constraints influencing the spacecraft attitude timeline are thermal control, communications, crew rest cycle, and preferred times of MCC's. The attitude profile for the transearth phase is complicated by more severe fuel slosh problems than for the other phases of the mission.

Sixth Period of Activity

Prior to atmospheric entry, the final MCC will be made and the CM will be separated from the SM using the SM RCS. The spacecraft will reach the entry interface (EI) at 400,000 feet, as shown in Figure 14. The S-band communication blackout will begin 26 seconds later followed by C-band communication blackout 30 seconds from EI. The rate of heating will reach a maximum 1 minute 10 seconds after entry. The spacecraft will exit from C-band blackout 3 minutes 4 seconds after entry and from S-band blackout 3 minutes 30 seconds after entry. Drogue parachute deployment will occur 8 minutes 32 seconds after entry at an altitude of 23,300 feet, followed by the main parachute deployment at 9 minutes 20 seconds. Splashdown will occur at entry plus approximately 14 minutes 19 seconds, 1285 NM from EI.

Earth touchdown will be in the Pacific at 165°W longitude, 15°S latitude and will occur 8 days 4 minutes after launch.

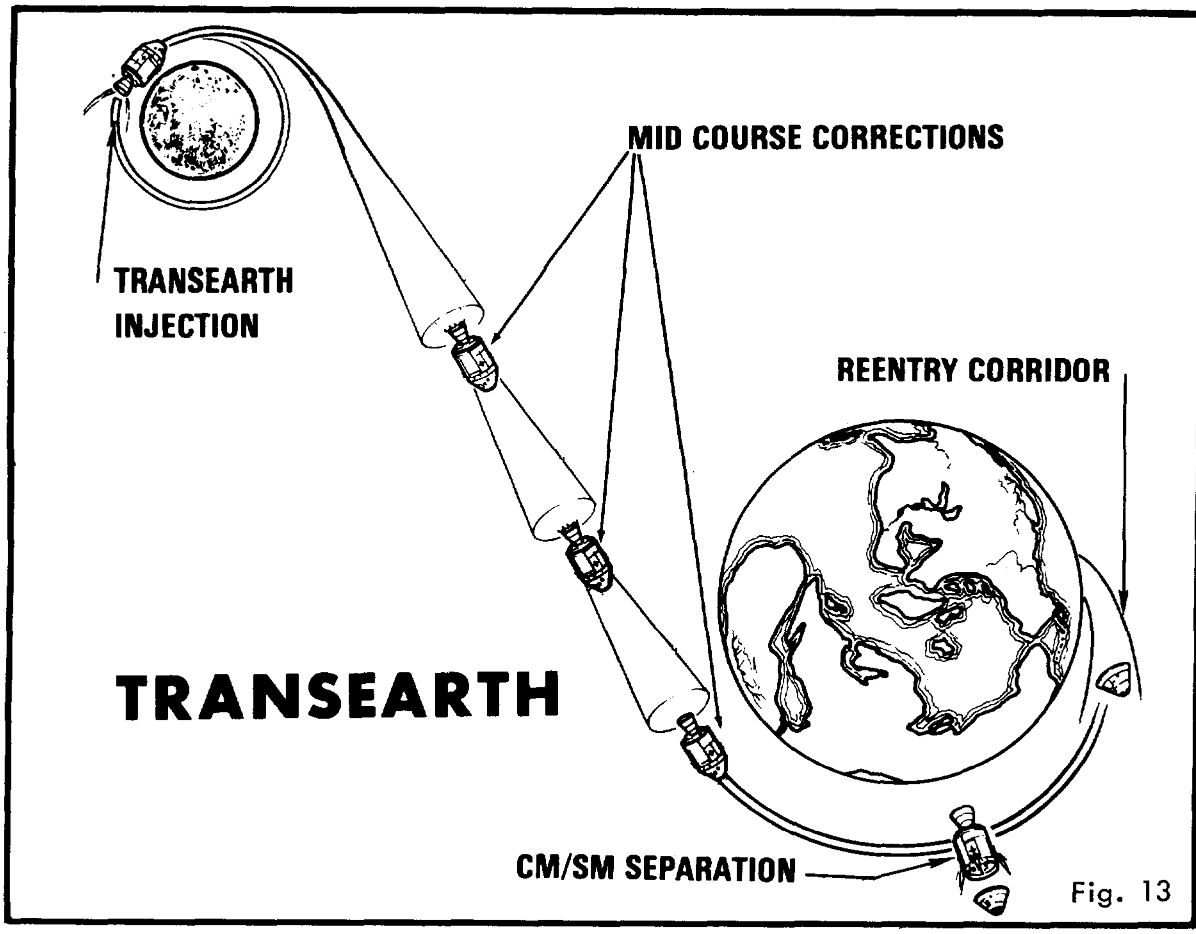

MID COURSE CORRECTIONS
TRANSEARTH
INJECTION
REENTRY CORRIDOR
TRANSEARTH
CM/SM SEPARATION

Fig. 13

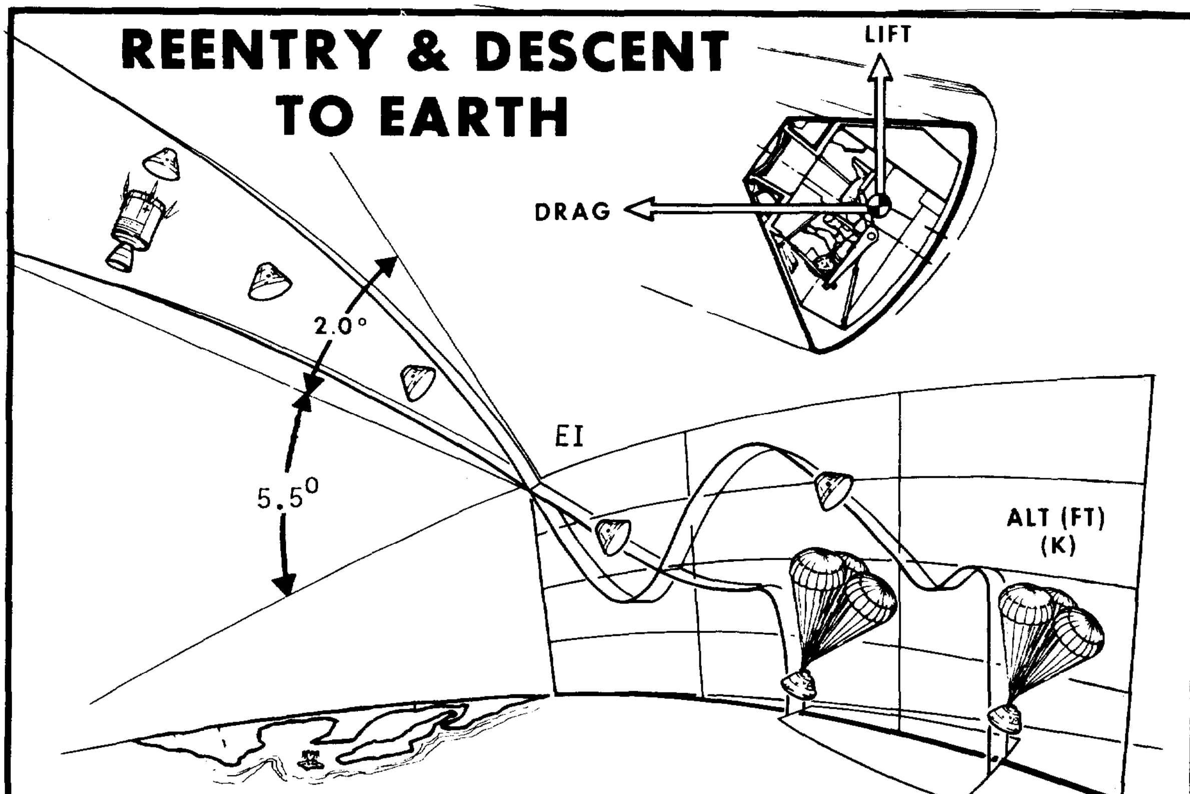

REENTRY & DESCENT
TO EARTH
LIFT
DRAG
2.0°
5.5°
EI
ALT (FT)
(K)

Fig. 14

CONTINGENCY OPERATIONS

GENERAL

If an anomaly occurs after lift-off 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 CM recovery while alternate missions will attempt to maximize the accomplishment of mission objectives as well as providing for an acceptable flight crew and CM recovery.

ABORTS

The following sections describe the abort procedures that may be used to safely return the CM to earth following emergencies that would prevent the space vehicle from following its normal flight plan. The abort descriptions are presented in the order of mission phase in which they could occur.

Launch

There are four different launch abort modes. The following descriptions of the four modes are based on aborts initiated from the nominal launch trajectory. Aborts from a dispersed trajectory will consist of the same procedures, but the times at which the various modes become possible and the resultant landing points may vary.

Mode I - The Mode I abort procedure is designed for safe recovery of the CM following aborts initiated between Launch Escape System activation, approximately 40 minutes prior to lift-off, and Launch Escape Tower jettison, approximately 3 minutes Ground Elapsed Time (GET). The procedure would consist of the Launch Escape Tower pulling the CM off the space vehicle and propelling it a safe distance downrange. The resulting landing point would lie between the launch site and approximately 520 NM downrange.

Mode II - The Mode II abort could be performed from the time the Launch Escape Tower is jettisoned until the full-lift CM landing point is 3200 NM downrange, approximately 10 minutes GET. The procedure would consist of separating the CSM from the launch vehicle, separating the CM from the SM, and then letting the CM free-fall to entry. The entry would be a full-lift, or maximum range trajectory, with a landing on the ground track 440 to 3200 NM downrange.

Mode III - The Mode III abort procedure could be performed from the time the full-lift landing point range reaches 3200 NM until orbital insertion. The procedure would consist of separating the CSM from the launch vehicle and then, if necessary, performing a retrograde burn with the SPS so that the half-lift landing point is no farther than 3350 NM downrange. A half-lift entry would be flown which causes the landing point to be approximately 70 NM south of the ground track between 3000 and 3350 NM downrange.

Mode IV and Apogee Kick - The Mode IV abort procedure is an abort to earth parking orbit and could be performed any time after the SPS has the capability to insert the CSM into orbit. This capability begins at approximately 8 minutes 40 seconds GET. The procedure would consist of separating the CSM from the launch vehicle and, shortly afterwards, performing a posigrade SPS burn to insert the CSM into earth orbit. This means that any time during the S-IVB burn portion of the launch phase the CSM has the capability to insert itself into orbit if the S-IVB should fail. The CSM could then remain in earth orbit to carry out an alternate mission, or, if necessary, return to the West Atlantic or Mid-Pacific Ocean after one revolution. The Mode IV abort to orbit capability occurring prior to S-IVB ignition time is a significant change from the previous Saturn V launch abort procedures. This mode of abort is preferred over the Mode II or Mode III aborts and would be used unless an immediate return to earth is necessary during the launch phase. Apogee kick is a variation of the Mode IV abort wherein the SPS burn to orbit would be performed at, or near, first apogee. The main difference between the two is the time at which the posigrade SPS burn is performed.

S-IVB Early Staging to Orbit - Under normal conditions the S-IVB is inserted into orbit with enough fuel to perform the TLI maneuver. This capability can be used, if necessary, during the launch phase to insure that the spacecraft is inserted into a safe parking orbit. Assuming a nominal launch trajectory until 6 minutes GET, the S-IVB then has the capability to be early staged off the S-II and achieve orbit. This means that any time after 6 minutes GET an S-II launch vehicle failure would probably not commit the CSM to a launch abort into the Atlantic. It is preferable to go to earth orbit, if possible, rather than perform a launch abort.

Earth Parking Orbit

Once the S-IVB/IU/LM/SLA/CSM is safely inserted into earth parking orbit, as in the nominal mission, a return-to-earth abort would be performed by separating the CSM from the remainder of the vehicle and then utilizing the SPS for a retrograde burn to place the CM on an atmosphere-intersecting trajectory. After entry the crew would fly a guided entry to a preselected target point, if available. This procedure would be similar to the deorbit and entry procedure performed on Apollo 7 and 9.

Translunar Injection

Ten-Minute Abort - There is only a remote possibility that an immediate return to earth will become necessary during the relatively short period of the TLI maneuver. However, if it should become necessary the S-IVB burn would be cut off early and the crew would initiate an onboard calculated retrograde SPS abort burn. The SPS burn would be performed approximately 10 minutes after TLI cutoff and would ensure a safe CM entry. The elapsed time from abort initiation to landing would vary from approximately 25 minutes to 4 hours, depending on the length of the TLI maneuver performed prior to S-IVB cutoff. For aborts initiated during the latter portion of TLI, a second SPS burn called a midcourse correction would be necessary to correct for dispersed entry conditions. Since this abort would be used only in extreme emergencies with respect to crew survival, the landing point would not be considered in executing the abort. No meaningful landing point predictions can be made because of the multiple variables involved including launch azimuth, location of TLI, the duration of the TLI burn prior to cutoff, and execution errors of the abort maneuvers.

Ninety-Minute Abort - A more probable situation than the previous case is that the TLI maneuver would be completed and then the crew would begin checking any malfunctions that may have been evident during the burn. If, after the check, it becomes apparent that it was necessary to return to earth, an abort would be initiated at approximately TLI cutoff plus 90 minutes. Unlike the previous procedure, this abort would be targeted to a preselected landing location called a recovery line. There are five recovery lines spaced around the earth: one is located in the Atlantic Ocean, one in the Indian Ocean, and three in the Pacific Ocean. The location of these lines is shown in Figure . If possible, the abort would be targeted to the Atlantic Ocean recovery line but for some time-critical situations, the abort could be targeted to the East Pacific line. The abort maneuver would be a retrograde SPS burn followed by a midcourse correction, if necessary, performed near apogee to provide the proper CM entry conditions.

Translunar Coast

For approximately 3 days the CSM will be in the translunar coast (TLC) phase of the mission. The abort procedure during this time would be similar to the 90-minute abort. Abort information specifying a combination of SPS burn time and CSM attitude would be sent to the crew to be performed at a certain time. All aborts initiated during translunar coast will return the CM to approximately the same inertial point in space where the TLI maneuver was performed. Therefore, since the point where the CM will contact the atmosphere is inertially fixed and the earth is rotating, the latitude of landing is constant but the longitude is changing 15° every hour, a movement equal to the earth's rate of rotation. This means that each of the five recovery lines pass through the predicted landing point once every 24 hours. The landing longitude is controlled by selecting an abort trajectory that causes the CM to enter the atmosphere and land at the time the target longitude is passing near the inertial point where TLI was performed.

Fixed times of abort that will return the CM to the Mid-Pacific recovery line will be selected during TLC. But, since the Mid-Pacific recovery line passes under the inertial position of TLI only once every 24 hours, a landing on this line can occur only once every 24 hours. A time-critical situation may dictate targeting the abort to one of the other four lines to decrease the elapsed time from abort to landing. Deep space aborts after TLI plus 90 minutes would be targeted to, in order of priority, (1) the Mid-Pacific line, (2) the Atlantic Ocean line, (3) the East Pacific line, the West Pacific line, or the Indian Ocean line. Regardless of the recovery line selected, the landing latitude should remain nearly the same. The minimum elapsed time between abort initiation and CM landing increases with translunar coast flight time. About the time the CSM enters the moon's sphere of gravitational influence, it becomes faster to perform a circulunar abort rather than returning directly to earth.

Lunar Orbit Insertion

Aborts following an early shutdown of the SPS during the lunar orbit insertion (LOI) maneuver are divided into three categories, Mode I, II, and III. All aborts performed during LOI will return the CM to the latitude of the moon's antipode at the time of the abort maneuver. The longitude will depend on the return flight time but will normally be the Mid-Pacific recovery line.

Mode I - The Mode I procedure would be used for aborts following SPS cutoffs from ignition to approximately 2 minutes into the LOI burn. This procedure would consist of performing a posigrade DPS burn approximately 2 hours after cutoff to put the spacecraft back on a return-to-earth trajectory.

Mode II - The Mode II procedure would be used for aborts following shutdown between LOI ignition plus 2 minutes and LOI ignition plus 3 minutes. The abort maneuver is performed in two stages. The first DPS burn would be done to reduce the lunar orbital period and to insure that the spacecraft does not impact the lunar surface. After one orbit a second DPS burn would be performed near pericynthion to place the spacecraft on a return-to-earth trajectory targeted to the Mid-Pacific recovery line.

Mode III - The Mode III procedure would be used for aborts following shutdowns from approximately 3 minutes into the burn until nominal cutoff. After 3 minutes of LOI burn, the spacecraft will have been inserted into an acceptable lunar orbit. Therefore, the abort procedure would be to let the spacecraft go through one or two lunar revolutions prior to doing a posigrade DPS burn at pericynthion. This would place the spacecraft on a return-to-earth trajectory targeted to the Mid-Pacific recovery line.

Lunar Orbit

Aborts from the lunar orbit would be accomplished by performing the transearth injection (TEI) burn early. The abort would be targeted to the Mid-Pacific recovery line.

Transearth Injection

The abort procedures for early cutoff of TEI are the inverse of the LOI abort procedures except that the maneuver would be performed with the SPS instead of the DPS and no Mode II abort would be necessary. This is due to the fact that jettisoning the LM reduces the weight of the spacecraft enough to allow a direct changeover from Mode III to Mode I. That is, for early cutoffs between TEI ignition and approximately 2 minutes, a Mode III abort would be performed. After this time a Mode I abort would be used. All TEI aborts should result in landings on the Mid-Pacific recovery line at the latitude of the moon's antipode at TEI.

Transearth Coast

From TEI until entry minus 24 hours, the only abort procedure that could be performed is to use the SPS or the SM RCS for a posigrade or retrograde burn that would respectively decrease or increase the transearth flight time and change the longitude of landing. After entry minus 24 hours, no further burns to change the landing point will be performed. This is to ensure that the CM maintains the desired entry velocity and flight path angle combination that will allow a safe entry.

Entry

If, during entry, the Guidance, Navigation, and Control System (GN&CS) fails, a guided entry to the end-of-mission target point cannot be flown. In this case, the crew would use their Entry Monitoring System (EMS) to fly a 1285-nautical mile range. The landing point would be abeam the guided entry target point on the north side of the ground track. If both the GN&CS and EMS fail, a "constant g" (constant deceleration) entry would be flown. The landing point would be approximately 185 NM uprange of the guided target point and 75 NM north of the ground track.

ALTERNATE MISSION SUMMARY

Consideration of previous mission accomplishments will aid in determining which available alternate would be most appropriate to implement in the event of certain Apollo 10 Mission contingencies.

Launch Vehicle Alternates

Alternate 1

Condition/Malfunction:
A. One S-IC stage engine out; or
B. One S-II stage engine out; or
C. Early staging of S-IVB from S-II

Perform: Nominal lunar landing mission TLI if capability exists.

Alternate 2

Condition/Malfunction: Same as Alternate 1.

Perform: Spacecraft alternate mission consistent with real-time evaluation of capability.

Alternate 3

Condition/Malfunction: D. Early shutdown of S-IVB engine during first burn.

Perform: SPS earth parking orbit insertion.

Alternate 4

Condition/Malfunction: E. S-IVB engine inhibited for first opportunity TLI burn.

Perform: Second TLI opportunity restart, and nominal lunar mission if restart successful.

Alternate 5

Condition/Malfunction:
F. S-IVB fails to restart for TLI; or
G. S-IVB fails to reach TLI velocity; or
H. S-IVB inhibited for second TLI opportunity.

Perform: TD&E, propellant dumping, S-IVB APS ullage motor firing, and stage safing.

Spacecraft Earth Orbit Alternates

Alternate 1 - CSM-Only Low Earth Orbit

Condition/Malfunction: LM not ejected, or S-IVB failed prior to 25,000-NM apogee; or SPS used to achieve earth orbit.

Perform: SPS LOI simulation (100 x 400-NM orbit), MCC's to approximate lunar timeline and for an approximate 10-day mission with landing in 150°W Pacific recovery area.

Alternate 2 - CSM-Only Semisynchronous

Condition/Malfunction: S-IVB fails during TLI with apogee greater than or equal to 25,000 NM, LM cannot be ejected.

Perform: SPS phasing maneuver for LOI tracking, LOI simulation, SPS phasing maneuver to place perigee over Pacific recovery zone at later time, SPS semisynchronous orbit, and further MCC's to approximate lunar timeline.

Alternate 3 - CSM/LM Earth Orbit Combined Operations with SPS Deboost

Condition/Malfunction: TLI does not occur or TLI apogee less than 4000 NM, TD&E successful.

Perform: SPS maneuver to raise or lower apogee for lifetime requirements if necessary, simulated LOI to raise or lower apogee to 400 NM, simulated DOI (in docked configuration), simulated powered descent insertion (PDI), SPS maneuver to circularize at 150 NM, LM-active rendezvous, APS burn to depletion (unmanned, Abort Guidance System (AGS)-controlled), and further SPS MCC's to complete lunar mission timeline.

Alternate 4 - CSM/LM Earth Orbit Combined Operations with DPS/SPS Deboost

Condition/Malfunction: S-IVB fails during TLI, SPS and DPS in combination can return CSM/LM to low earth orbit without sacrificing LM rescue (apogee less than 10,000 NM but greater than 4000 NM).

Perform: SPS phasing maneuver, simulated DOI, PDI to lower apogee to about 4000 NM, SPS phasing (simulated MCC) maneuver to ensure tracking for LOI, SPS maneuver to circularize at 150 NM, LM-active rendezvous, APS burn to depletion (unmanned, AGS-controlled), SPS maneuvers to complete lunar mission timeline, and achieve nominal 90 x 240 NM end of mission orbit for an approximate 10-day mission with landing on 150°W Pacific recovery area.

Alternate 5 - CSM/LM Semisynchronous

Condition/Malfunction: SPS and DPS in combination cannot place CSM/LM in low earth orbit without sacrificing LM rescue, SPS propellant not sufficient for CSM/LM circumlunar mission.

Perform: SPS phasing maneuver (to place a later perigee over an MSFN site), SPS LOI (approximately semisynchronous), SPS phasing maneuver if necessary to adjust semisynchronous orbit, docked DPS DOI, docked DPS PDI simulation, SPS phasing to put perigee over or opposite recovery zone, SPS to semisynchronous orbit, and further MCC's to approximate lunar mission timeline.

Spacecraft Lunar Alternates

Alternate 1a - DPS LOI

Condition/Malfunction: Non-nominal TLI such that: CSM/LM LOI and TEI No-Go with SPS, CSM/LM LOI Go with DPS LOI-1.

Perform: TD&E, SPS free-return CSM/LM, DPS LOI-1, and SPS LOI-2. After LOI-2, the Descent Stage is jettisoned and the Ascent Stage rendezvous is performed.

Alternate 1b - CSM Solo Lunar Orbit

Condition/Malfunction: Non-nominal TLI such that: CSM/LM LOI No-Go, CSM only LOI Go.

Perform: TD&E, SPS free-return CSM/LM, LM testing during TLC, DPS staging, unmanned APS depletion burn during TLC, and CSM lunar mission (Alternate 2).

Alternate 1c - CSM/LM Flyby

Condition/Malfunction: Non-nominal TLI, such that: CSM/LM Flyby Go, CSM/LM LOI No-Go, CSM only LOI No-Go.

Perform: Transposition, docking, and ejection; LM testing near pericynthion, docked DPS maneuver to raise pericynthion, DPS staging, unmanned APS depletion burn, and SPS for fast return.

Alternate 2 - CSM-Only Lunar Orbit

Condition/Malfunction: Failure to TD&E

Perform: CSM-only lunar orbit mission, landmark tracking, lunar surface photography, and low pericynthion MSFN tracking. Follow lunar landing mission work-rest cycle.

Alternate 3a - DPS TEI and/or APS Depletion

Condition/Malfunction: LM No-Go for undocking and rendezvous, but DPS Go for a burn.

Perform: Landmark tracking, DPS TEI, unmanned APS depletion burn, and SPS maneuver for fast return.

Alternate 3b - APS Depletion in Lunar Orbit

Condition/Malfunction: LM No-Go for undocking, DPS No-Go for a burn.

Perform: Simulated nominal timeline closely until nominal time for phasing, two additional revolutions of LM testing, unmanned APS depletion burn, landmark tracking. Revert to nominal timeline.

Alternate 4 - TEI with Docked Ascent Stage

Condition/Malfunction: CSM communication failure in lunar orbit.

Perform: TEI and keep LM as communication system. If DPS available, perform DPS TEI as in Alternate 3. If Descent Stage jettisoned, perform SPS TEI with Ascent Stage attached.

Spacecraft Rendezvous Alternates

Alternate 1a - Descent Stage - Unstaged

Condition/Malfunction: Descent Stage cannot be jettisoned.

Perform: CSM minifootball (SM RCS), DOI (DPS), phasing (DPS), insertion (DPS), CSI (DPS), CDH (DPS), TPI (DPS), and TPF (SM RCS).

Alternate 2 - APS Rendezvous

Condition/Malfunction: DPS cannot be used.

Perform: CSM minifootball (SM RCS), Descent Stage jettison (LM RCS), DOI to about 58-NM pericynthion (APS), phasing (APS), CSI (LM RCS, interconnect), CDH (APS), and TPI and TPF (LM RCS).

Alternate 3 - Modified Football

Condition/Malfunction: Unusable DPS and APS - no other rendezvous possible.

Perform: Descent Stage jettison (LM RCS), TPI (LM RCS), and TPF (LM RCS).

SPACE VEHICLE DESCRIPTION

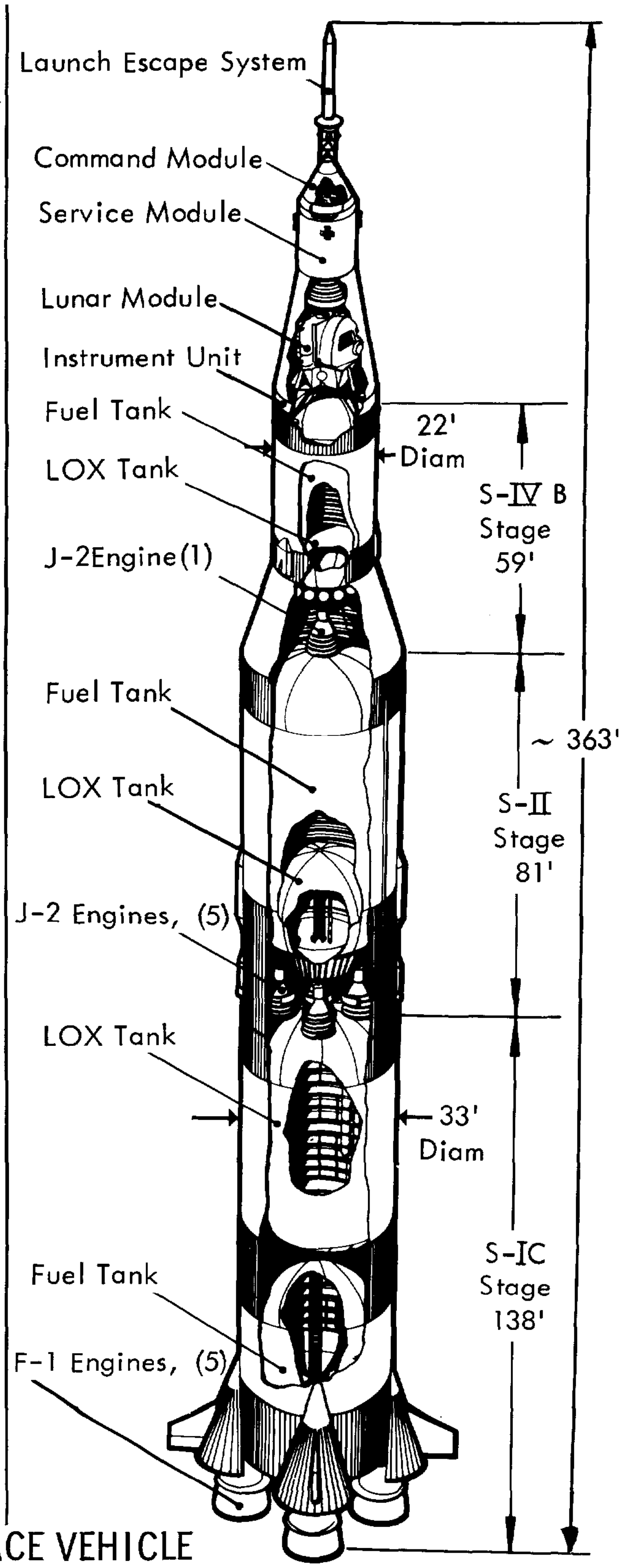
The Apollo 10 Mission will be performed by an Apollo/Saturn V Space Vehicle (Figure 15) designated AS-505, which consists of a three-stage Saturn V Launch Vehicle, and a complete Apollo Block II Spacecraft. A more comprehensive description of the space vehicle and its subsystems is included in the Mission Operation Report Supplement. The following is a brief description of the various stages of AS-505.

The Saturn V Launch Vehicle (SA-505) consists of three propulsion stages (S-IC, S-II, S-IVB) and an Instrument Unit (IU). The Apollo Spacecraft payload for Apollo 10 consists of a Launch Escape System (LES), Block II Command/Service Module (CSM 106), a Spacecraft LM Adapter (SLA 13), and a Lunar Module (LM-4). A list of current weights for the space vehicle is contained in Table 2.

LAUNCH VEHICLE DESCRIPTION

First Stage (S-IC)

The S-IC is powered by five F-1 rocket engines each developing approximately 1,522,000 pounds of thrust at sea level and building up to 1.7 million pounds before cutoff. One engine, mounted on the vehicle longitudinal centerline, is fixed; the remaining four engines, mounted in a square pattern about the center line, are gimballed for thrust vector control by signals from the control system housed in the IU. The F-1 engines utilize LOX (liquid oxygen) and RP-1 (kerosene) as propellants.



APOLLO/SATURN V SPACE VEHICLE

Fig. 15

TABLE 2

APOLLO 10 WEIGHT SUMMARY
(Weight in Pounds)

STAGE/MODULE	INERT WEIGHT	TOTAL EXPENDABLES	TOTAL WEIGHT	FINAL SEPARATION WEIGHT
S-IC Stage	294,300	4,738,320	5,032,620	368,070
S-IC/S-II Interstage	11,450	--	11,450	--
S-II Stage	84,490	988,480	1,072,970	98,080
S-II/S-IVB Interstage	8,080	--	8,080	--
S-IVB Stage	25,710	236,040	261,750	28,930
Instrument Unit	4,250	--	4,250	--
Launch Vehicle at Ignition (SA-505)			6,391,120	
SC/LM Adapter (SLA-13)	4,060	--	4,060	--
Lunar Module (LM-4)	10,170	20,610	30,780	--
Service Module (SM-106)	10,160	40,640	51,250	13,160
Command Module (CM-106)	12,250	--	12,250	11,141 (Splashdown)
Launch Escape System	8,890	--	8,890	--
Spacecraft at Ignition			107,230	
Space Vehicle at Ignition (AS-505)			6,498,350	
S-IC Thrust Buildup			-86,100	
Space Vehicle at Lift-off			6,412,250	
Space Vehicle at Earth Orbit Insertion			295,150	

Second Stage (S-II)

The S-II is powered by five high-performance J-2 rocket engines each developing approximately 230,000 pounds of thrust in a vacuum. One engine, mounted on the vehicle longitudinal centerline, is fixed; the remaining four engines, mounted in a square pattern about the centerline, are gimbaled for thrust vector control by signals from the control system housed in the IU. The J-2 engines utilize LOX and LH_2 (liquid hydrogen) as propellants.

Third Stage (S-IVB)

The S-IVB is powered by a single J-2 engine developing approximately 230,000 pounds of thrust in a vacuum. As installed in the S-IVB, the J-2 engine features a multiple start capability. The engine is gimbaled for thrust vector control in pitch and yaw. Roll control is provided by the Auxiliary Propulsion System (APS) modules containing motors to provide roll control during mainstage operations and pitch, yaw, and roll control during non-propulsive orbital flight.

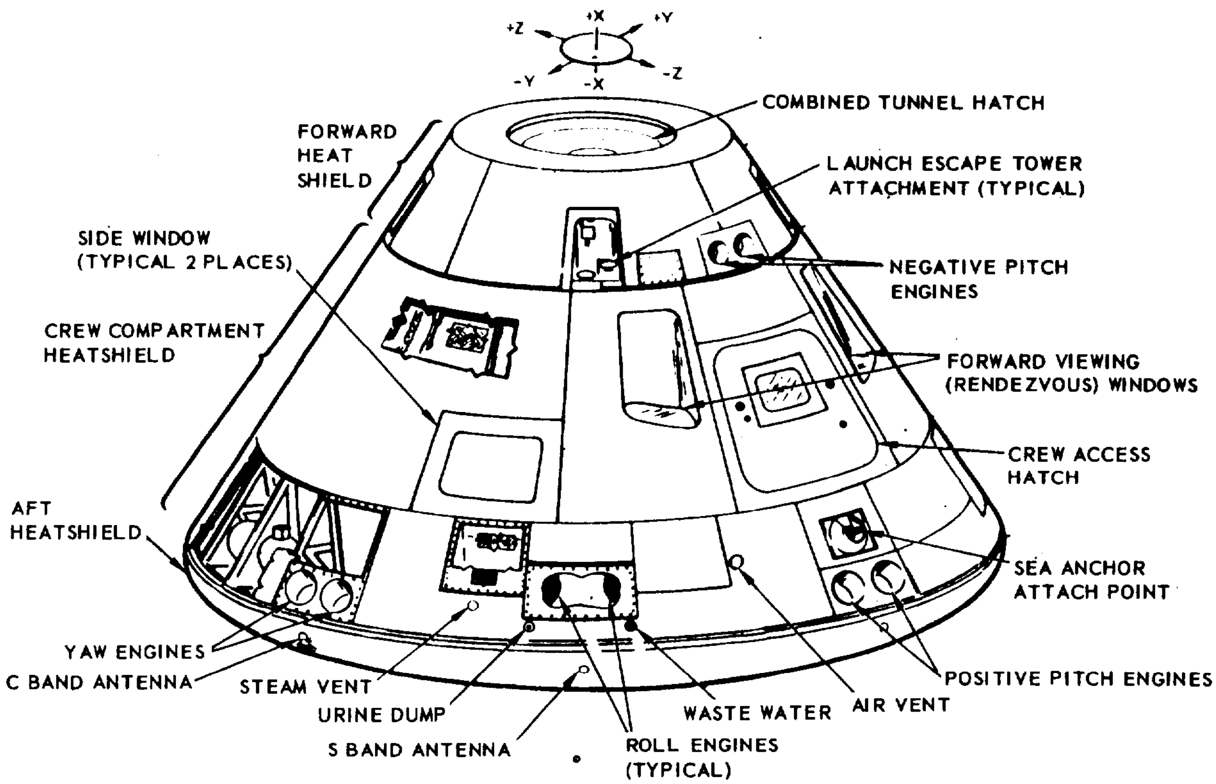
Instrument Unit

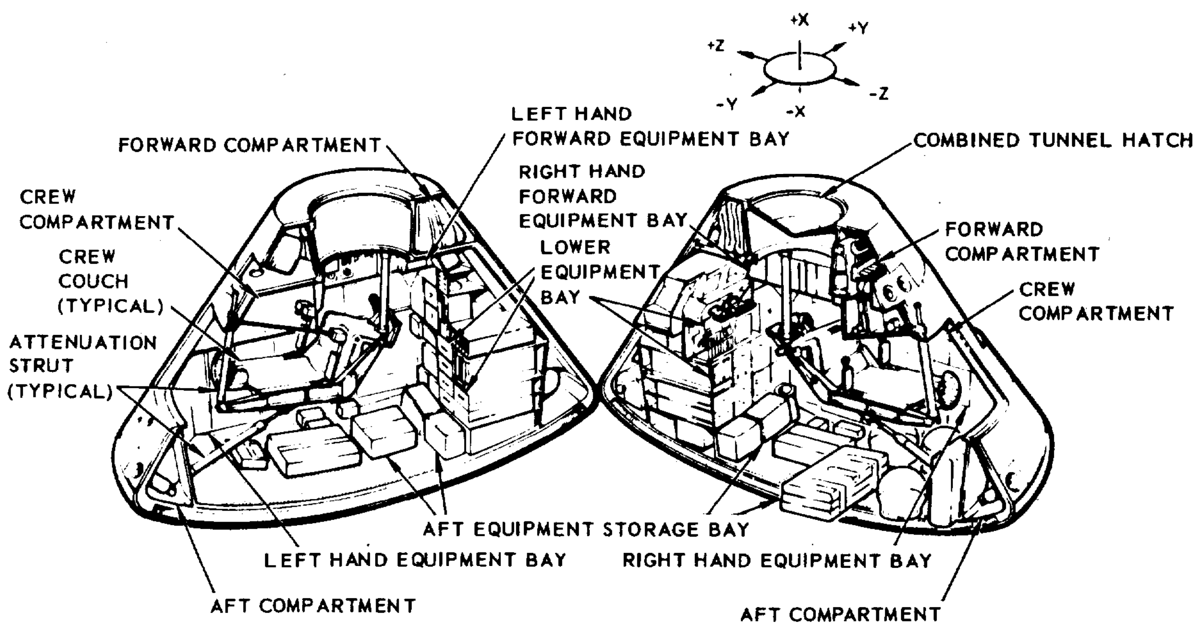
The Instrument Unit (IU) contains the following: Electrical System, supplies electrical power for all IU system components; Environmental Control System, provides thermal conditioning for the electrical components and guidance systems contained in the assembly; Guidance and Control System, solves guidance equations and controls the attitude of the vehicle; Measuring and Telemetry System, monitors and transmits flight parameters and vehicle operation information to ground stations; Radio Frequency System, provides for tracking and command signals; components of the Emergency Detection System (EDS).

SPACECRAFT DESCRIPTION

Command Module

The Command Module (CM) (Figure 16) serves as the command, control, and communications center for most of the mission. Supplemented by the Service Module, it provides all life support elements for three crewmen in the mission environments and for their safe return to earth's surface. It is capable of attitude control about three axes and some lateral lift translation at high velocities in earth atmosphere. It also permits Lunar Module attachment, Command Module/Lunar Module ingress and egress, and serves as a buoyant vessel in open ocean.





BLOCK II COMMAND MODULE

Fig. 16

Service Module

The Service Module (SM) (Figure 17) provides the main spacecraft propulsion and maneuvering capability during the mission. The Service Propulsion System (SPS) provides up to 20,500 pounds of thrust in a vacuum. The Service Module Reaction Control System (SM RCS) provides for maneuvering about and along three axes. The SM provides most of the spacecraft consumables (oxygen, water, propellant, hydrogen). It supplements environmental, electrical power, and propulsion requirements of the CM. The SM remains attached to the CM until it is jettisoned just before CM entry.

Common Command/Service Module Systems

There are a number of systems which are common to the CSM.

Guidance and Navigation System

The Guidance and Navigation (G&N) System measures spacecraft attitude and acceleration, determines trajectory, controls spacecraft attitude, controls the thrust vector of the SPS engine, and provides abort information and display data.

Stabilization and Control System

The Stabilization and Control System (SCS) provides control and monitoring of the spacecraft attitude, backup control of the thrust vector of the SPS engine and a backup inertial reference.

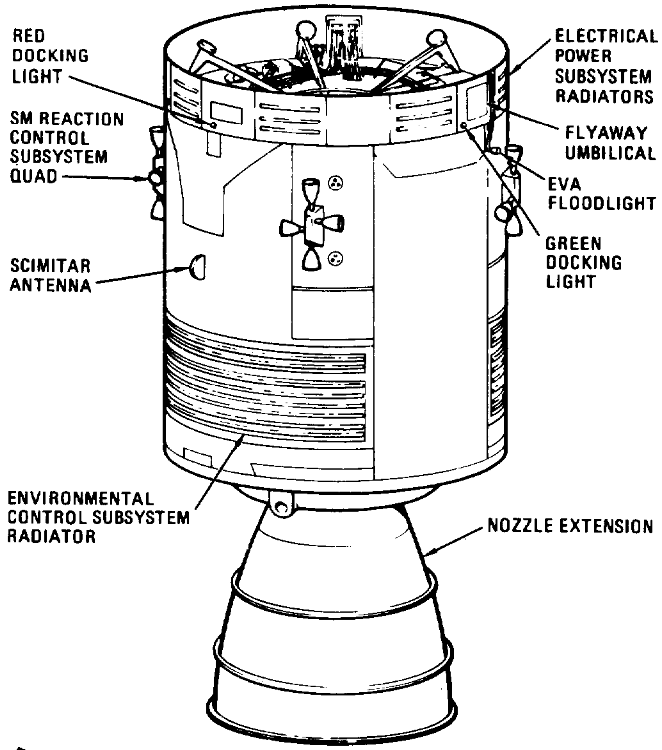
Reaction Control Systems

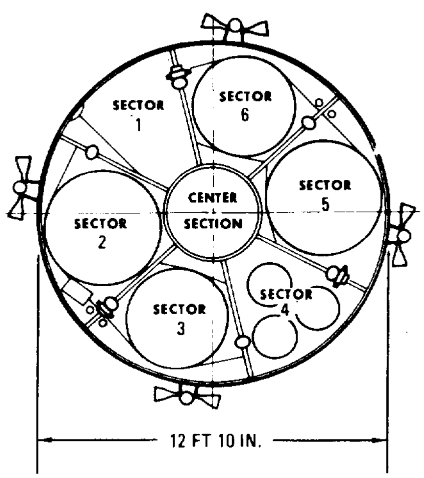
The reaction control systems (RCS) provide thrust for attitude and small translational maneuvers of the spacecraft in response to automatic control signals from the SCS in conjunction with the G&N system. The CM and SM each has its own independent and redundant system, the CM RCS and the SM RCS respectively. Propellants for the RCS are hypergolic.

Electrical Power System

The Electrical Power System (EPS) supplies all electrical power required by the CSM. The primary power source is located in the SM and consists of three fuel cells which are the prime spacecraft power from lift-off through CM/SM separation. Five batteries -- three for peak load intervals, entry and post-landing, and two for pyrotechnic uses -- are located in the CM.

SERVICE MODULE





SECTOR 2 } SECTOR 3 }	SERVICE PROPULSION SUBSYSTEM OXIDIZER TANKS
SECTOR 4	OXYGEN TANKS, HYDROGEN TANKS, FUEL CELLS
SECTOR 5 } SECTOR 6 }	SERVICE PROPULSION SUBSYSTEM FUEL TANKS

CENTER SECTION - SERVICE PROPULSION ENGINE AND HELIUM TANKS

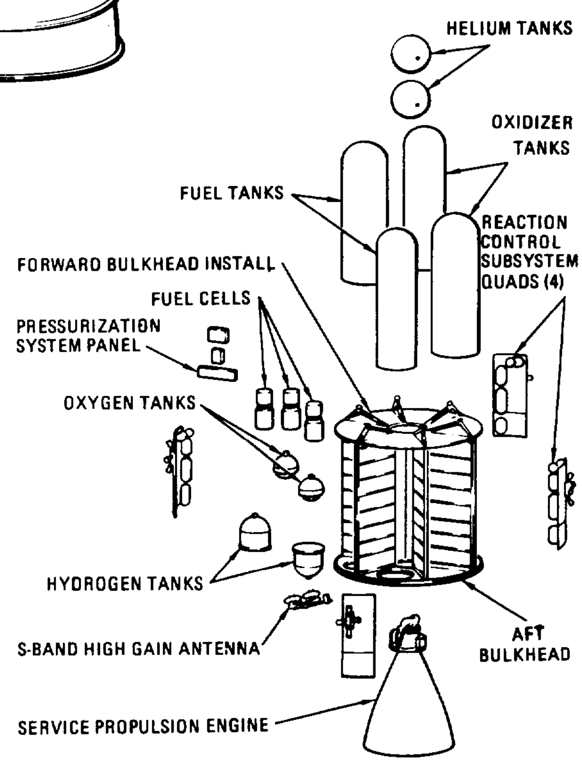


Fig. 17

Environmental Control System

The Environmental Control System (ECS) provides a controlled cabin environment and dispersion of CM equipment heat loads.

Telecommunications System

The Telecommunications (T/C) System provides for the acquisition, processing, storage, transmission and reception of telemetry, tracking, and ranging data among the spacecraft and ground stations.

Sequential System

Major Sequential Subsystems (SEQ) are the Sequential Events Control System (SECS), Emergency Detection System (EDS), Launch Escape System (LES), and Earth Landing System (ELS). The subsystems interface with the RCS or SPS during an abort.

Spacecraft LM Adapter

The Spacecraft LM Adapter (SLA) is a conical structure which provides a structural load path between the LV and SM and also supports the LM. Aerodynamically, the SLA smoothly encloses the SM engine nozzle and irregularly-shaped LM, and transitions the SV diameter from that of the upper LV stage to that of the SM. The upper section is made up of four panels that swing open at the top and are jettisoned away from the spacecraft by springs attached to the lower fixed panels.

Lunar Module

The Lunar Module (LM) (Figure 18) is a two-stage vehicle designed to transport two crewmen from a docked position with the CSM to the lunar surface, serve as a base for lunar surface crew operations, and provide for their safe return to the dockea position. The upper stage is termed the Ascent Stage (AS) and the lower stage, the Descent Stage (DS). In the nominal mission, the two stages are operated as a single unit until the lunar landing is accomplished. The AS is used for ascent from the lunar surface and rendezvous with the CSM.

The LM's main propulsion includes a gimbaled, throttleable Descent Propulsion System (DPS) engine and a fixed, non-throttleable Ascent Propulsion System (APS) engine. A 16-jet LM Reaction Control System (LM RCS) on the AS provides for stabilization and maneuvering. All propulsive systems utilize storable hypergolic propellants. The Guidance, Navigation, and Control System (GN&CS) has the capability to implement automatically all parameters required for safe landing from lunar orbit and accomplish a CSM/LM rendezvous from lunar launch. Landing and rendezvous radar systems aid

LUNAR MODULE

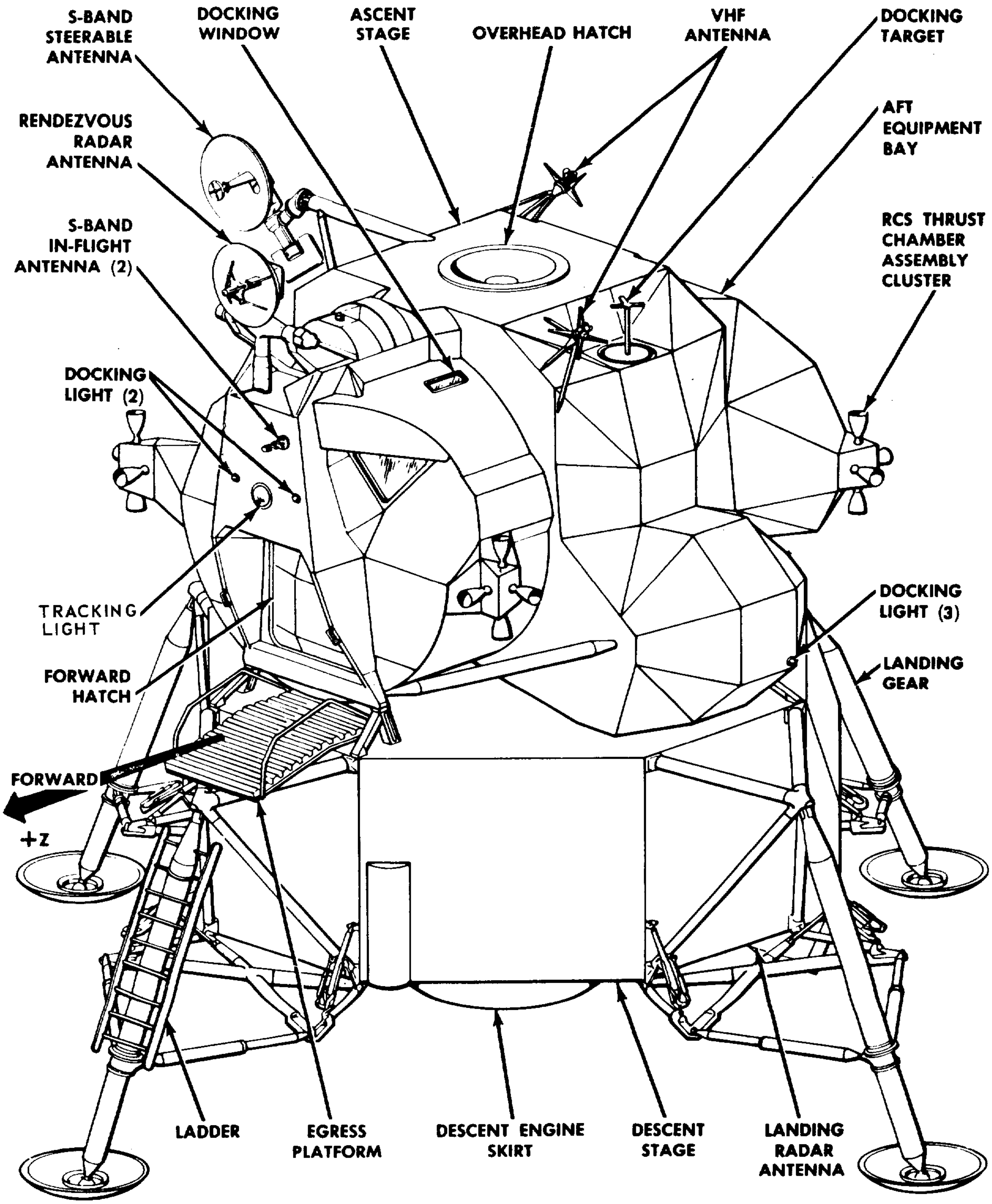


Fig. 18

the GN&CS system. The Instrumentation System (IS) provides for LM systems checkout and displays data for monitoring or manually controlling LM systems. The ECS provides a satisfactory environment for equipment and human life. The EPS relies upon four batteries in the DS and two batteries in the AS when undocked from the CSM. Electrical power is provided by the CSM when the LM is docked. Telecommunications is provided to the MSFN and the CSM.

Cameras

Hasselblad Cameras

One Hasselblad camera will be carried in the CM and in the LM. Lens provisions will include an 80mm lens for each camera and a 250mm lens will be carried in the CM.

The Hasselblad cameras will be used for long distance earth and lunar terrain/surface photography as well as coverage of LM-active rendezvous and TD&E.

Data Acquisition Cameras

One 16mm Maurer (Data Acquisition) camera will be carried in the CM and in the LM. Maurer camera provisions will include 5, 18, and 75mm lenses.

The data acquisition cameras will be used to photograph crew activities, star/horizon/lunar landmarks, LM inspection, and to cover LM-active rendezvous and TD&E.

Television Cameras

A black and white TV camera (RCA) and a color TV camera (Westinghouse) will be carried in the CM. The cameras will provide realtime views of the lunar surface, the earth from lunar distances, and the crew activities inside the CM.

Launch Escape System

The Launch Escape System (LES) provides the means for separating the CM from the LV during pad or suborbital aborts through approximately one-half minute of the second stage burn. This system consists primarily of the Launch Escape Tower (LET), Launch Escape Motor, Tower Jettison Motor, and Pitch Motor. All motors utilize solid propellants. A Boost Protective Cover (BPC) is attached to the LET and covers the CM from LES rocket exhaust and also from aerodynamic heat generated during LV boost.

CONFIGURATION DIFFERENCES

The space vehicle for Apollo 10 varies in its configuration from that flown on Apollo 9 and those to be flown on subsequent missions because of normal growth, planned changes, and experience gained on previous missions. Following is a list of the major configuration differences between AS-504 and AS-505.

COMMAND/SERVICE MODULE (CM-106)

- Added VHF ranging capability as a backup to CSM/LM rendezvous radar (RR).

LUNAR MODULE (LM-4)

- Added VHF ranging capability as an RR backup.
- Incorporated CM to LM power transfer capability after LM stage separation to extend hold capability between docking and final separation (contingency).
- Provided CM/LM power transfer redundancy as a power transfer backup.
- Deleted EVA antenna because no EVA planned for Apollo 10.
- Increased digital uplink voice output (up to 20 db) because required for lunar distance communication.
- Added landing gear deployment mechanism protective shield to prevent possible malfunction due to DPS plume impingement.
- Added AS plume heat blanket and venting to improve thermal control.
- Added separate power source for utility/floodlight to prevent simultaneous loss of both lights.
- Added APS muffler to prevent APS regulator loss.
- Provided RR and VHF bus isolation to prevent simultaneous RR and VHF loss.
- Deleted TV camera.
- Substituted Luminary I (onboard program).

SLA-13

- (No significant differences.)

INSTRUMENT UNIT (S-IU-505)

- Incorporated IU network change (software) to enable SC control of LV during launch phase.

- Added damping compound to and removal of channels from ST-124M platform support because of the first time application of this damping approach to IU.

S-IVB STAGE (SA-505)

- Substituted new design helium regulator valve because of the first-time flight of new hardware fix - SA-504 malfunction.

S-II STAGE (SA-505)

- Planned center engine early cutoff as a possible elimination of longitudinal oscillations.

S-IC STAGE (SA-505)

- (No significant differences.)

HUMAN SYSTEM PROVISIONS

The major human system provisions included for the Apollo 10 mission are: Space Suits, Bioinstrumentation System, Medical Provisions, Crew Personal Hygiene, Crew Meals, Sleeping Accommodations, Oxygen Masks, and Survival Equipment. These systems provisions are described in detail in the Mission Operation Report Supplement.

LAUNCH COMPLEX

The AS-505 Space Vehicle (SV) will be launched from Launch Complex (LC) 39, Pad B at the Kennedy Space Center (KSC). The major components of LC 39 include the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), the Mobile Launcher (ML), the Crawler Transporter (C/T), the Mobile Service Structure (MSS), and the Launch Pad.

The LCC is a permanent structure located adjacent to the VAB and serves as the focal point for monitoring and controlling vehicle checkout and launch activities for all Saturn V launches. The ground floor of the structure is devoted to service and support functions. Telemetry equipment occupies the second floor and the third floor is divided into firing rooms, computer rooms, and offices. Firing room 3 will be used for Apollo 10.

The AS-505 SV was received at KSC and assembly and initial overall checkout was performed in the VAB on the mobile launcher. Rollout occurred on 11 March 1969. Transportation to the pad of the assembled SV and ML was provided by the Crawler Transporter (C/T) which also moved the MSS to the pad after the ML and SV had been secured. The MSS provides 360-degree access to the SV at the launch pad by means of five vertically-adjustable, elevator-serviced, enclosed platforms. The MSS will be removed to its park position prior to launch.

The emergency egress route system at LC 39 is made up of three major components: the high speed elevators, slide tube, and slide wire. The primary route for egress from the CM is via the elevators and, if necessary, through the slide tube which exits into an underground blast room.

A more complete description of LC 39 is in the MOR Supplement.

An aerial view of Launch Complex 39 with AS-505 on Pad B is shown in Figure 19.

AERIAL VIEW OF APOLLO 10 SPACE VEHICLE ON PAD B, LC-39

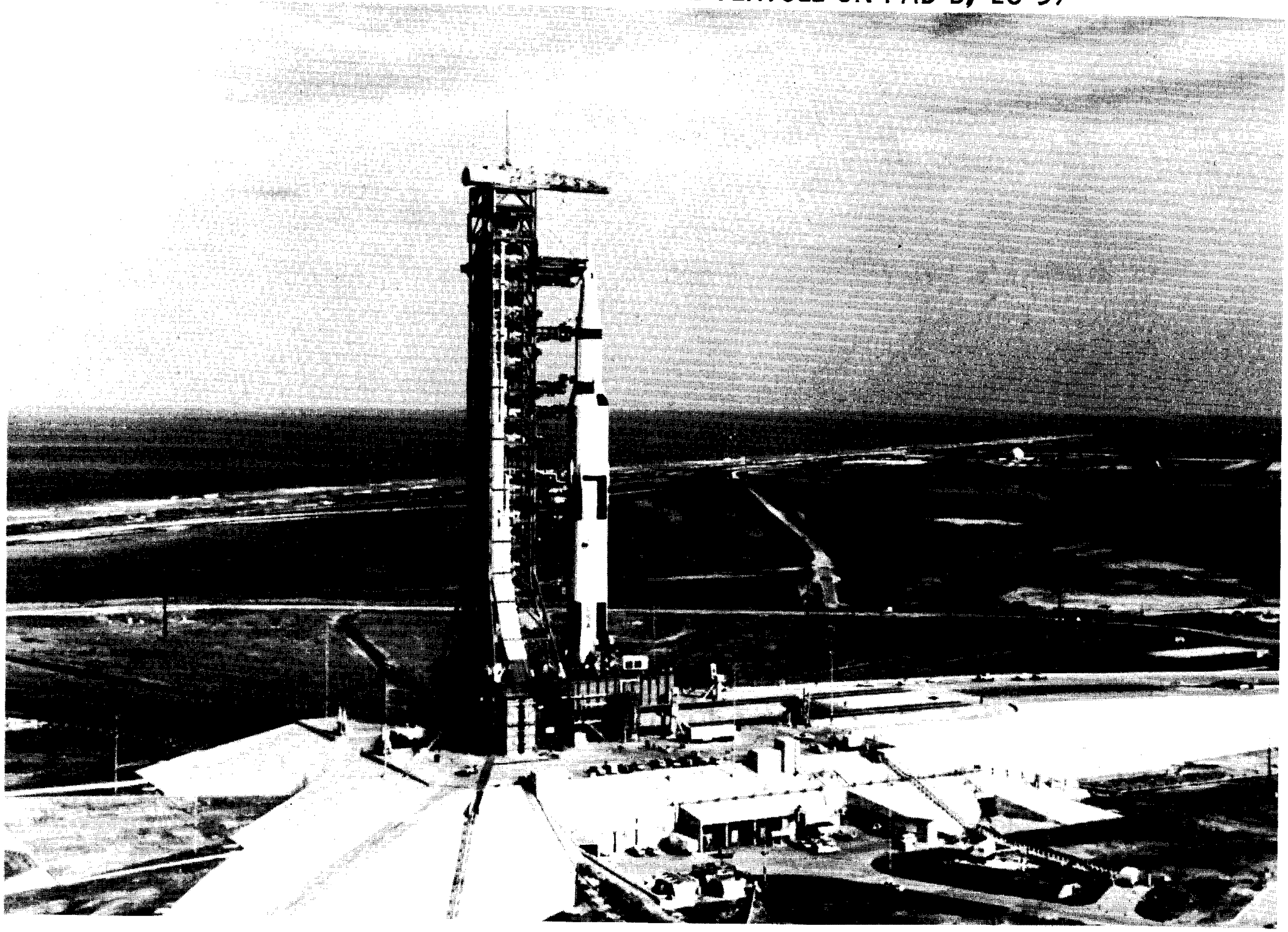


Fig. 19

MISSION SUPPORT

Mission support is provided by the Launch Control Center (LCC), the Mission Control Center (MCC), the Manned Space Flight Network (MSFN), and the recovery forces. The LCC is essentially concerned with prelaunch checkout, countdown, and with launching the SV, while MCC located at Houston, Texas, provides centralized mission control from lift-off through 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). These systems allow the flight control personnel to remain in contact with the spacecraft, 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 is staffed with specialists in all aspects of the mission who provide the Mission Director and Flight Director with real time evaluations of mission progress.

The MSFN is a worldwide communications network which is controlled by the MCC during Apollo missions. The network is composed of fixed stations (Figure 20) and is supplemented by mobile stations (Table 3) which are optimally located within a global band extending from approximately 40° south latitude to 40° north latitude. Station capabilities are summarized in Table 4.

The functions of these stations are to provide tracking, telemetry, and command and communications both on an updata link to the spacecraft and on a downdata link to the MCC. Connection between these many MSFN stations and the MCC is provided by NASA Communications Network (NASCOM). More detail on Mission Support is in the MOR Supplement.

TABLE 3

MSFN MOBILE FACILITIES

SHIPS	LOCATION	SUPPORT
USNS Vanguard	25°N 49°W	Insertion
USNS Mercury	32°S 131°E	Injection
USNS Redstone	14°S 145.5°E / 17°S 169°E	Injection / Reentry (tentative)
USNS Huntsville	21°S 173°W	Reentry (tentative)

APOLLO RANGE INSTRUMENTATION AIRCRAFT (ARIA)

Eight ARIA will be available to support the AS-505 mission. The aircraft will operate in the Pacific or Atlantic sector as appropriate. The mission plan calls for ARIA support of translunar injection (TLI) on revolution 2 or 3 and from reentry (400,000-foot altitude) to recovery of the spacecraft crew after splashdown.

TABLE 4

NETWORK CONFIGURATION FOR APOLLO 10 MISSION

Systems / Facilities	Tracking				USB					TLM					CMD			Data Processing			Comm						Other	
	C-band (High Speed)	C-band (Low Speed)	ODOP	Optical	USB	Voice (A/G)	Command	Telemetry	TV	VHF Links	FM Remoting	Mag Tape Recording	Decoms	Displays		CMD Destruct		642B TLM	642B CMD	1218	High Speed Data	Wideband Data	TTY	Voice (SCAMA)	VHF A/G Voice	TV Remoting	SPAN	Riometer
CIF								X	X	X		X	X								X	X		X				
TEL 4										X		X																
CNV	X		X	X												X												
PAT	X	X																										
MLA	X	X																										
MIL					X	X	X	X	X	X	X	X	X	X				X	X	X	X		X	X	X	X		
GBI										X		X				X												
GBM					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			
GTK	X	X														X												
ANG					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			
ANT	X	X										X																
BDA	X	X			X	X	X	X	X	X	X	X	X	X		X		X	X	X	X		X	X	X			
ACN					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			
ASC	X	X																										
MAD					X	X	X	X	X		X	X	X					X	X	X	X		X	X		X		
MADX					X	X	X	X	X											X			X	X				
CYI					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X		X	X
PRE		X																										
TAN		X								X		X											X	X	X			
CRO	X	X			X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X		X	X
HSK					X	X	X	X	X		X	X	X					X	X	X	X		X	X				
HSKX					X	X	X	X	X											X			X	X				
GWM					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			
HAW	X	X			X	X	X	X	X	X	X	X	X	X				X	X	X	X		X	X	X			
CAL	X	X																					X	X	X			
GDS					X	X	X	X	X		X	X	X					X	X	X	X		X	X		X		
GDSX					X	X	X	X	X											X			X	X				
GYM					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			
TEX					X	X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			
HTV		X			X	X		X		X		X	X										X	X	X			
RED	X	X			X	X	X	X	X	X	X	X	X					X	X		X	X	X	X	X			
VAN	X	X			X	X	X	X	X	X	X	X	X					X	X		X		X	X	X			
MER	X	X			X	X	X	X	X	X	X	X	X					X	X		X		X	X	X			
ARIA (6)					X	X		X		X		X												X	X			
LIMA (Peru)																												X

RECOVERY SUPPORT PLAN

GENERAL

The major responsibilities of the recovery forces in supporting this mission include the rapid location and safe retrieval of the flight crew, the CM photographic film and recordings, and return of test data and test hardware. This responsibility commences when the space vehicle leaves the launch pad and ends with safe return of the CM and the flight crew to designated points within the continental United States. Recovery force locations and functions are listed in Table 5.

LAUNCH PHASE

Launch Site Area

The launch site area includes all possible CM landing points which would occur following aborts initiated between Launch Escape System (LES) activation and approximately 90 seconds GET. Planned recovery forces will have a capability to provide a maximum access time of 30 minutes to any point in the area. This support is required from the time the LES is armed (approximately lift-off minus 40 minutes) until 90 seconds after lift-off. However, prior to LES arming, the launch site forces are required to be ready to provide assistance if needed to the Pad Egress Team and, after lift-off plus 90 seconds, they are required to provide assistance to the launch abort area recovery forces.

Launch Abort Area

The launch abort area is where the CM will land following an abort initiated during the launch phase of flight. The launch abort area is divided into two sectors, A and B. These sectors are used to differentiate between the recovery force support required in the eastern and western portions of the area. Sector A is all the area in the launch abort area that is within 1000 nautical miles of the launch site. This sector includes the area where the CM would land following aborts initiated prior to the time the launch vehicle achieves early S-IVB staging to orbit capability. Sector B is all the remaining area in the launch abort area.

Recovery forces have the capability to provide a maximum access time of 4 hours to any point on the spacecraft ground track within the area, a maximum CM and crew retrieval time of 24 hours to any point in Sector A,and a maximum CM and crew retrieval time of 48 hours to any point on the spacecraft ground track for a 72° launch azimuth in Sector B. Landings in the remainder of Sector B are considered to be contingency landings with no maximum retrieval time defined.

Table 5

RECOVERY FORCE LOCATIONS, APOLLO 10

Nominal Mission Phase Ships

Designation	Location	Mission Coverage
Primary Recovery Ship (PRS) USS Princeton	24°00'S latitude 165°00'W longitude 15°08'S latitude 165°00'W longitude	TLC to LOI minus 10 hours Entry minus 6 hours to landing
Secondary Recovery Ship (SRS) 1 USS Rich	28°00'N latitude 70°00'W longitude	Launch window opening to earth parking orbit insertion.
Secondary Recovery Ship (SRS) 2 USS Vanguard	25°00'N latitude 49°00'W longitude	Launch window opening to earth parking orbit insertion.
Secondary Recovery Ship (SRS) 3 USS Chilton	30°00'N latitude 38°30'W longitude	Launch window opening to earth parking orbit insertion and stand-by for possible earth orbital alternate mission.
Secondary Recovery Ship (SRS) 4 USS Ozark	25°00'S latitude 25°00'W longitude 15°08'S latitude 25°00'W longitude	TLC to LOI minus 10 hours Entry minus 6 hours to landing
Secondary Recovery Ship (SRS) 5 USS Carpenter	21°45'N latitude 148°00'W longitude 12°30'S latitude 158°00'W longitude	Earth parking orbit insertion to TLI Entry minus 6 hours to landing

TABLE 5 (Continued)

Nominal Mission Phase Aircraft

Designation	Location	Mission Coverage
3 HC-130	Ascension	Earth parking orbit insertion to entry minus 24 hours.
2 HC-130	Howard AFB, Canal Zone	Earth parking orbit insertion to entry minus 24 hours.
1 HC-130	Mauritius Island	Earth parking orbit insertion to entry minus 24 hours.
2 HC-130	Anderson AFB, Guam	Earth parking orbit insertion to entry minus 24 hours.
2 HC-130	Hickam AFB, Hawaii	Earth parking orbit insertion to entry minus 24 hours.
4 HC-130	Pago Pago, Samoa	Support primary landing area.
	Logistic Aircraft	
1 Helicopter (2 flights)	PRS to Samoa	Transport flight crew and NASA personnel
1 C-141	Cape Kennedy or Long Beach Municipal Airport to CM deactivation site	Transport deactivation equipment and personnel
	Then, Samoa to Ellington AFB, Texas	Transport flight crew and NASA personnel
1 C-133B	Hickam AFB, Hawaii to Long Beach Municipal Airport	Return CM to North American Aviation, Inc.

EARTH PARKING ORBIT PHASE

Earth Orbital Secondary Landing Areas

An earth orbital secondary landing area is where the probability of landing after insertion and prior to TLI is sufficiently high to require secondary recovery ship support. For Apollo 10 these areas are 210- by 80-nautical mile ellipses centered on the target point and oriented with the major axis along the entry ground track. Planned recovery forces will have a capability to provide a maximum access time of 6 hours to any point in the area, and a maximum crew and CM retrieval time of 40 hours to any point in the area.

Earth Orbital Contingency Landing Area

The contingency landing area is that area where the probability of landing is very low and requires only land-based aircraft support. The contingency landing area during the earth orbital phase of Apollo 10 is all the area in a band around the earth between 30°N and 34°S that lies outside the earth orbital secondary landing areas.

The recovery forces will have a capability to achieve a maximum access time of 18 hours in the major portion of the area. It is accepted that portions of the area lie outside the 18-hour capability of the aircraft. In these portions of the area the probability of landing is extremely small and the access time requirement is as soon as possible with no maximum limit defined.

TRANSLUNAR INJECTION TO END OF MISSION

Deep Space Secondary Landing Areas

A deep space secondary landing area is an area where the probability of landing after TLI is sufficiently high to require secondary recovery ship support. For the Apollo 10 Mission, these areas are defined as the areas where landing would occur following (1) translunar coast aborts targeted to the Mid-Pacific line and (2) any abort after TLI targeted to the Atlantic Ocean line (Figure 21).

The recovery forces will have a capability to achieve a maximum access time of 10 hours to any point in the area and a maximum crew and CM retrieval time of 26 hours to any point in the area.

RECOVERY LINES

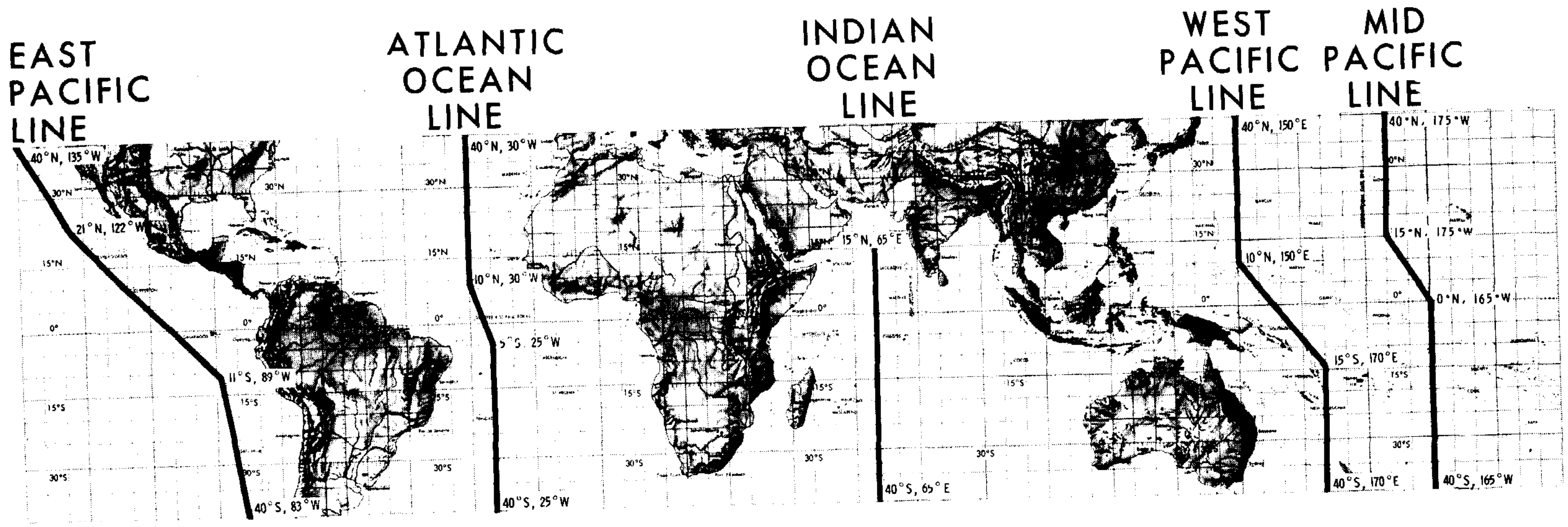


Fig. 21

Deep Space Contingency Landing Area

The contingency landing area for the deep space phase of the mission is associated with very low probabilities of landing and requires land-based recovery aircraft support only.

Recovery forces will provide a capability to achieve a maximum access time of 18 hours to any point on the West Pacific, East Pacific, and Indian Ocean recovery lines after TLI. Certain portions of the recovery lines and some of the area between lines lie outside of the 18-hour capability of aircraft. Since the probability of landing in these areas is extremely small this is acceptable and no maximum access time is defined for these landings. The aircraft required for the West Pacific, East Pacific, and Indian Ocean recovery lines, coupled with the aircraft required for the secondary landing areas previously described, will adequately support these portions of the area.

END OF MISSION

The primary landing area is that area where the probability of landing is sufficiently high to warrant a requirement for primary recovery ship support. For Apollo 10, the primary landing area (Figure 22) is where the spacecraft will land following circumlunar or lunar orbital trajectories that are targeted to the Mid-Pacific recovery line. End of mission landing points for various Apollo 10 launch dates is shown in Figure 23.

Recovery forces will provide a capability to achieve a maximum access time of 2 hours to any point in the area, a maximum crew retrieval time of 16 hours to any point in the area, a maximum CM retrieval time of 24 hours to any point in the area, and a helicopter from which photographers may take pictures of the CM as soon as possible after landing.

PRIMARY LANDING AREA

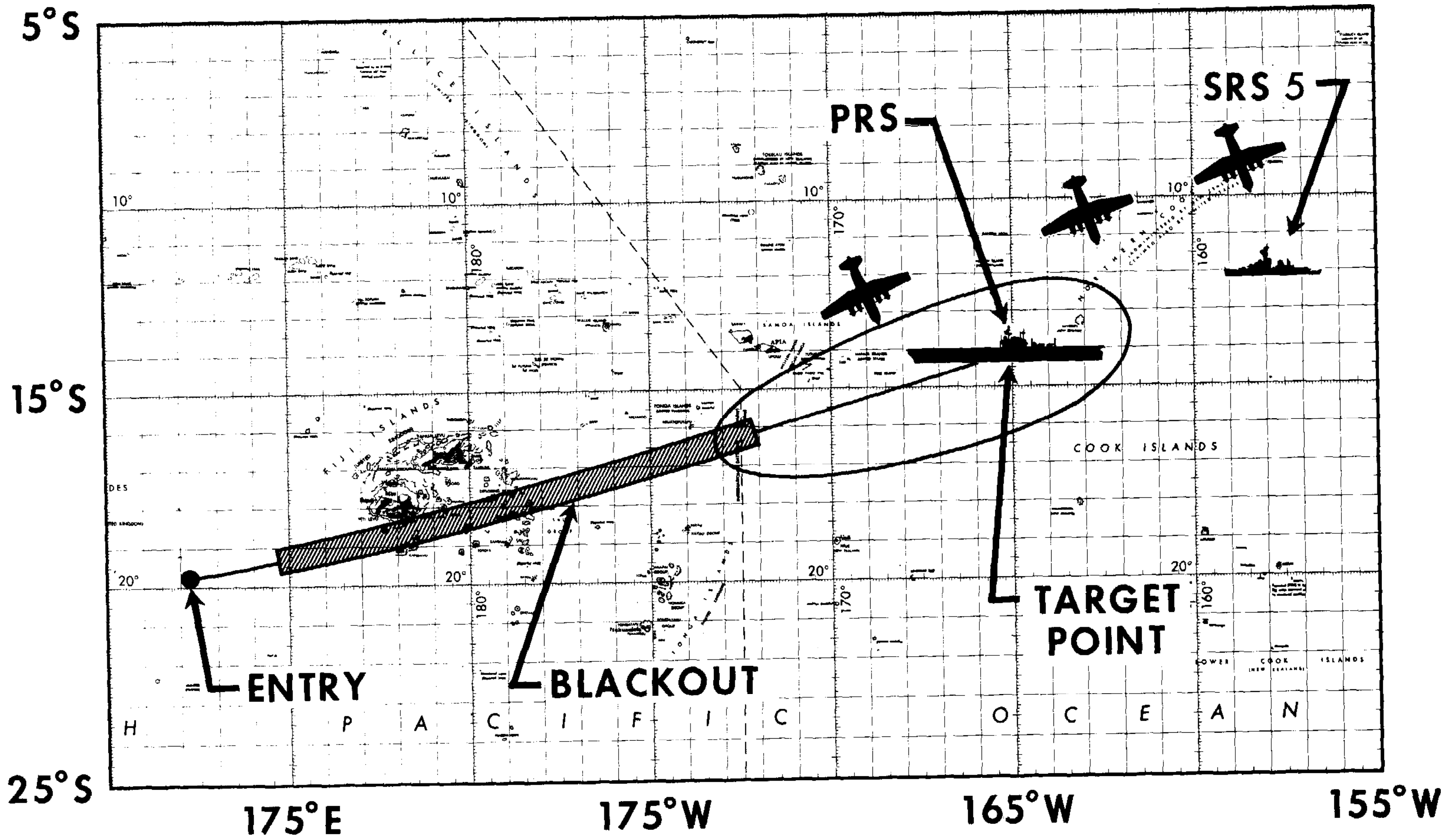


Fig. 22

END-OF-MISSION LANDING POINTS

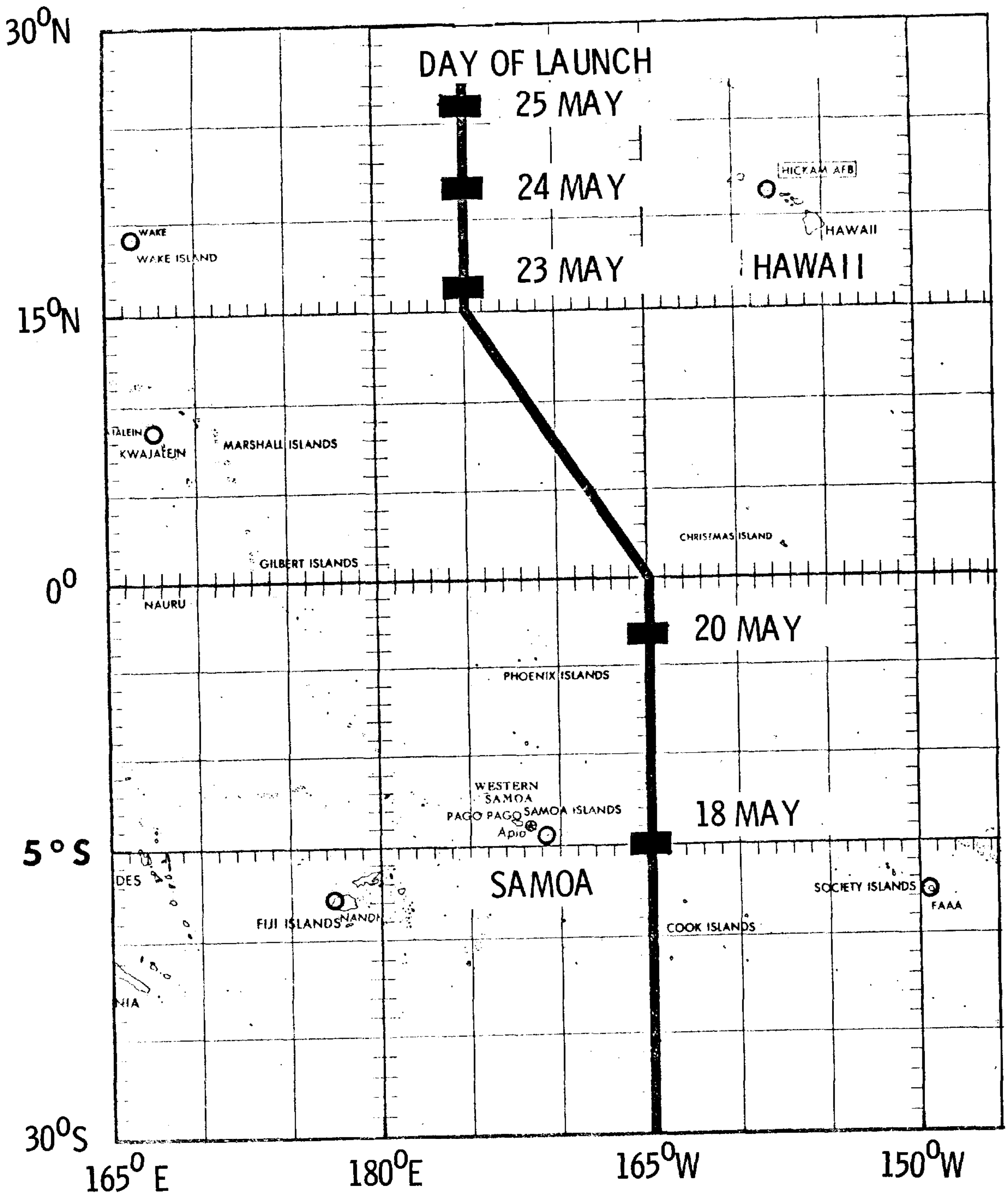


Fig. 23

FLIGHT CREW

FLIGHT CREW ASSIGNMENTS

Prime Crew (Figure 24)

Commander (CDR) - T. P. Stafford (Colonel, USAF)
Command Module Pilot (CMP) - J. W. Young (Commander, USN)
Lunar Module Pilot (LMP) - E. A. Cernan (Commander, USN)

Backup Crew (Figure 25)

Commander (CDR) - L. G. Cooper (Colonel, USAF)
Command Module Pilot (CMP) - D. F. Eisele (Lt. Colonel, USAF)
Lunar Module Pilot (LMP) - E. D. Mitchell (Commander, USN)

If necessary, the backup crew can be substituted for the prime crew up to about two weeks prior to an Apollo launch. During this period, the flight hardware and software, ground hardware and software, 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 two-week period to the prelaunch schedule, which for a lunar mission would require rescheduling for the next lunar window.

PRIME CREW BIOGRAPHICAL DATA

Commander (CDR)

NAME: Thomas P. Stafford (Colonel, USAF)

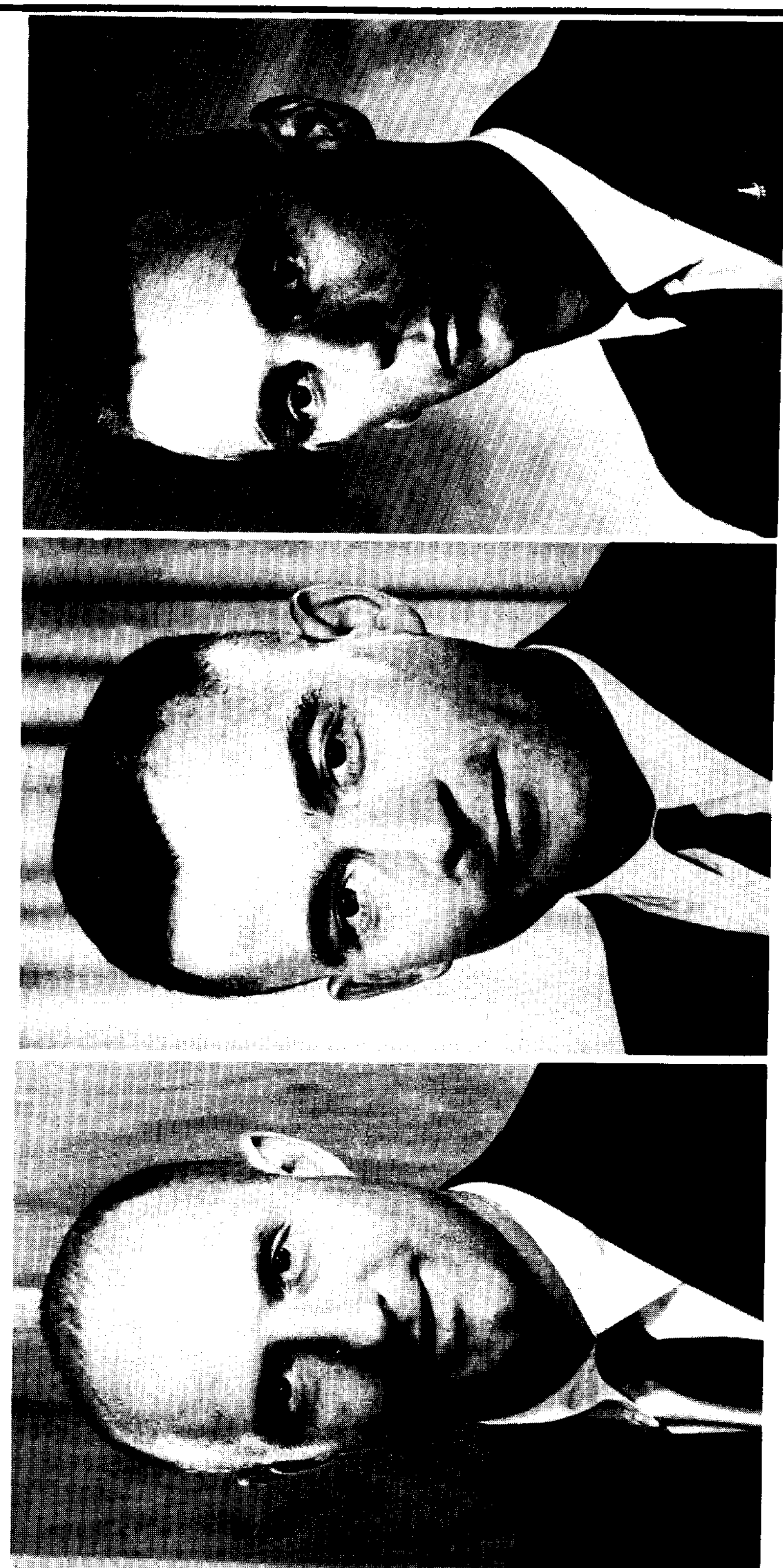
BIRTHPLACE AND DATE: Weatherford, Oklahoma; 17 September 1930.

PHYSICAL DESCRIPTION: Black hair; blue eyes; height: 6 ft; weight: 175 lbs.

EDUCATION: Graduated from Weatherford High School, Weatherford, Oklahoma; received a Bachelor of Science degree from the United States Naval Academy in 1952; recipient of an Honorary Doctorate of Science from Oklahoma City University in 1967.

ORGANIZATIONS: Member of the Society of Experimental Test Pilots.

APOLLO 10 PRIME CREW



THOMAS P. STAFFORD JOHN W. YOUNG EUGENE A. CERNAN

Fig. 24

APOLLO 10 BACK-UP CREW

L. GORDON COOPER DONN F. EISELE EDGAR D.MITCHELL

Fig. 25

SPECIAL HONORS: Awarded two NASA Exceptional Service Medals and the Air Force Astronaut Wings; the Distinguished Flying Cross; the AIAA Astronautics Award; and co-recipient of the 1966 Harmon International Aviation Trophy.

EXPERIENCE: Stafford, commissioned in the United States Air Force upon graduation from Annapolis, flew fighter interceptor aircraft in the United States and Germany after finishing his flight training. He later attended the USAF Experimental Flight Test School at Edwards Air Force Base, California and then served as Chief of the Performance Branch in the USAF Aerospace Research Pilot School there. He is co-author of the Pilots' Handbook for Performance Flight Testing and the Aerodynamics Handbook for Flight Testing.

CURRENT ASSIGNMENT: Colonel Stafford was selected as an astronaut by NASA in September 1962.

On 15 December 1965, he and Command Pilot Walter M. Schirra were launched into space on the Gemini 6 mission and participated in the first successful rendezvous of two manned maneuverable spacecraft by joining the already orbiting Gemini 7 crew. On his second flight he was Command Pilot of the Gemini 9, a 3-day mission which began on 3 June 1966. The spacecraft attained a circular orbit of 161 statute miles; the crew performed three different types of rendezvous with the previously launched augmented Target Docking Adapter; and Pilot Eugene Cernan logged 2 hours 10 minutes outside the spacecraft in extravehicular activity.

Command Module Pilot (CMP)

NAME: John W. Young (Commander, USN)

BIRTHPLACE AND DATE: San Francisco, California, 24 September 1930.

PHYSICAL DESCRIPTION: Brown hair; green eyes; height: 5 ft 9 in; weight: 165 lbs.

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.

ORGANIZATIONS: Member of the American Institute of Aeronautics and Astronautics and the Society of Experimental Test Pilots.

SPECIAL HONORS: Awarded two NASA Exceptional Service Medals, the Navy Astronaut Wings, and three Distinguished Flying Crosses.

EXPERIENCE: Upon graduation from Georgia Institute of Technology, Young entered the US Navy in 1952. He was a test pilot at the Naval Air Test Center from 1959 to 1962 and set world time-to-climb records to 3000 and 25,000 meter altitudes in the F4B in 1962. Prior to his assignment to NASA he was Maintenance Officer of All-Weather-Fighter Squadron 143 at the Naval Air Station, Miramar, California.

CURRENT ASSIGNMENT: Commander Young was selected as an astronaut by NASA in September 1962.

He served as Pilot on the first manned Gemini flight on 3 March 1965, during which the crew accomplished the first manned spacecraft orbital trajectory modifications and lifting reentry.

On 18 July 1966, Young was Command Pilot for the Gemini 10 mission and, with Michael Collins as Pilot, effected a successful rendezvous and docking with the Agena target vehicle.

Lunar Module Pilot (LMP)

NAME: Eugene A. Cernan (Commander, USN)

BIRTHPLACE AND DATE: Chicago, Illinois, 14 March 1934.

PHYSICAL DESCRIPTION: Brown hair; blue eyes; height: 6 ft; weight: 170 lbs.

EDUCATION: Graduated from Proviso Township High School in Maywood, Illinois; received a Bachelor of Science degree in Electrical Engineering from Purdue University and a Master of Science degree in Aeronautical Engineering from the US Naval Postgraduate School.

ORGANIZATIONS: Member of Tau Beta Pi, national engineering society; Sigma Xi, national science research society; and Phi Gamma Delta, national social fraternity.

SPECIAL HONORS: Awarded two Distinguished Flying Crosses, two NASA Exceptional Service Medals, and the Navy Astronaut Wings; recipient of Princeton's Distinguished Alumnus Award for 1965, the US Jaycee's 10 Outstanding Young Men Award in 1965, and the American Astronautical Society Flight Achievement Award for 1966.

EXPERIENCE: Cernan received his commission through the naval ROTC program at Purdue and entered flight training upon his graduation. Prior to attending the Naval Postgraduate School, he was assigned to Attack Squadrons 125 and 113 at the Miramar, California, Naval Air Station.

CURRENT ASSIGNMENT: Commander Cernan was one of the third group of astronauts selected by NASA in October 1963.

On the Gemini 9 mission on 3 June 1966, he was Pilot with Command Pilot Tom Stafford and participated in three different techniques to effect rendezvous with the previously launched Augmented Target Docking Adapter. During the 3-day flight, he logged 2 hours 10 minutes outside the spacecraft in extra-vehicular activity.

He also served as backup pilot for Gemini 12.

BACKUP CREW BIOGRAPHICAL DATA

Commander (CDR)

NAME: L. Gordon Cooper (Colonel, USAF)

BIRTHPLACE AND DATE: Shawnee, Oklahoma, 5 March 1927.

PHYSICAL DESCRIPTION: Brown hair; blue eyes; height: 5 ft 8 in; weight: 150 lbs.

EDUCATION: Attended primary and secondary schools in Shawnee, Oklahoma and Murray, Kentucky; received a Bachelor of Science degree in Aeronautical Engineering from the Air Force Institute of Technology (AFIT) in 1956; recipient of an Honorary Doctorate of Science from Oklahoma City University in 1967.

ORGANIZATIONS: Member of American Institute of Aeronautics and Astronautics, the Society of Experimental Test Pilots, the American Astronautical Society, the Blue Lodge Masons, the Scottish Rite Masons, the York Rite Masons, the Shrine, the Jesters, the International Rotary Club, and the Confederate Air Force.

SPECIAL HONORS: Awarded the NASA Distinguished Service Medal, the NASA Exceptional Service Medal, Air Force Command Astronauts Wings, Distinguished Flying Cross with cluster, the Air Force Command Missileman's Badge, the Scottish Rite 33°, and the York Rite Knight of the Purple Cross.

EXPERIENCE: Colonel Cooper received an Army Commission after completing three years of schooling at the University of Hawaii. He transferred his commission to the Air Force and was placed on active duty in 1949. He then flew F-84's and F-86's for four years with the 86th Fighter Bomber Group in Munich, Germany. He returned to the United States and, after two years of study at AFIT, reported to the Air Force Experimental Flight Test School at Edwards Air Force Base, California. Upon graduation in 1957, he was assigned as an aeronautical engineering and test pilot in the Performance Engineering Branch of the Flight Test Division at Edwards.

CURRENT ASSIGNMENT: Colonel Cooper was selected as a Mercury astronaut in April 1959.

On 15-16 May 1963, he commanded the "Faith 7" spacecraft on a 22-orbit mission which concluded the operational phase of Project Mercury.

He served as Command Pilot of the 8-day, 120-revolution Gemini 5 mission which began on 21 August 1965 and, with Pilot Charles Conrad, established a new space endurance record. Cooper also became the first man to make a second orbital flight.

Command Module Pilot (CMP)

NAME: Donn F. Eisele (Lt. Colonel, USAF)

BIRTHPLACE AND DATE: Columbus, Ohio, 23 June 1930.

PHYSICAL DESCRIPTION: Brown hair; blue eyes; height: 5 ft 9 in; weight: 150 lbs.

EDUCATION: Graduated from West High School, Columbus, Ohio; received a Bachelor of Science degree from the United States Naval Academy in 1952 and a Master of Science degree in Astronautics in 1960 from the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

ORGANIZATIONS: Member of Tau Beta Pi (national engineering society).

EXPERIENCE: Eisele chose a career in the Air Force after graduating from the US Naval Academy. He is also a graduate of the Air Force Aerospace Research Pilot School at Edwards Air Force Base, California.

He was a project engineer and experimental test pilot at the Air Force Special Weapons Center at Kirkland Air Force Base, New Mexico.

CURRENT ASSIGNMENT: Lt. Colonel Eisele was one of the third group of astronauts selected by NASA in October 1963. He served as Command Module Pilot on Apollo 7.

Lunar Module Pilot (LMP)

NAME: Edgar Dean Mitchell (Commander, USN)

BIRTHPLACE AND DATE: Hereford, Texas, 17 September 1930.

PHYSICAL DESCRIPTION: Brown hair; green eyes; height: 5 ft 11 in; weight: 180 lbs.

EDUCATION: Graduated from Artesia High School, 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 US Naval Postgraduate School in 1961, and a Doctor of Science degree in Aeronautics/Astronautics from the Massachusetts Institute of Technology in 1964.

ORGANIZATIONS: Member of the American Institute of Aeronautics and Astronautics; Sigma Xi; and Sigma Gamma Tau.

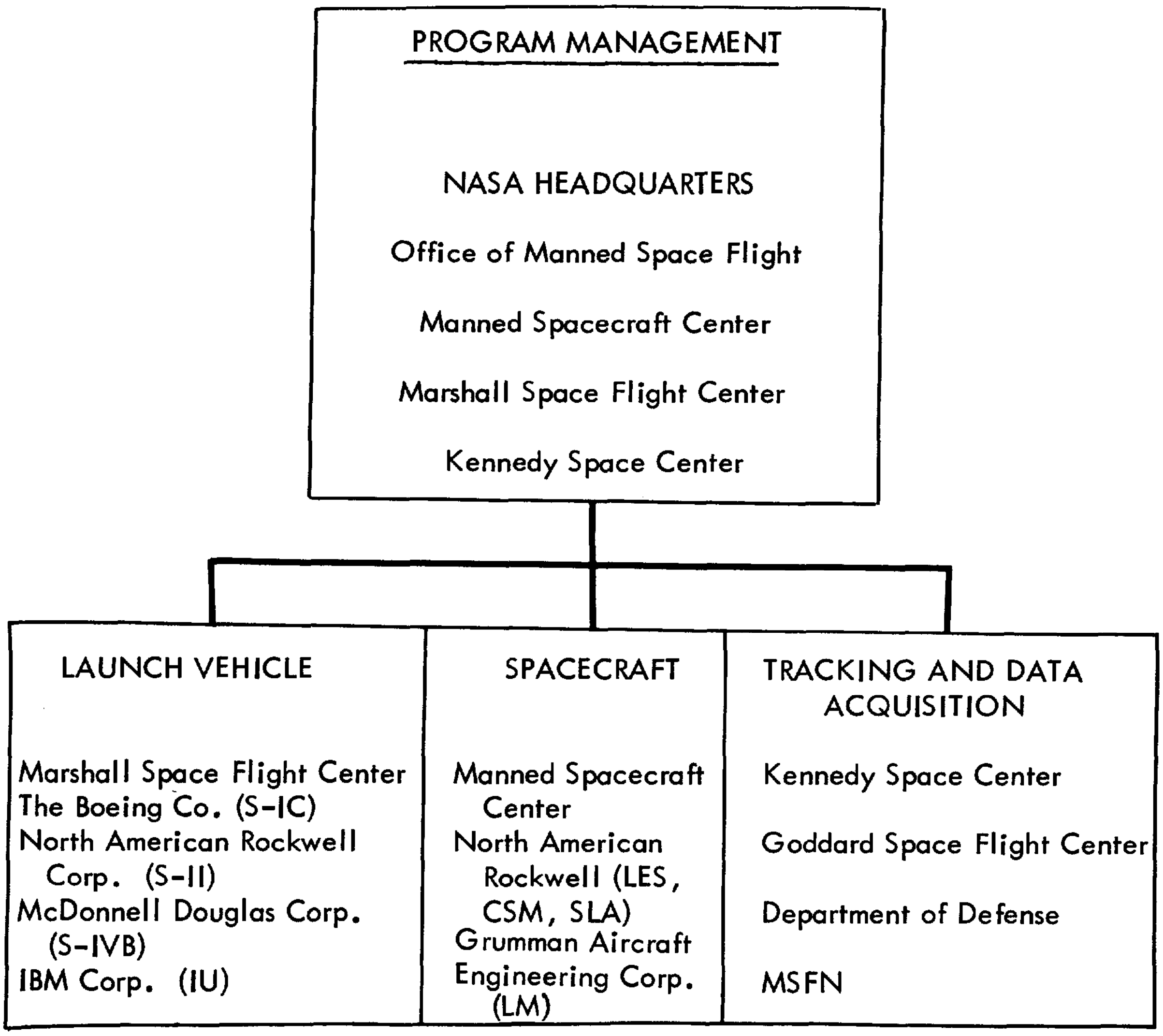
EXPERIENCE: Commander Mitchell entered the Navy in 1952 and completed his basic training at the San Diego Recruit Depot. In May 1953, after completing instruction at the Officer's Candidate School at Newport, Rhode Island, he was commissioned as an Ensign. He completed his flight training in July 1954 at Hutchinson, Kansas, and 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.

CURRENT ASSIGNMENT: Commander Mitchell was in the group selected for astronaut training in April 1966.

MISSION MANAGEMENT RESPONSIBILITY

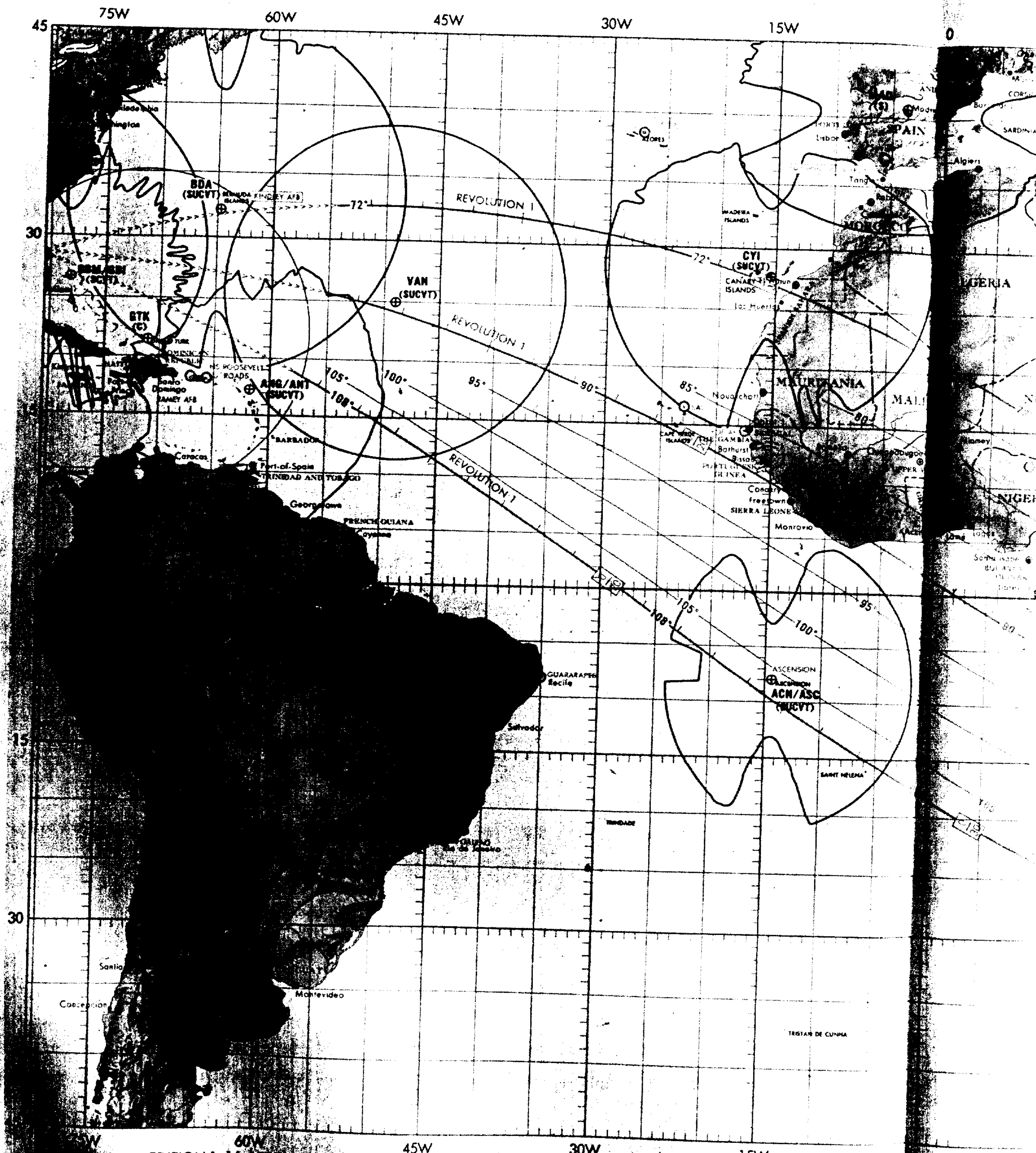
Title	Name	Organization
Director, Apollo Program	Lt. Gen. Sam C. Phillips	NASA/OMSF
Director, Mission Operations	Maj. Gen. John D. Stevenson (Ret)	NASA/OMSF
Saturn V Vehicle Prog. Mgr.	Mr. Lee B. James	NASA/MSFC
Apollo Spacecraft Prog. Mgr.	Mr. George M. Low	NASA/MSC
Apollo Prog. Manager KSC	R. Adm. Roderick O. Middleton	NASA/KSC
Mission Director	Mr. George H. Hage	NASA/OMSF
Assistant Mission Director	Capt. Chester M. Lee (Ret)	NASA/OMSF
Assistant Mission Director	Col. Thomas H. McMullen	NASA/OMSF
Director of Launch Operations	Mr. Rocco Petrone	NASA/KSC
Director of Flight Operations	Mr. Christopher C. Kraft	NASA/MSC
Launch Operations Manager	Mr. Paul C. Donnelly	NASA/KSC
Flight Directors	Mr. Glynn S. Lunney Mr. M. P. Frank Mr. Gerald D. Griffin	NASA/MSC
Spacecraft Commander (Prime)	Col. Thomas P. Stafford	NASA/MSC
Spacecraft Commander (Backup)	Col. L. G. Cooper	NASA/MSC


PROGRAM MANAGEMENT
NASA HEADQUARTERS
Office of Manned Space Flight
Manned Spacecraft Center
Marshall Space Flight Center
Kennedy Space Center
LAUNCH VEHICLE
Marshall Space Flight Center
The Boeing Co. (S-IC)
North American Rockwell Corp. (S-II)
McDonnell Douglas Corp. (S-IVB)
IBM Corp. (IU)
SPACECRAFT
Manned Spacecraft Center
North American Rockwell (LES, CSM, SLA)
Grumman Aircraft Engineering Corp. (LM)
TRACKING AND DATA ACQUISITION
Kennedy Space Center
Goddard Space Flight Center
Department of Defense
MSFN

ABBREVIATIONS

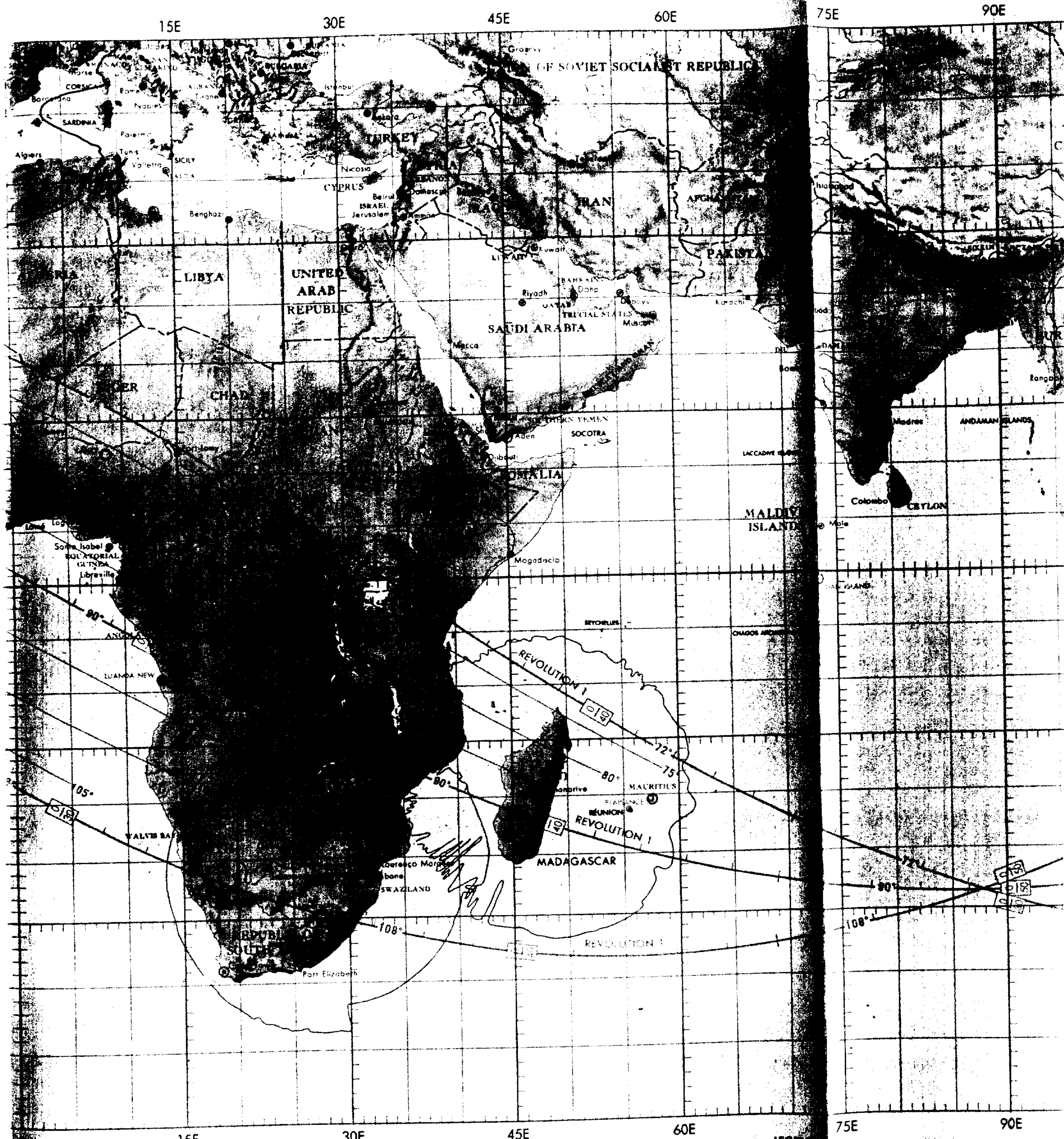
AGS	Abort Guidance System
AOL	Atlantic Ocean Line
AOS	Acquisition of Signal
APS	Ascent Propulsion System (LM)
APS	Auxiliary Propulsion System (S-IVB)
AS	Ascent Stage
BPC	Boost Protection Cover
CDH	Constant Delta Height
CDR	Commander
CES	Control Electronics System
CM	Command Module
CMP	Command Module Pilot
COI	Contingency Orbit Insertion
CSI	Concentric Sequence Initiation
CSM	Command/Service Module
DOI	Descent Orbit Insertion
DPS	Descent Propulsion System
DS	Descent Stage
DTO	Detailed Test Objective
EDS	Environmental Control System
EDS	Emergency Detection System
EDT	Eastern Daylight Time
EI	Entry Interface
EPS	Electrical Power System
EPO	Earth Parking Orbit
EVA	Extravehicular Activity
GET	Ground Elapsed Time
GHe	Gaseous Helium
GN&CS	Guidance, Navigation, and Control System
GOX	Gaseous Oxygen
IMU	Inertial Measurement Unit
IS	Instrumentation System
IU	Instrument Unit
IVT	Intervehicular Transfer
KSC	Kennedy Space Center
LC	Launch Complex
LCC	Launch Control Center
LES	Launch Escape System
LET	Launch Escape Tower
LH_2	Liquid Hydrogen
LM	Lunar Module
LMP	Lunar Module Pilot
LOI	Lunar Orbit Insertion
LOR	Lunar Orbit Rendezvous
LOS	Loss of Signal
LOX	Liquid Oxygen
LPO	Lunar Parking Orbit

LV	Launch Vehicle
MCC	Midcourse Correction
MCC	Mission Control Center
MOCR	Mission Operations Control Room
MOR	Mission Operation Report
MPL	Mid-Pacific Line
MSFN	Manned Space Flight Network
MSS	Mobile Service Structure
NM	Nautical Mile
PC	Plane Change
PDI	Powered Descent Initiation
PGNCS	Primary Guidance, Navigation, and Control System
PRS	Primary Recovery Ship
PTC	Passive Thermal Control
PTP	Preferred Target Point
RCS	Reaction Control System
RR	Rendezvous Radar
SAR	Search and Rescue
SC	Spacecraft
SCS	Stabilization and Control System
SEA	Sun Elevation Angle
SEQ	Sequential System
SHe	Supercritical Helium
SLA	Spacecraft LM Adapter
SM	Service Module
SPS	Service Propulsion System
SRS	Secondary Recovery Ship
SV	Space Vehicle
TB	Time Base
T,D&E	Transposition, Docking, and Ejection
T/C	Telecommunications
TEC	Transearth Coast
TEI	Transearth Insertion
TLC	Translunar Coast
TLI	Translunar Injection
TPF	Terminal Phase Finalization
TPI	Terminal Phase Initiation
T-time	Countdown time (referenced to lift-off time)
TV	Television
VAB	Vehicle Assembly Building
VHF	Very High Frequency



EDITION 1, 16 APRIL 1969
DER THE DIRECTION OF THE DEPARTMENT OF DEFENSE BY THE
CHART AND INFORMATION CENTER, UNITED STATES AIR FORCE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.
Lithographed by ACIC 4-69

NOTE: The representation of international boundar
on this chart is not necessarily authoritative.



MERCATOR PROJECTION
SCALE 1:40,000,000 AT THE EQUATOR

LEGEND

International boundary
Capital cities
Other cities
Airfields
HC 130 home base airfields

Location symbo
Station capabi
B. Unified S Ba
U. UHF Comma
C. C Band Rad
V. VHF A-G V
T. VHF Teleme

TRACKING STATION SYMBOLS

Location symbol and call letters . . . . ⊕ MIL/MLA/CNV

Station capabilities . . . . (SUCVT)

S. Unified S Band (Command, Radar Tracking, Telemetry and A-G Voice. NOTE: Ship HTV does not have command capability.)

U. UHF Command

C. C Band Radar Tracking

V. VHF A-G Voice

T. VHF Telemetry (PRE, TAN, CAL and HTV have record telemetry only)

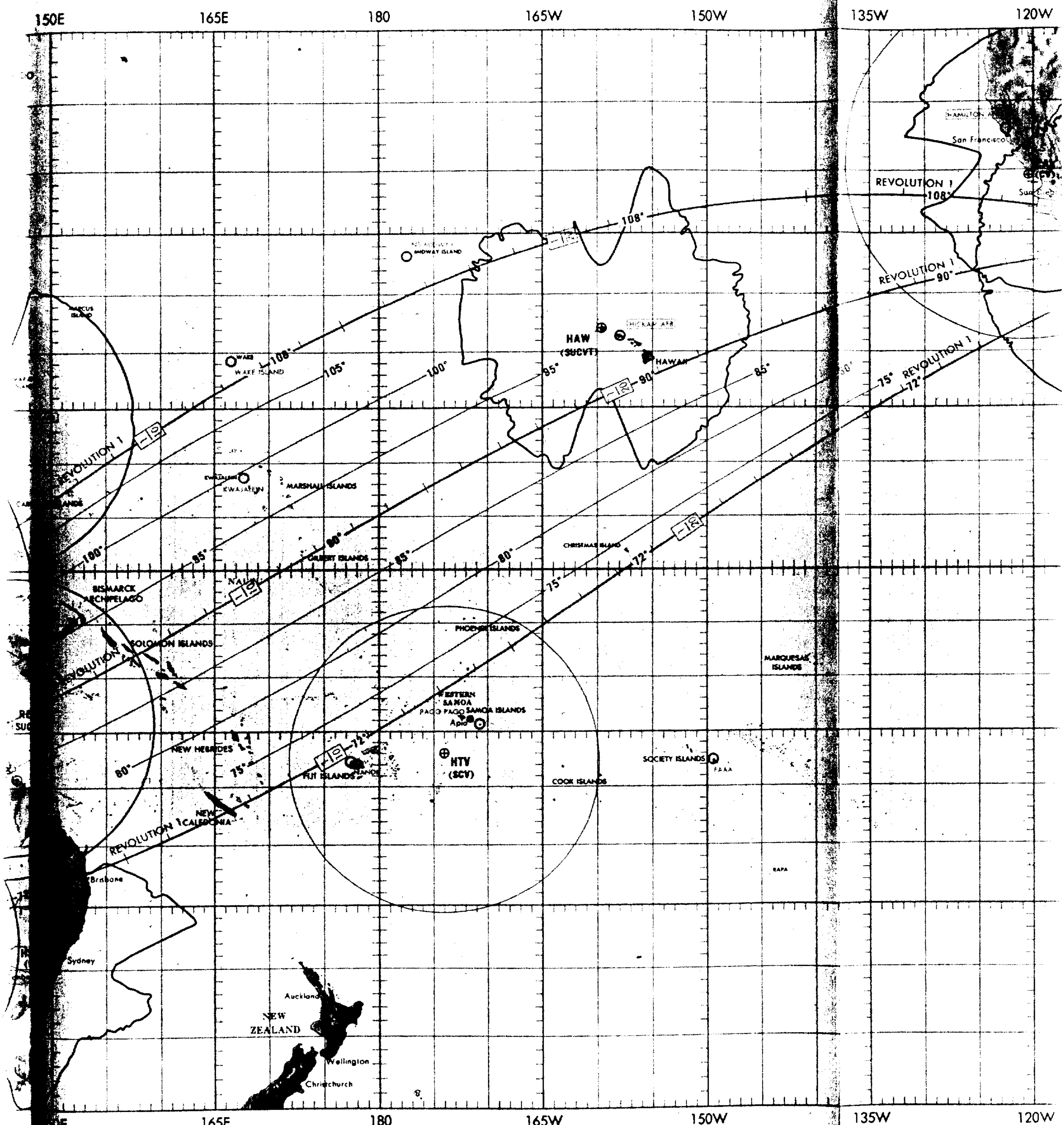
TRACKING LIMIT SYMBOLS

Command capability . . . .

No command capability . . . .

Tracking limits are based upon 100 NM spacecraft altitude for a 0° antenna elevation.

NOTE: POSITIONS FOR SHIPS RED, MER AND HTV ARE NOMINAL FOR 18 MAY 1969 LAUNCH DATE ONLY AND CURRENT THROUGH FSR 6 DATED 3 APRIL 1969



...IT S...OLS

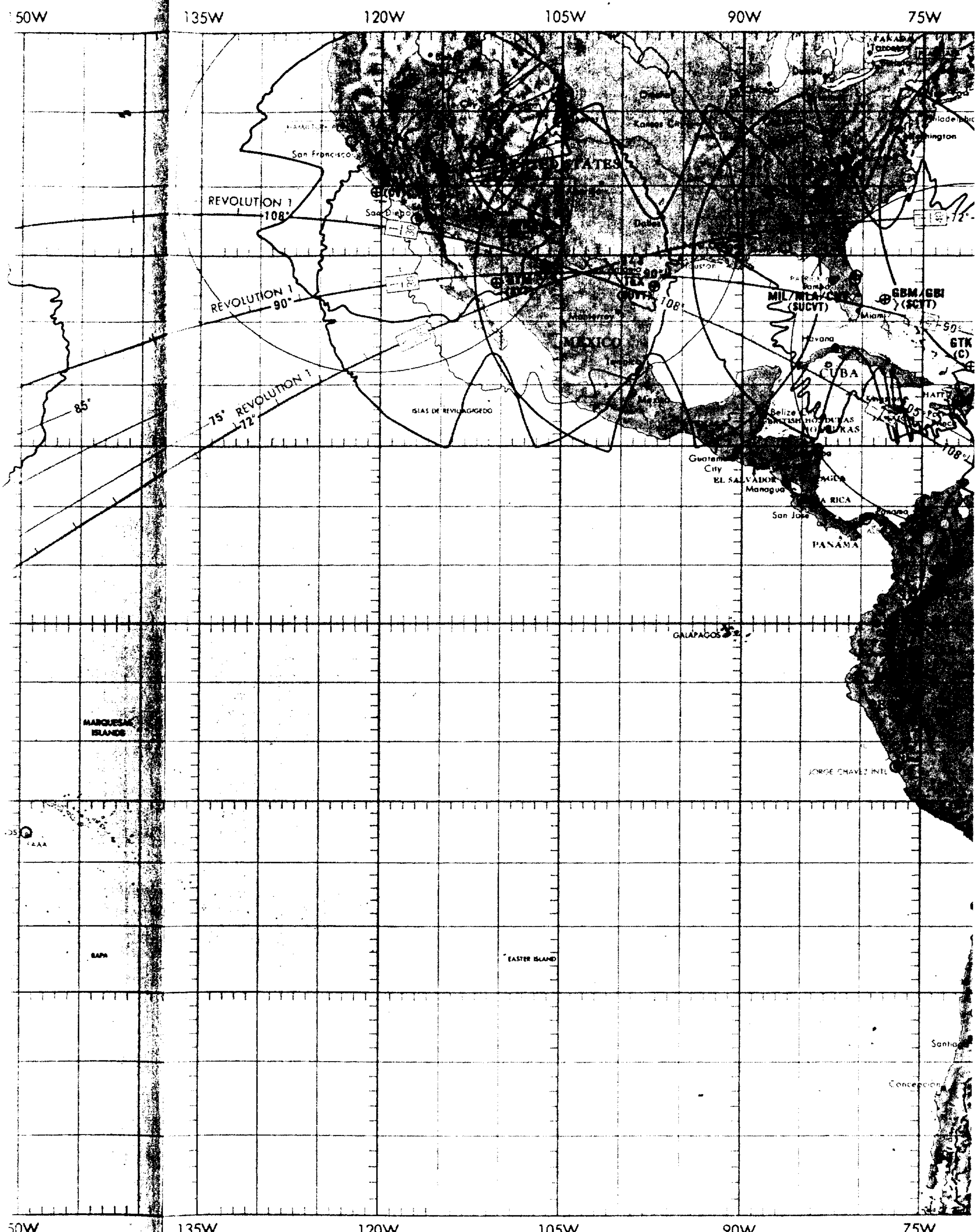
NM ...craft altitude for a 0°

ME... HTV ARE NOMINAL
...D CURRENT THROUGH

GROUND TRACK SYMBOLS

Apollo Spacecraft . . . . ——⊢1⊢—72°—

Elapsed time from launch is indicated by ticks at one minute intervals and by values at 10 minute intervals (in hours and minutes) for each launch azimuths of 72°, 90° and 108°. Ground track segments are shown for specific intermediate launch azimuths. Launch azimuths are labeled in degrees on the ground tracks and segments.



APOLLO EARTH ORBIT CHART (AEO)

APOLLO MISSION 10

REVOLUTION 1

FOR MAY 1969 LAUNCH DATES

Fig. 20