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MSC #113

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO LUNAR EXPLORATION MISSIONS (ALEM) PROGRAM PLAN

JULY 1969

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Program Plan Distribution List

DATE: AUG 11 1969

FROM : PA/Manager, Apollo Spacecraft Program

SUBJECT: Apollo Lunar Exploration Missions (ALEM) Program Plan

Enclosed is the Apollo Lunar Exploration Mission (ALEM) Program Plan, dated July 30, 1969. This program plan supports the requirements of Apollo Program Directive 4K and is based on the most current information available at the time of publication.

It is requested that each directorate review this program plan and submit to me in writing the detailed plans and schedules for achieving the requirements reflected in this document in the areas of the directorate's responsibility. This information should be submitted no later than September 5, 1969. Please contact Mr. C. L. Taylor for information regarding level of detail and format.

It is my intention that a review be conducted with each directorate having management responsibility for the timely completion of the milestones contained in this program plan. The results of the review will be the basis for the first revision of this plan. A detailed explanatory memorandum with an agenda for the review will be issued in the near future.

George M Low 8-11
George M. Low

Enclosure

PP3:AShapiro:blt 7-29-69

5010-106

MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Program Plan distribution list

DATE: AUG 1 1969

FROM : PA/Manager, Apollo Spacecraft Program

SUBJECT: Apollo Spacecraft Program schedule and hardware planning guidelines and requirements

Action

All MSC Apollo Lunar Exploration Missions (ALEM) supporting elements are to implement the requirements of this directive effective with the issuance date and on a continuing basis.

Purpose

This directive defines the ALEM schedule and hardware planning guidelines and requirements to be used as a baseline for detailed Apollo spacecraft programming. Also, this directive reflects the requirements of Apollo Program Directive 4 (APD-4).

Scope

Attachment "A" specifies significant decision/activity schedules, hardware assignments, spacecraft deliveries, and APD-4 launch readiness dates that form the integrated baseline for implementation of this directive.

Attachment "B" designates a summary of mission definitions as required to achieve the Apollo Lunar Exploration missions in accordance with APD-4 and Apollo Flight Mission Assignments Document.

Attachment "C" provides extracts from the CSM and LM Statement of Work, and summary charts delineating CSM and LM manufacturing and delivery schedules.

Attachment "D" contains summary charts depicting required CSM and LM ground test schedules as necessary to support attachment "A" above.

Attachment "E" delineates a listing of all controlled milestones as required in support of the Apollo Spacecraft Program objectives.

Within the ASPO, certain key or major events have been designated as controlled milestones. Controlled milestones are those milestones that represent the completion of tests constraining flight missions, deliveries of certain ground test hardware, deliveries of all flight hardware, deliveries of specified GFE and GSE, and other significant milestones as specified in attachment "E."

Responsibilities

All ASPO division offices and MSC directorates providing support to the ASPO in fulfilling the requirements of this directive are responsible for the timely completion of the controlled milestones under their management responsibility. ASPO division offices and MSC directorates are to notify Mr. C. L. Taylor, Assistant Chief, Program Control Division, immediately whenever a situation exists or is anticipated to exist that will impact or potentially impact established controlled milestones. Mr. Taylor will review impacted controlled milestones at specially called meetings as required.

Status of this directive will be maintained current and updated by the ASPO Program Control Division based on approved schedule changes. Revisions will be issued as required.

George M. Low 8-11

George M. Low

Enclosures

PP3:AShapiro:sp 7-30-69

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BG3/A. Garrison
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BH/J. Kinzler
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BM3/J. Powell
EB4/R. Puffer
BM6/Technical Library(2)
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BR4/T. Wilkes(3)
CA/D. Gregory
CA/D. Slayton
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CB/A. Shepard, Jr.(3)
CF/L. Nichols
CF/W. North
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CF3/C. Woodling(4)
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CF23/L. Allen
CF24/P. Kramer
CF32/J. Peacock
CF32/H. Kuehnel
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CFK/R. McCafferty
DA/C. Berry
DA3/W. Hull
DC/W. Kemmerer
DC4/J. Droescher
DC4/C. Jernigan
DC12/S. Martin
DD/W. Hawkins(2)
SEPT/E. Rees (MSFC)
KP/W. Wolhart
EA/M. Faget
EA1/A. Bond
HA /J. Heberlig
EA5 /J. Jones
EA8/J. Lee
EA2/R. Gardiner
ED8/B. Johnson
ND5/J. Cohen
EA7/E. Jones(6)
ND5/M. Keough
EA5/J. Demuth
EA8/R. Burt
EA8/P. Deans
EB/P. Vavra
EB2/R. Moorehead
EB3/M. Franklin
EB4/J. Overton
EB5/W. Bradford
EB5/I. Burtzlaff
EC/H. Fleming
EC/W. Kincaide
EC/R. Mayo
EC/F. McAllister
EC/E. Tucker
EC/R. Smylie
EC9/C. Lutz
EC9/F. DeVos
ED8/B. Johnson
EE/A. Compos
EE/A. Olsen
EE/R. Dietz
EE/N. Farmer
EE/R. Fenner
EE/D. Hickman
EE/M. Luse
EE/R. Munford
EE/R. Rotramel
EE/R. Giesecke
EE/V. Melliff
EE/F. Eastman
EE2/P. Coan
EE11/R. Sawyer
EE13/A. Spivey(2)
EG/R. Chilton
EG/G. Holloway
EG/R. Lewis
EG/P. Kurten
EG/R. Reina
EG/D. Shelton
EG25/G. Miller
EG42/G. Rice
EG43/R. Wilson
EG44/C. Frazier
EG44/A. Metzger
EG443/W. Swingle
EL/W. Petynia
EL/P. Campbell
EL/J. McLane
EP/D. Bell
EP/W. Hammock
EP/C. Humphries
EP/W. Karakulko
BG/P. Carroll
EP/C. Lambert
EP/R. McSheehy
EP/R. Taeuber
EP/J. Thibodaux
EP/W. Simmons
EP2/N. Townsend
EP4/H. Pohl
EP5/J. Grayson
EP5/W. Rice
ES/L. Chauvin
ES/P. Glynn
ES/J. Kotanchik
ES/R. Langley
ES/W. McMullen
ES/R. West
ES12/G. Sandars
ES26/R. Wren
ES26/W. Dorland
EX/M. Silveira
EX2/B. Redd
FA/C. Critzos
FA/C. Kraft
FA/R. Rose(2)
FA23/D. Durns
FC/E. Kranz
FC1/C. Howard
FL/J. Hammack
FL/J. Shannon
FL/J. Stonesifer
FL/G. Hrable
FL/H. Granger
FM/J. Mayer
FM8/J. A. Owens
FM13/M. Collins(2)
FM13/D. Parten(2)
FS/L. Dunseith
FS4/P. Whalen
FS5/T. Gibson
FS12/S. Beckner
GSF-L/W. Easter
HA/J. Loftus(2)
HA/R. Young
JA/J. Kratovil
JA/D. Lang
JB/J. Bone,Jr.
JC2/A. Atkinson
JB/D. Doherty
JB23/J. Ryan
JC/H. Yschek
JC2/J. Alldredge
JC2/J. Neal
JC2/L. Damewood
BR9/B. Weinert(4)
EC6/W. Hufstetler
JB2/R. Willmann

ADDRESSEES (Continued)

JC34/F. Battersby
JD/G. MacDougal
KA/R. Thompson
KF/H. Gartrell
MA0/G. Chandler,Jr.
MAP/J. Skaggs(4)
NA/L. Menear
NA/W. Bland
NA2/J. Donnell
NB/J. Levine
ND/T. Adams
PA/G. Low
PA/C. Bolender
PA/J. A. McDivitt
PA/G. Abbey
PA/K. Kleinknecht
PA/S. Simplinson
PA2/R. Bailey
PB/A. Hobokan
PC/W. Gray(2)
PB8/R. Bartosh
PC5/H. Ash(4)
PD/O. Maynard
PD/E. Hamblett
PD/R. Kubicki
PD/C. Perrine
PD/R. Ward
PD/R. Colonna
PD/H. Byington
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PD5/J. Goree
PD5/J. Bullard
PD7/R. Kohrs
PD8/J. Goodman(3)
ND5/D. Greenly
PD9/J. Craig
PD9/J. Dolke
PD12/J. Sevier
PE/O. Morris
PE2/D. Corcoran
PE5/J. Turner
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PE7/W. Fischer
PE8/J. Presnell
PF/J. Thompson
PF/A. Cohen
PF2/H. Rees
PF2/D. Broome
PF2/G. Coultas
PF2/J. Lowe
PF2/D. Mayhew
PD7/C. Glancy
PT7/J. Cooper
PF2/G. Metz
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PF3/H. Brendle
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PP6/J. Shannon
PP6/K. Vogel
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PP7/W. Kelly(2)
PP7/A. Brady
PP7/J. Lynch
PP7/J. Vyner
PP32/R. Phillips
PSK/A. Morse(3)
PT/D. Arabian
PT2/J. Dodson
PT3/G. Foster
PT5/J. Lobb
RA/M. Raines
RB/M. Clelland
RD/L. Gomez
RL/J. Hamilton
SA/J. French(7)
SAK/J. Bailey,Jr.
TA/A. Calio
TA/W. Hess
TA/E. Rubenstein(2)
TB/F. Pearce
TD/D. Wiseman
TD2/A. Carroway
TE/B. Jackson
TF/A. Grandfield
TF/R. Clemence(2)
TG/C. Warren
TH/R. Erb
TD5/R. Moke
TD3/D. Gerke
TH/D. Cole
TJ/J. Sasser(3)
ZR1/Chief
ZS5/W. Remini
1-MO-F/C. Casey
AC Electronixs, Houston
GAEC, Houston (2)
NR, Houston
KSC Hdqtrs, Rm 3118/W. Sawyer(3)
TRW Technical Library, Houston,
Bldg. H-2, Room 1067 (4)

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APOLLO SPACECRAFT PROGRAM PLAN

REVISION

INDEX

ATTACHMENT	TITLE	PAGE(S)
A	Significant Decision/Activity Schedules, Hardware Assignments, Spacecraft Deliveries, and Launch Readiness Dates	1 through 5
B	Flight Mission Definitions	1 through 9
C	Extracts From CSM and LM Statements of Work and CSM and LM Manufacturing and Delivery Schedules	1 through 19
D	CSM and LM Ground Test Schedules	1 through 3
E	Controlled Milestones	1 through 14
	Extended PLSS/Secondary Life Support System (SLSS)	
	Advanced Extra Vehicular Suits	
	Modified ALSEP	
	Lunar Orbit Experiments	
	G and N Systems	
	ACE S/C Computer	
	MCC Mission Support	
	Mission Documentation	

APOLLO LUNAR LANDING MISSION
SPACECRAFT DELIVERY AND LAUNCH READINESS SCHEDULE

MISSION DESIGNATION	MISSION TYPE	LAUNCH VEHICLE	CSM	C S M DELIVERY	SLA	LM	LM A/S DELIVERY	LAUNCH READINESS WORKING DATE
Apollo 11	G	506	107	Jan. 19, 1969A	14	5	Jan.8, 1969A	July 16, 1969A
				APOLLO LUNAR EXPLORATION MISSIONS				
Apollo 12	H-1	507	108	Mar. 28, 1969A	15	6	Mar.24,1969A	Nov. 14, 1969
Apollo 13	H-2	508	109	June 25, 1969A	16	7	June 27, 1969A	Mar. 9, 1970
Apollo 14	H-3	509	110	Nov. 30, 1969	17	8	Nov. 15 , 1969	July, 1970
Apollo 15	H-4	510	111	March 31, 1970	18	9	Mar.15 , 1970	Nov. 1970
Apollo 16	J-1	511	112	Aug. 31, 1970	19	10	Sept. 15, 1970	April, 1971
Apollo 17	J-2	512	113	Jan. 31, 1971	20	11	Feb. 15, 1971	Sept., 1971
Apollo 18	J-3	513	114	June 30, 1971	21	12	June 15, 1971	Feb., 1972
Apollo 19	J-4	514	115	Nov. 30, 1971	22	13	Nov. 15, 1971	July, 1972
Apollo 20	J-5	515	115A	April 30, 1972	23	14	April 15, 1972	Dec., 1972

An I-type Mission (Lunar Orbit only; no LM required) is a possible alternate for any of the missions above.

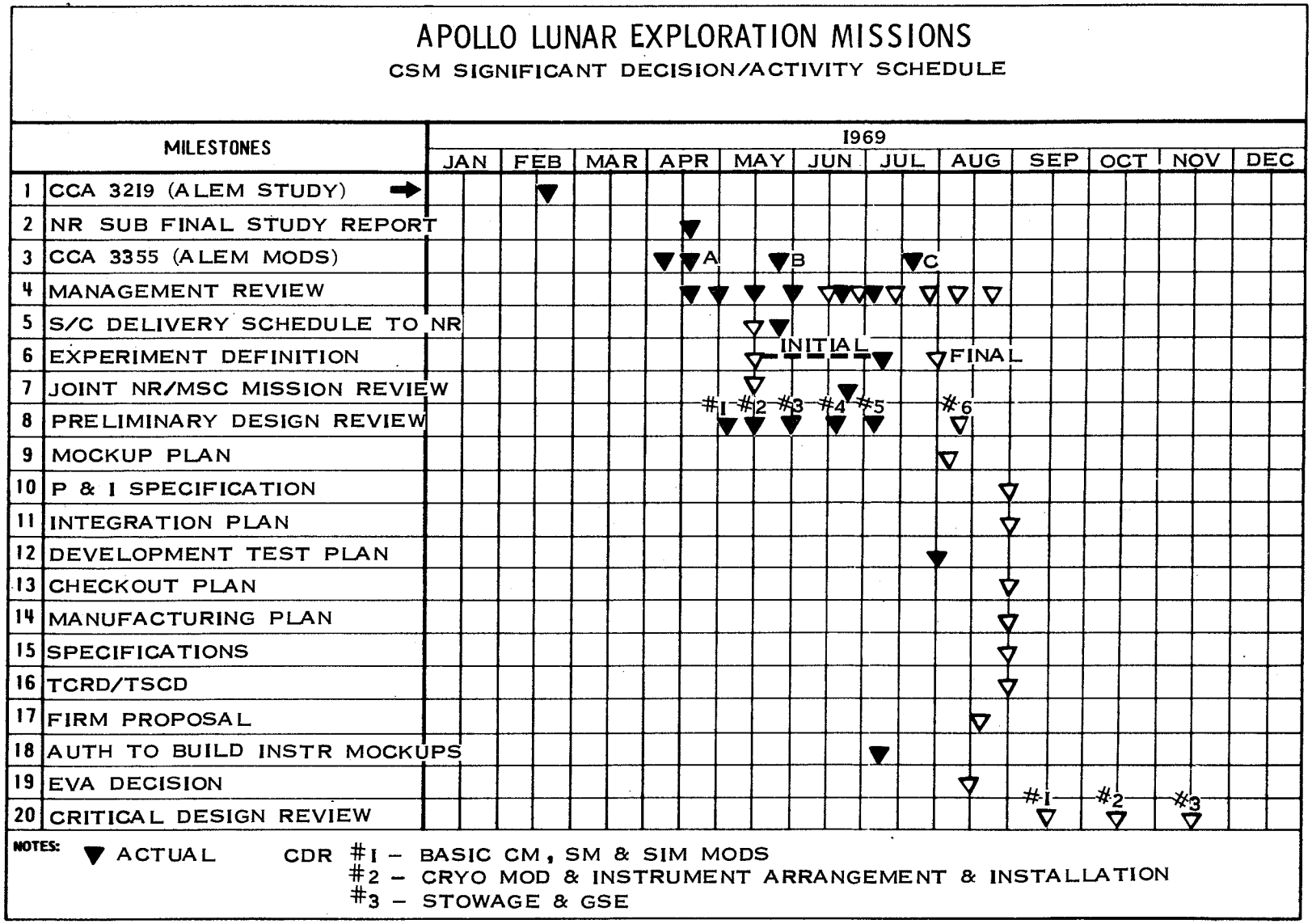
LC-39 FACILITIES ASSIGNMENTS

MISSION DESIGNATION	MOBILE LAUNCHER	HI BAY	FIRING ROOM	PAD
Apollo 8	1	1	1	39A
Apollo 9	2	3	2	39A
Apollo 10	3	2	3	39B
Apollo 11	1	1	1	39A
Apollo 12	2	3	2	39A
Apollo 13	3	2	3	39A
Apollo 14	1	1	1	39A
Apollo 15	2	2	2	39A

7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

CSM SIGNIFICANT DECISION/ACTIVITY SCHEDULE



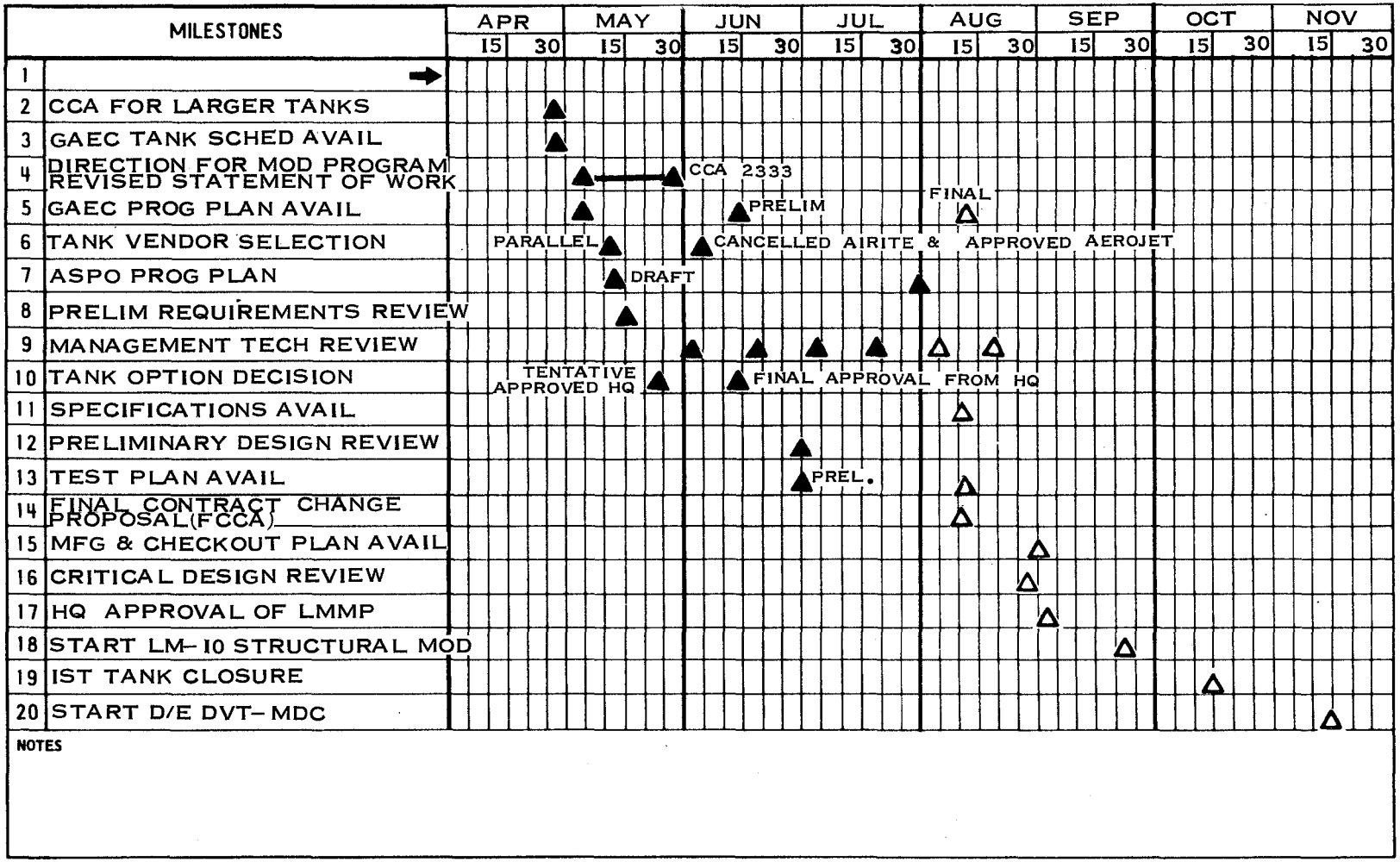
NOTES: ▼ ACTUAL

CDR #1 – BASIC CM, SM & SIM MODS
#2 – CRYO MOD & INSTRUMENT ARRANGEMENT & INSTALLATION
#3 – STOWAGE & GSE

7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

SIGNIFICANT DECISION/ACTIVITY SCHEDULE – LM



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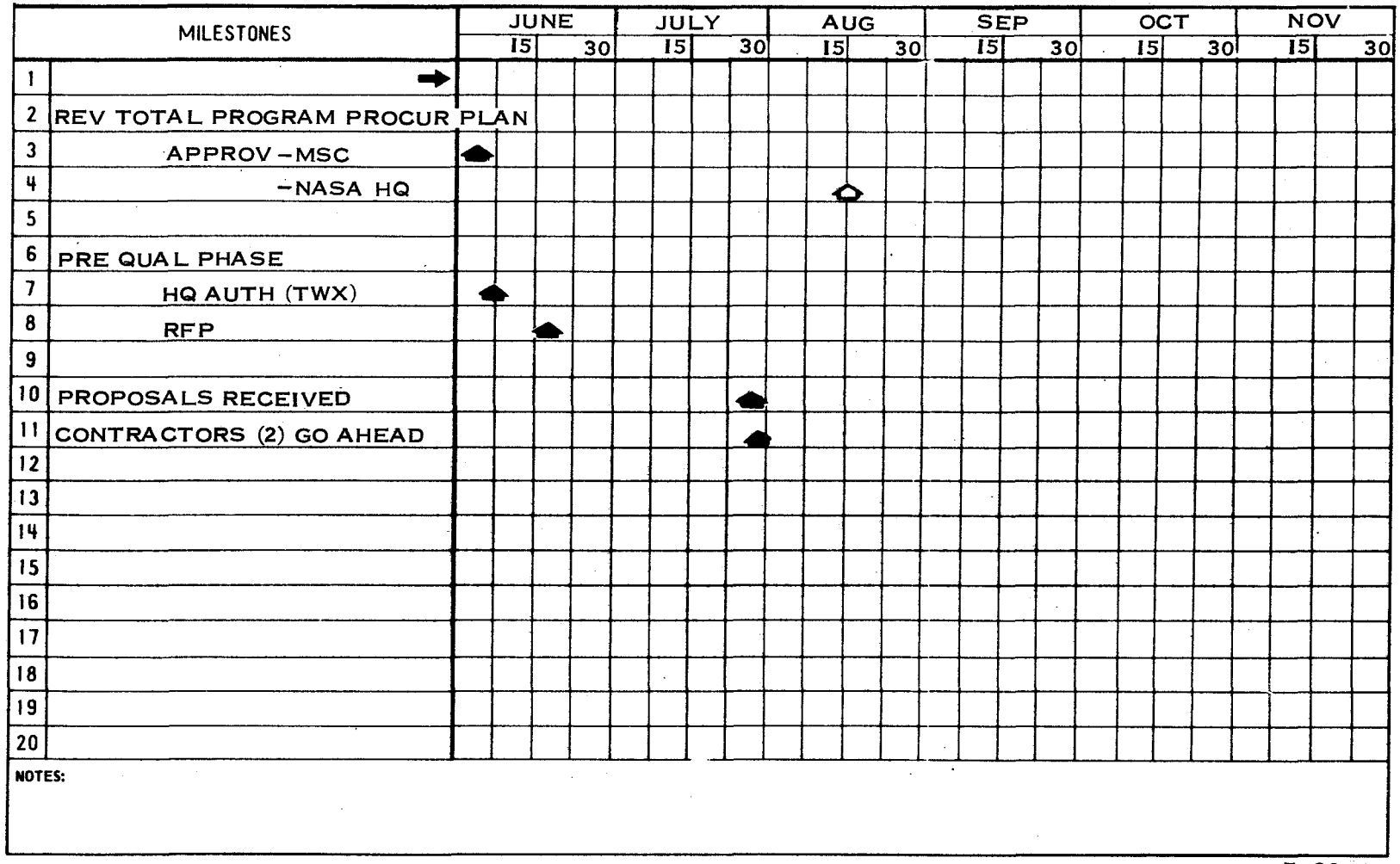
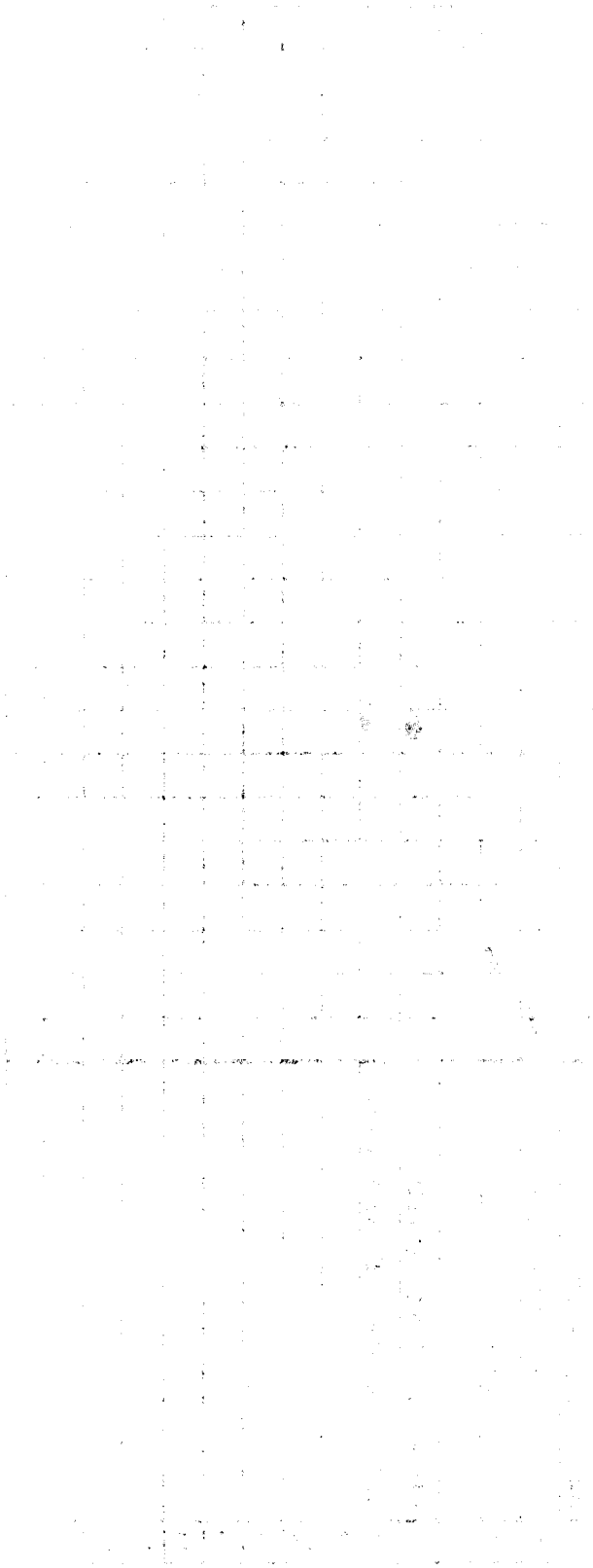
APOLLO LUNAR EXPLORATION MISSIONS

SIGNIFICANT DECISION/ACTIVITY SCHEDULE – ADVANCED EXTRAVEHICULAR SUITS



7–30–69



MISSION DEFINITIONS

MISSION DEFINITIONS

Mission Types

The planned flight missions of the Apollo Lunar Exploration Program are of four types which differ primarily with respect to spacecraft configuration and purpose. The four types are categorized in the following way:

Mission Type	CSM Configuration	LM Configuration	Mission Category
G	Standard Block II	Standard	First Lunar Landing
H	Standard Block II	Standard	Lunar Surface Science
I	Modified Block II	None	Lunar Orbital Science (alternate for a landing mission)
J	Modified Block II	Modified LM	Lunar Surface and Orbital Science

The plans for this program include one G-type mission, four H-type missions, and five J-type missions. An I-type mission may be substituted for any other mission.

Translunar trajectories may be of the free-return or hybrid type. The free return translunar trajectory is targeted to provide for transearth return to an acceptable entry corridor without the use of SPS or LM DPS propulsion but SM RCS maneuvers may be required. The hybrid translunar trajectory initially provides a free return circumlunar flight with a perilune above the nominal lunar parking orbit altitude. Shortly after the TLI burn a maneuver is performed to transfer to a non-free return trajectory constrained such that a safe earth return can be accomplished at some prespecified time after nominal LOI, using the SPS or the LM DPS.

The following sections define the four types of missions in greater detail and present the objectives and profiles of the ten planned missions.

Mission G

This was the first lunar landing mission. The lunar landing was made at Apollo site 2. The LM remained on the lunar surface for approximately 22 hours. A single 2-man EVA was accomplished for approximately 2 hours, 40 minutes. The total mission duration from launch to earth touchdown was approximately 196 hours.

Primary Objective:

- Perform a manned lunar landing and return.

Subordinate Objectives:

- Perform selenological inspection and sampling.
- Obtain data to assess the capability and limitations of the astronaut and his equipment in the lunar surface environment.

Detailed Objectives:

- Collect a contingency sample.
- Egress from the LM to the lunar surface, perform lunar surface EVA operations and ingress into the LM from the lunar surface.
- Perform lunar surface operations with the EMU.
- Obtain data on the landing effects on the LM.
- Obtain data on the characteristics and mechanical behavior of the lunar surface.
- Collect samples of lunar material.
- Determine the position of the LM on the lunar surface.
- Obtain data on the effects of illumination and contrast conditions on crew visual perception.
- Demonstrate procedures and hardware used to prevent contamination of the Earth's biosphere.
- Obtain television coverage during the lunar stay period.
- Obtain photographs during lunar landing and the lunar stay period.
- Deploy the Passive Seismic Experiment.
- Deploy the Laser Ranging Retroreflector Experiment.
- Conduct the Solar Wind Composition Experiment.
- Conduct those portions of the Apollo Lunar Field Geology Experiment (S-059) assigned to Apollo Mission G.
- Conduct experiments S-051, Cosmic Ray Experiment, and T-029, Pilot Describing Function

Type H Missions

Missions H1 through H4 will follow Mission G and all will be flown with standard Apollo hardware. The translunar trajectories may be of either free-return or hybrid type. The LM will remain on the lunar surface up to 35 hours, during which there will be two periods of EVA by both LM crew members. The maximum radius of operation from the LM will be limited by the purge flow time limit of the OPS and is estimated to be approximately 1500 feet. Total mission duration will not exceed 11 days.

Mission H1

Missions H1 will be targeted to land at Apollo site 7 with site 5 as an alternate.

Primary Objectives:

- Perform selenological inspection, survey and sampling in a mare area.
- Deploy ALSEP.
- Develop techniques for a point landing capability.
- Develop man's capability to work in the lunar environment.

Detailed Objectives:

- Collect a contingency sample.
- Perform lunar surface EVA operations.
- Perform PLSS recharge in the landed LM.
- Obtain data on a technique for updating the pre-PDI LM state vector.
- Obtain crew comments on their ability to recognize known surface features and determine the LM location during powered descent.
- Collect samples of lunar material.
- Obtain data on the characteristics and mechanical behavior of the lunar surface.
- Obtain data on the effects of illumination and contrast conditions on crew visual perception.
- Determine the position of the LM on the lunar surface.

- o Perform undocked AGS alignments using the AOT.
- o Obtain photographs during lunar landing and the lunar stay period.
- o Obtain photographs of candidate lunar exploration sites.
- o Obtain television coverage during the lunar stay period.
- o Deploy the Apollo Lunar Surface Experiments Package Array A (ALSEP I).
- o Conduct those portions of the Apollo Lunar Field Geology Experiment (S-059) assigned to Apollo Mission H1.
- o Conduct the Solar Wind Composition Experiment.
- o Conduct experiment T-029, Pilot Describing Function.
- o Obtain multispectral photographs of the lunar surface.
- o Inspect and obtain samples of Surveyor III if feasible.

Sites listed for the remaining H and J series missions listed below are tentative at this time.

Mission H2

The Mission H2 landing site is not yet determined.

Primary Objectives:

- o Perform selenological inspection, survey and sampling.
- o Deploy ALSEP.
- o Develop the capability to conduct a mission to a specific site.
- o Demonstrate the point landing capability.
- o Develop man's capabilities to work in the lunar environment.

Detailed Objectives:

- o Collect a contingency sample.
- o Demonstrate a technique that will improve the pre-PDI state vector.
- o Verify the capability to redesignate the landing target.
- o Collect samples of lunar material.

- o Obtain data on the lunar soil mechanical behavior, and on the surface and sub-surface characteristics.
- o Obtain quantitative data on the operational luminous environment on the lunar surface.
- o Obtain photographs during lunar landing and the lunar stay period.
- o Obtain television coverage during the lunar stay period.
- o Obtain photographs of candidate lunar exploration sites.
- o Short duration SM RCS ullage maneuvers.
- o Deploy the Apollo Lunar Surface Experiments Package Array B (ALSEP III).
- o Conduct those portions of the Apollo Lunar Field Geology Experiment (S-059) assigned to Apollo Mission H2.
- o Conduct experiment T-029, Pilot Describing Function.
- o Obtain multispectral photographs of the lunar surface.

Mission H3

The primary landing site for Mission H3 is not yet determined.

Primary Objectives:

- o Perform selenological inspection, survey, and sampling in a highland structure.
- o Deploy ALSEP.

Detailed Objectives:

- o Collect a contingency sample.
- o Collect samples of lunar material.
- o Evaluate the effects of rough lunar terrain on landing radar and guidance system performance.
- o Obtain data on reflectance of nonvisible radiation by the lunar surface.
- o Obtain data on the lunar surface and sub-surface characteristics, and on the soil mechanical behavior.

- o Autonomous or independent navigation by the CSM (under consideration).
- o Demonstrate the capability to redesignate the landing target in both the downrange and crossrange directions.
- o Demonstrate pre-PDI LM state vector update.
- o Obtain photographs during lunar landing and the lunar stay period.
- o Obtain television coverage during the lunar stay period.
- o Deploy the Apollo Lunar Surface Experiments Package Array C (ALSEP IV).
- o Conduct those portions of the Apollo Lunar Field Geology Experiment (S-059) assigned to Apollo Mission H3.

Mission H4

The primary lunar landing site for Mission H4 is not yet determined.

Primary Objectives:

(Primary objectives have not been established for Mission H4. The following representative objectives are for information only.)

- o Perform selenological inspection, survey and sampling.
- o Deploy ALSEP.

Detailed Objectives: (representative; for information only)

- o Conduct the lunar field geology experiment.
- o Deploy Apollo Lunar Surface Experiments Package Array D (ALSEP II).
- o Obtain television coverage during the lunar stay period.

Type J Missions

Mission J1 through J5 will follow the H-series and will be flown with modified Apollo hardware designed to provide additional hover capability. Modifications to extend mission duration and lunar surface stay time, to increase landed payload and sample return, to extend lunar surface EVA operations and increase mobility, and to provide for scientific experiments and mapping to be accomplished in lunar orbit are also being considered.

An interval of lunar orbit coast up to four days may be available between rendezvous and TEI for lunar orbit experiments operation and mapping. Earlier operation is under study. A 44-minute period of EVA (from hatch egress to ingress) will be conducted to recover data from the scientific instrument module (SIM) in the SM. Total mission duration will not exceed 16 days.

Neither primary nor detailed objectives have yet been established for Type J missions. The objectives that follow are representative and are for information only.

Mission J1

The primary lunar landing site for Mission J1 has not yet been determined.

Primary Objectives:

- o Perform selenological inspection, survey and sampling.
- o Deploy modified ALSEP (MALSEP).
- o Perform a lunar orbital science survey.
- o Demonstrate the capabilities of the modified PLSS and OPS.

Missions J2 through J5

The lunar landing sites for these missions are still under study.

Primary Objectives:

- o Perform selenological inspection, survey and sampling.
- o Deploy MALSEP.
- o Perform a lunar orbital science survey.

Mission I

This mission is a potential alternate for any of the landing missions. It would be a lunar orbit only flight for the purpose of mapping a large area of the lunar surface and exploring it with remote sensors. The area overflown would include as much as but no more than 200 degrees of longitude between 45 degrees south and 45 degrees north latitude. A hybrid translunar trajectory would be flown, and the CSM would be inserted into a lunar orbit of 45 degrees inclination using multiple-impulse techniques. Lunar orbit mapping and scientific activities would be conducted for approximately eight days, after which multiple-impulse techniques would again be used to inject the spacecraft into a transearth trajectory.

Primary Objectives:

- Perform a lunar orbital science survey in an orbit of high inclination.
- Obtain metric and panoramic photographs for lunar mapping.

STATEMENT OF WORK

CSM LUNAR EXPLORATION MISSIONS

JULY 16, 1969

(IMPLEMENTATION OF THIS WORK
IS NOT YET APPROVED)

SCOPE

The Contractor shall be responsible for the integration of scientific experiments described herein, for modification to the CSM required to accommodate the experiments and for obtaining increased CSM mission flexibility in conjunction with a lunar landing or a CSM alone lunar orbit mission. The Contractor shall perform the associated analysis, certification, and testing, and provide the necessary documentation consistent with existing contract provisions.

COMMAND AND SERVICE MODULE MODIFICATIONS

Structures Subsystem Modifications

The following modifications are required for the service module (SM) and command module (CM) structures.

Structure Modification for the SM

A scientific instrument module (SIM) shall be provided for CSM's 112 through 115A to mount scientific experiments for installation in Section I of the service module. The SIM shall be capable of being removed from the SM while the CSM is in a stacked configuration for checkout and alignment of the experiments. The SIM shall be made to comply with maximum handling size in the vehicle assembly building (VAB) and launch pads 39 A&B.

The SIM door shall be a structural pyrotechnically jettisonable panel allowing for a maximum unobstructed opening in flight. The door design shall provide for experiment access as necessary for such things as film installation and instrument servicing. Additional protection shall be provided as required for thermal and RCS plume impingement protection of Sector I after door jettison.

The SIM shall include all of the required mounting provisions for instruments, equipment, mechanical devices and electrical harnesses.

Provisions for installing a 50 percent increase in cryogenic capability shall be added.

Structure Modifications for the CM

Support structures shall be provided for new equipment control panels as required. Structural mounting shall be provided for additional stowage as required.

Stowage Modifications

Stowage shall be provided for return of experiment data including film and nuclear particle detectors. Additional stowage for a third sample return container shall be provided in the CM.

Stowage of consumables shall be provided in support of lunar exploration missions for periods up to the maximum provided by the modified CSM cryo capability.

Stowage shall be provided for extravehicular activity equipment if performed from the CM for data retrieval from the SIM.

Electrical Power Subsystem Modifications

The primary low level dc power source for the experiments and mechanisms shall be derived from existing circuit breakers. High power requirements shall be supplied by the SM busses, appropriately fused, and shall be controlled remotely from the CM. All ac power requirements shall be supplied by the CM ac busses through circuit breakers. Controls for the experiments and mechanisms shall be located on a control panel in the CM. Overlay wire harnesses shall be installed in the CM and SM, mating with the SM Sector I equipment at a new connector interface.

Controls for the additional cryogenics shall be provided in the CM. The Sector I harness shall be configured to allow the cryogenic harness to be installed independently from the SIM.

Communications and Data Subsystem Modifications

The experiment data system shall utilize the existing CSM capability. In parallel, the contractor shall proceed with design and development of the expanded data system. Planning shall be for implementation of the expanded system on the earliest CSM consistent with the defined delivery schedule of this CCA.

Existing Data System

The present scientific data experiment transmission requirements shall be fulfilled by time sharing the existing S-band RF link. Use shall be made of unassigned PCM data channels and the three unused scientific instrumentation subcarrier oscillators (95 kHz, 125kHz, and 165 kHz) to transmit the experiment data.

a. The existing PCM channel usage shall be optimized for experiment data handling by considering low priority data tradeoffs and possible reassignments of high and low bit rate channels.

b. In addition, subcommutating experiment data channels shall be utilized in conjunction with channel reassignment.

Expanded Data System

Provisions shall be made for an additional S-band RF link for simultaneous transmission of both real time and stored (recorded) scientific experiment

data via the existing high gain antenna. This system will provide for handling a variety of data formats such as PCM, FM analog, and video.

Provisions shall be made for the recovery of data such as that obtained on the lunar far side. This equipment shall have the capability of storing up to one hour of wide band digital and analog data.

Environmental Control Subsystem Modifications

Consumables

The LiOH canister quantities shall be based on the present 12 hour replacement cycle.

Cryogenic Storage Subsystem Modifications

Cryogenic storage capability shall be increased by 50% by adding one Beech Aircraft (BAC) Block II Apollo oxygen tank, one BAC Block II hydrogen tank, and the additional valve modules, signal conditioners and wiring to provide the necessary control and management functions. Cryogenic control for the two added cryogenic tanks will be accomplished with relays in lieu of motor switches.

Controls and Displays

Standard displays and controls for the experiment instruments and added cryogenics shall be provided in the CM for all of the lunar exploration missions. Typical functions to be considered are power on, power off, deployment, calibration and housekeeping.

EVA Provisions

Provisions will be made for extravehicular activity (EVA) to retrieve experiment data from the SIM at the completion of the lunar science portion of the mission. Design shall be based on use of the Portable Life Support Systems/Oxygen Purge System (PLSS/OPS) with egress and ingress through the CM. An alternate design shall be pursued utilizing a high pressure, low flow oxygen and communication umbilical to back up the Life Support System. For lunar landing missions the LM will be retained on the CSM after rendezvous for PLSS/OPS storage and disposal until the experiments have been completed, and EVA accomplished. For CSM alone missions, stowage for the PLSS/OPS shall be provided in the CM.

EVA handrails, handholds, foot restraints and other aids shall be provided on the CM and SM as necessary to facilitate retrieval of data from the SIM.

MOCKUP AND TRAINING

The following mockups shall be provided as a minimum. Additional requirements shall be proposed in the Mockup Plan.

An Engineering mockup of the SM SIM shall be provided to evaluate experiment mounting layout, view angles, accessibility, wiring interface, etc. Another SIM mockup shall be provided to MSC and updated as required for one "g" training.

Mod kits shall be provided to update mockup MSC-1 as required to support crew training for launch and entry stowage.

Mod kits shall be provided for updating the CM simulator crew compartment and loose equipment stowage.

A CM mockup shall be provided at Downey to reflect those changes described herein.

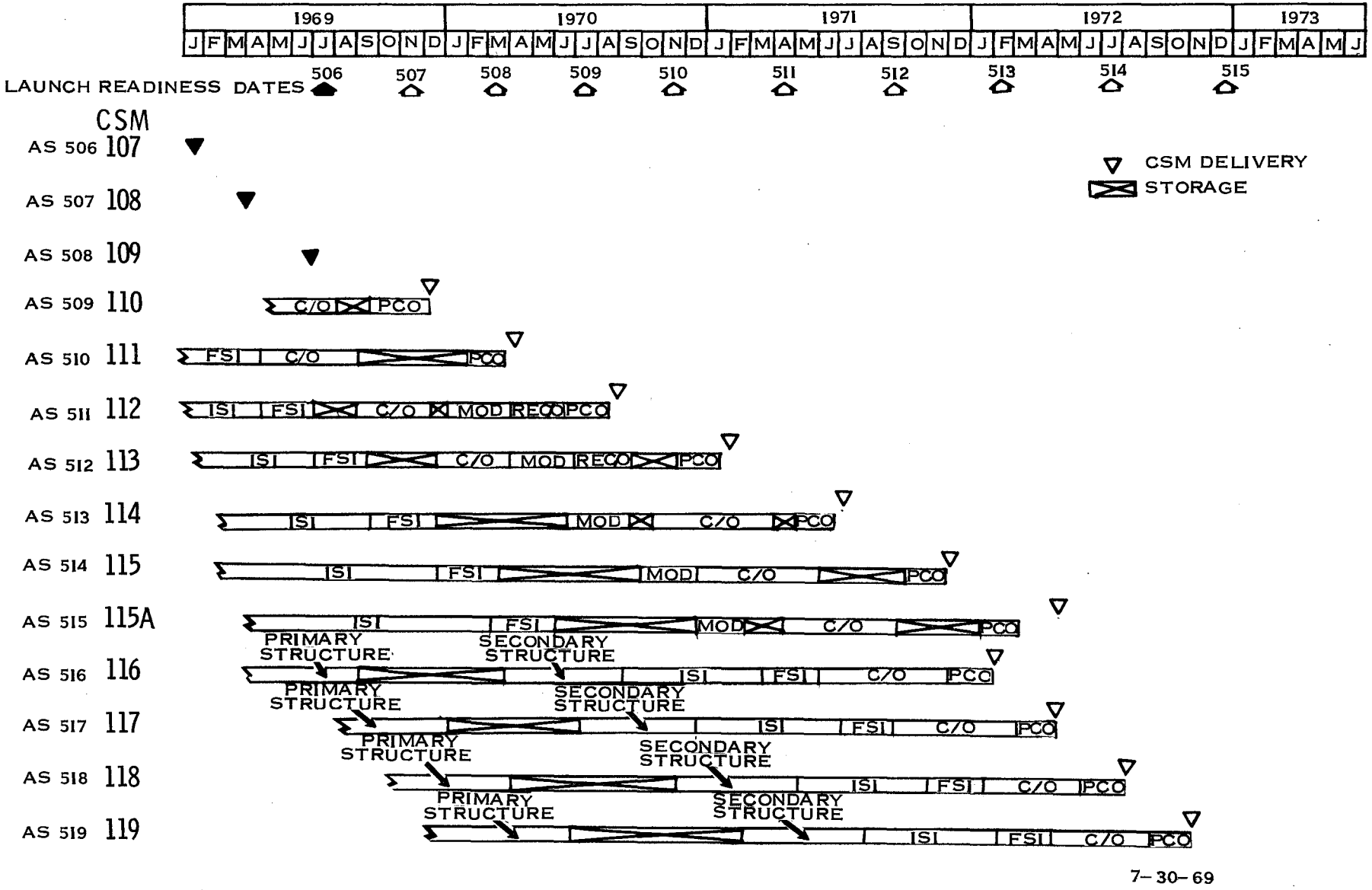
A mockup shall be provided to MSC sufficient to allow underwater training for tasks associated with EVA and zero "g" evaluations.

KSC egress trainer shall be updated as required.

Training courses, procedures, and documentation shall be provided as required for associated changes.

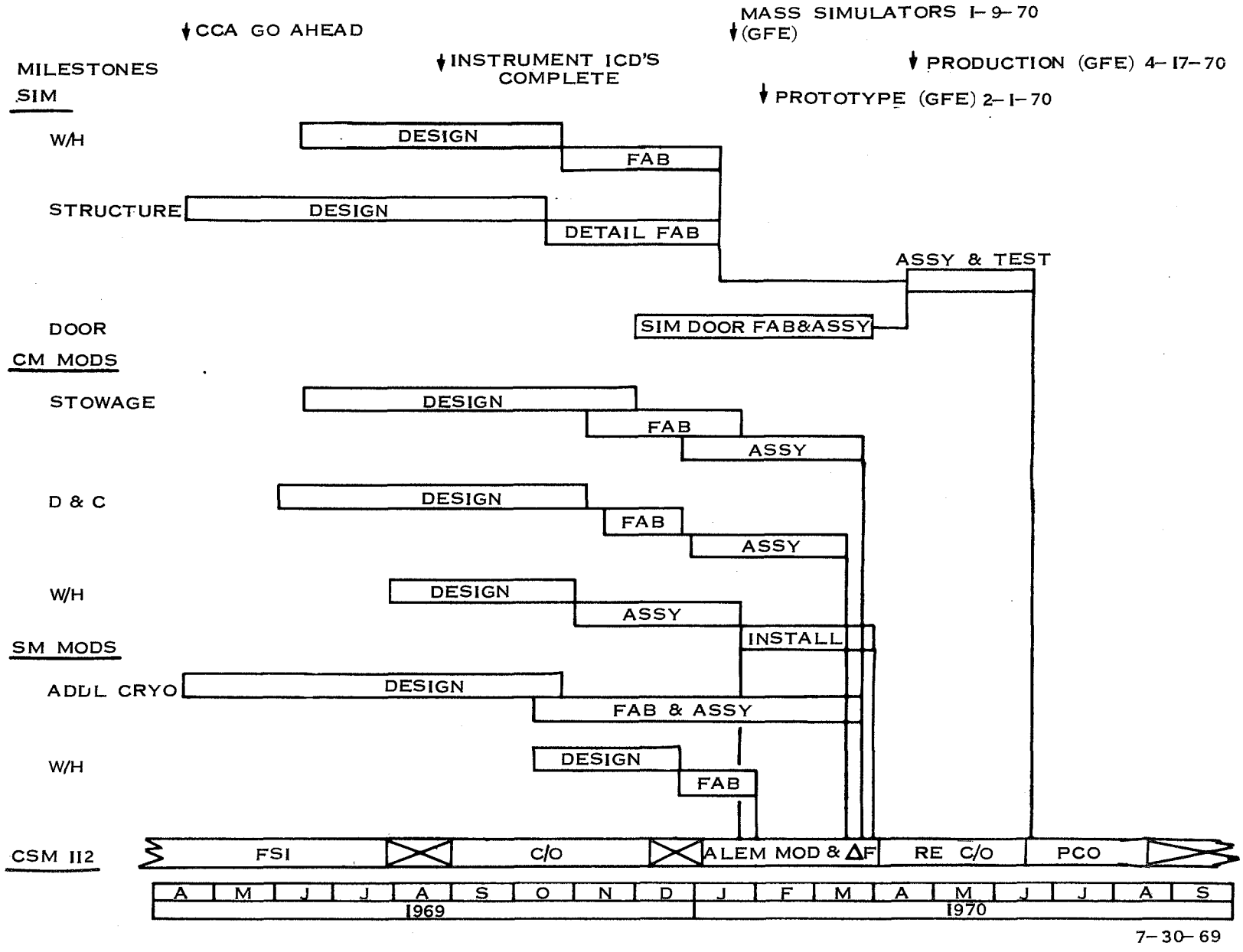
APOLLO LUNAR EXPLORATION MISSIONS

CSM MANUFACTURING AND CHECK OUT SCHEDULE



APOLLO LUNAR EXPLORATION MISSIONS

FIRST ARTICLE SCHEDULE (CSM 112)



7-30-69

EXTRACT FROM

STATEMENT OF WORK

LM LUNAR EXPLORATION MISSION

JUNE 5, 1969

EXTRACT FROM

STATEMENT OF WORK

LM LUNAR EXPLORATION MISSION

JUNE 5, 1969

(LARGER TANKS ONLY)

SCOPE

The contractor shall supply the necessary skills, services, materials and equipment to conduct a program of engineering, manufacturing, testing, procurement and planning in order to provide NASA with the design and necessary planning for the modification of Lunar Modules 10 through 14. The development of the LM modifications shall be in accordance with all existing Apollo LM Program procedures, specifications, ICD's, documentation terms and conditions as defined under the provisions of NASA contract NAS 9-1100.

DESIGN REQUIREMENTS

Structures and Mechanisms

This modification shall be incorporated as a block change on LM-10 and subsequent. Changes shall be made inline as opposed to retrofit to the maximum degree practical.

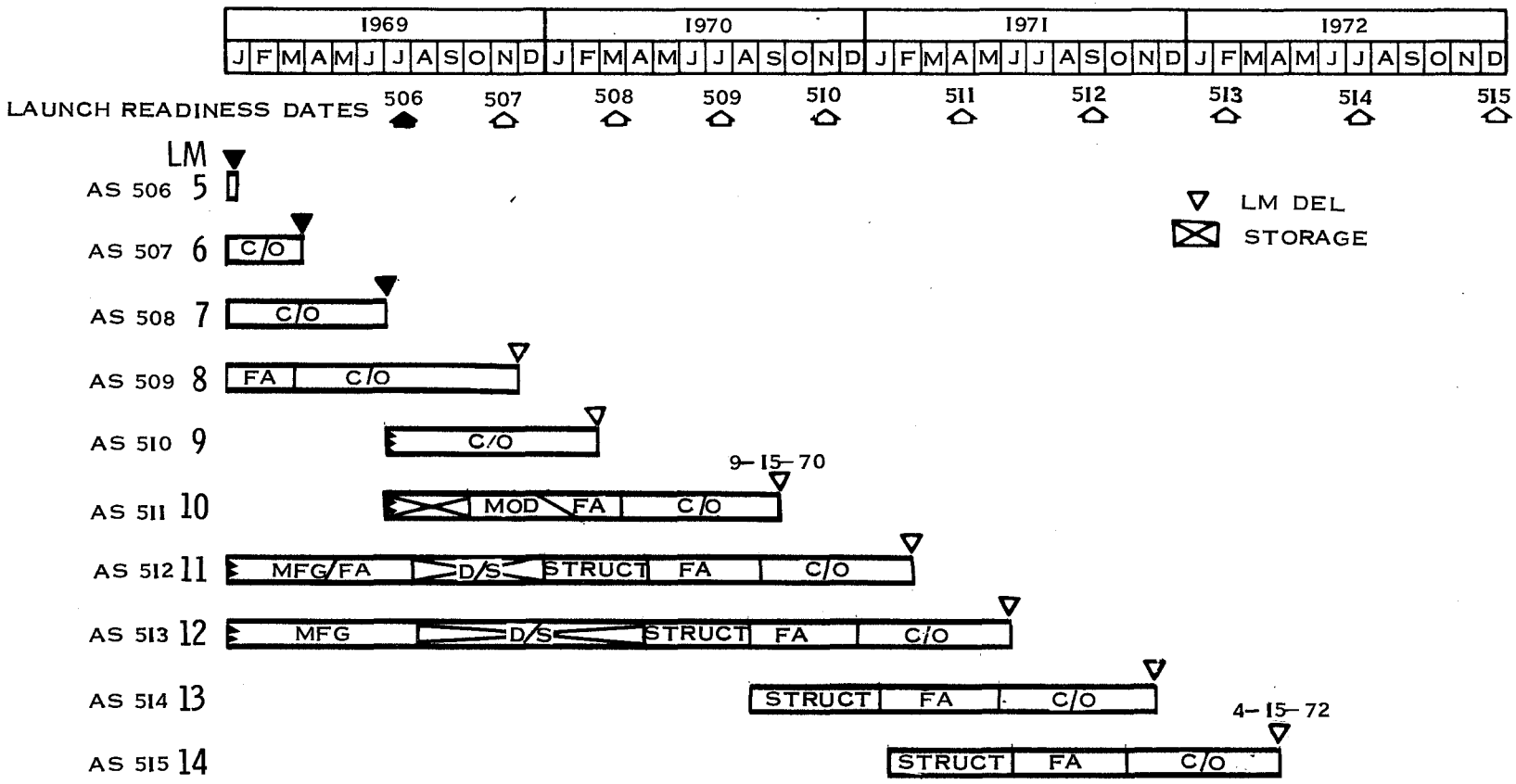
The LM will have the elongated (3.36 in.) hemispherical-end-dome descent propellant tanks, with the associated descent stage structural and piping modifications.

Positive margins are to exist in both the modified and existing structure to ensure the structural integrity of the vehicle for the launch-to-boost environment, all docking and docked maneuvers and the lunar landing. Safety margins existing in LM-9 configuration will not be reduced prior to detailed NASA review and approval. Adequacy of the landing gear shall be verified by analysis and test as necessary for the heavier vehicle.

Note: CCA 2205 which authorizes enlarged tanks, is to be implemented in such a fashion that it is not dependent upon any element of the total LMMP design effort authorized by CCA 2333. Specifically LM-10 and subsequent shall be capable of performing lunar landing missions in which all or any portions of the additional propellant is used in the descent burn.

APOLLO LUNAR EXPLORATION MISSIONS

LM MANUFACTURING SCHEDULES

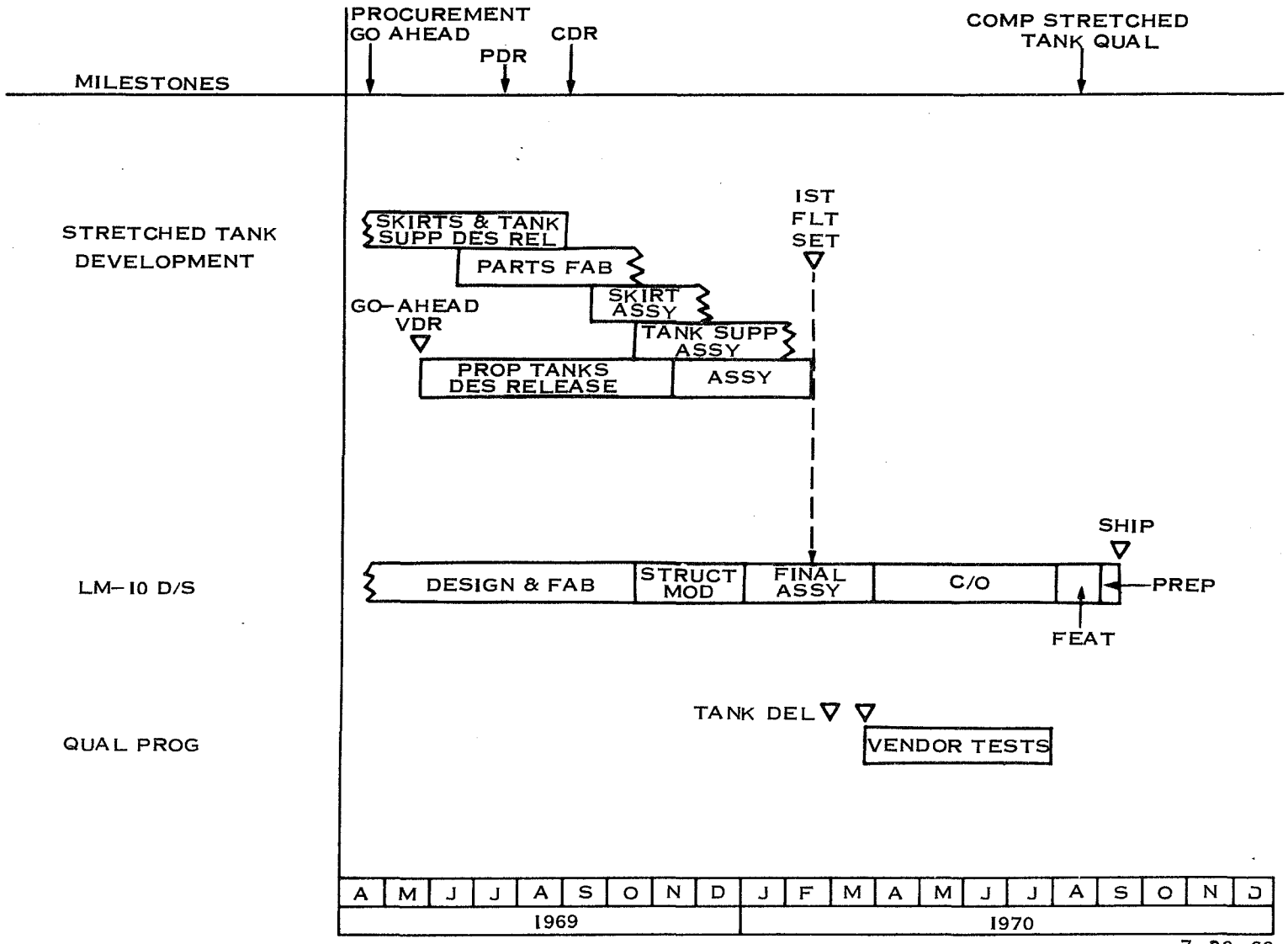


ABOVE SCHEDULE IS FOR D/S WHICH IS PACING

7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

FIRST ARTICLE SCHEDULE – LM-10
(LARGER TANKS ONLY)



7-30-69

ALEM
LM D/S TANK MFG & TEST SCHEDULE

	MILESTONES	CY 1969												CY 1970												CY 1971												CY 1972											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1		→																																														
2	GO AHEAD					▼																																										
3																																															
4	COMPL DESIGN DWGS							▼																																								
5																																															
6	DEL FIRST VEH. SET (4 TANKS) (LM-10)													▽																																		
7																																															
8	COMPL QUAL TANKS														▽																																		
9																																															
10	COMPL QUAL TEST																				▽																												
11																																															
12	DEL OTHER VEH. SETS																																														
13	SECOND SET (LTA-5)																▽																																
14	THIRD SET (LM-11)																	▽																															
15	FOURTH SET (LM-12)																				▽																												
16	FIFTH SET (LM-13)																						▽																										
17	SIXTH SET (LM-14)																									▽																						
18	SEVENTH SET (SPARE)																										▽																					
19	EIGHT SET (SPARE)																											▽																				
20																																															

NOTES

7-30-69

EXTRACT FROM

STATEMENT OF WORK

IM LUNAR EXPLORATION MISSION

JUNE 5, 1969

(IMPLEMENTATION OF THIS WORK
IS NOT YET APPROVED)

EXTRACT FROM STATEMENT OF WORK

LM LUNAR EXPLORATION MISSION

JUNE 5, 1969

LARGE TANKS AND LMMP

SCOPE

The contractor shall supply the necessary skills, services, materials and equipment to conduct a program of engineering, manufacturing, testing, procurement and planning in order to provide NASA with the design and necessary planning for the modification of Lunar Modules 10 through 14. The development of the LM modifications shall be in accordance with all existing Apollo LM Program procedures, specifications, ICD's, documentation terms and conditions as defined under the provisions of NASA contract NAS 9-1100.

Note: The modifications delineated in this extract are the total modifications in planning for ALEM. To date, the only approved modification is the elongated descent propellant tanks, with the associated descent stage structural and piping modifications.

DESIGN REQUIREMENTS

Structures and Mechanisms

All modifications shall be incorporated as a block change on LM-10 and subsequent. Changes shall be made inline as opposed to retrofit to the maximum degree practical.

The LM will have the elongated (3.36 in.) hemispherical-end-dome descent propellant tanks, with the associated descent stage structural, thermal and piping modifications.

Positive margins are to exist in both the modified and existing structure to ensure the structural integrity of the vehicle for the launch-to-boost environment, all docking and docked maneuvers and the lunar landing. Safety margins existing in LM-9 configuration will not be reduced prior to detailed NASA review and approval. Adequacy of the landing gear shall be verified by analysis and test as necessary for the heavier vehicle.

The modified LM shall be configured for a 78 hr. mission; any shorter mission capability will be obtained by offloading consumables.

One descent stage corner quadrant shall be made available for payload stowage, in addition to the Scientific Equipment Bay; payload carried in the Scientific Equipment Bay will meet the present interface requirements. The payload for the corner quadrant is not yet defined. Pending such definition, GAC shall identify hard points for attachment and mass moment characteristics permissible.

If no payload is supplied for the SEQ, ballast may be carried to provide the necessary landing radar dynamic stability and cg control if required.

The descent stage corner quadrants shall be configured to accommodate the increased equipment requirements in such a manner as to minimize the residual propellant effects of cg offsets within the payload requirements.

STRUCTURE and MECHANISMS (Cont'd)

Structural analysis and test shall certify capability for all of the conditions defined by the performance cases. Ballast required for cg control in lieu of payload in empty quadrant and/or SEQ shall be defined.

Crew Provisions

Provisions shall be made in the ascent stage cabin to provide suitable crew facilities for the longer mission and increased cabin activity.

An improved urine and PLSS condensate waste management system shall be provided.

Provisions shall be included for 7 PLSS recharges; each recharge will require 11.3 lb. of water, 1.2 lb. of oxygen, one battery (5.5 lb.) and one LiOH cartridge (6.8 lb.).

Electrical

A solar-cell array shall be used to provide the primary electrical power during the lunar surface phase; the array will be deployed after the lunar landing. The array should not require reorientation for a 78-hour staytime after the initial erection.

Three primary descent batteries shall be used to provide the electrical power during the earth launch-to-transposition and docking, preseparation checkout-to-solar array deployment and peaking loads during solar array operation. The vehicle design shall be such that four primary descent batteries may be utilized if desired without any change to vehicle configuration except addition of a battery.

Electronics

Provisions shall be made for shirt-sleeve voice communications.

Fluids

The descent propulsion pressurization system shall provide up to 190 hour standby time.

Operation of the descent engine shall be verified for the worst case conditions established by the performance requirements. The maximum capability to use additional V at T/W = 1 shall be defined and the necessary verification tests identified.

A separation weight of 36,322 lb. and total usable descent propellant quantity of 19,071 lb. (18,621 usable for nominal delta-V) shall be used for DPS design studies.

Increased ascent delta-V and/or return payload capability shall be provided only within the present ascent propulsion system.

Increased oxygen storage capacity shall be provided by adding a LM descent GOX tank.

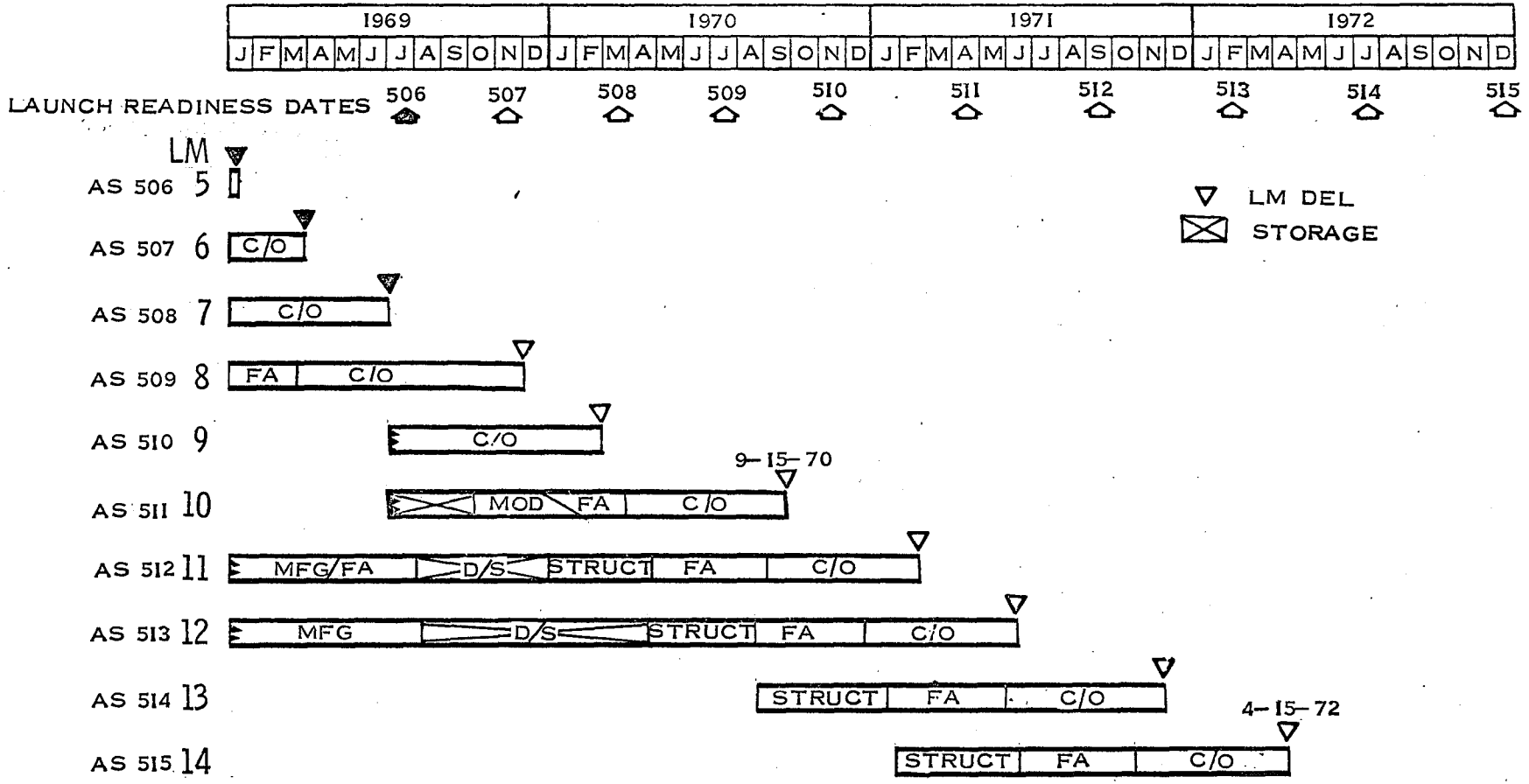
Active spacecraft heat rejection shall be by water sublimation.

Increased water storage capacity shall be provided by adding a LM descent water tank.

The ascent stage cabin environment shall be suitable for unsuited operations and sleep during the period on the lunar surface. "Shirtsleeve" environment shall be as specified in NASA TWX PP6-T45-69-PP6-T0237, dated April 1, 1969.

APOLLO LUNAR EXPLORATION MISSIONS

LM MANUFACTURING SCHEDULES

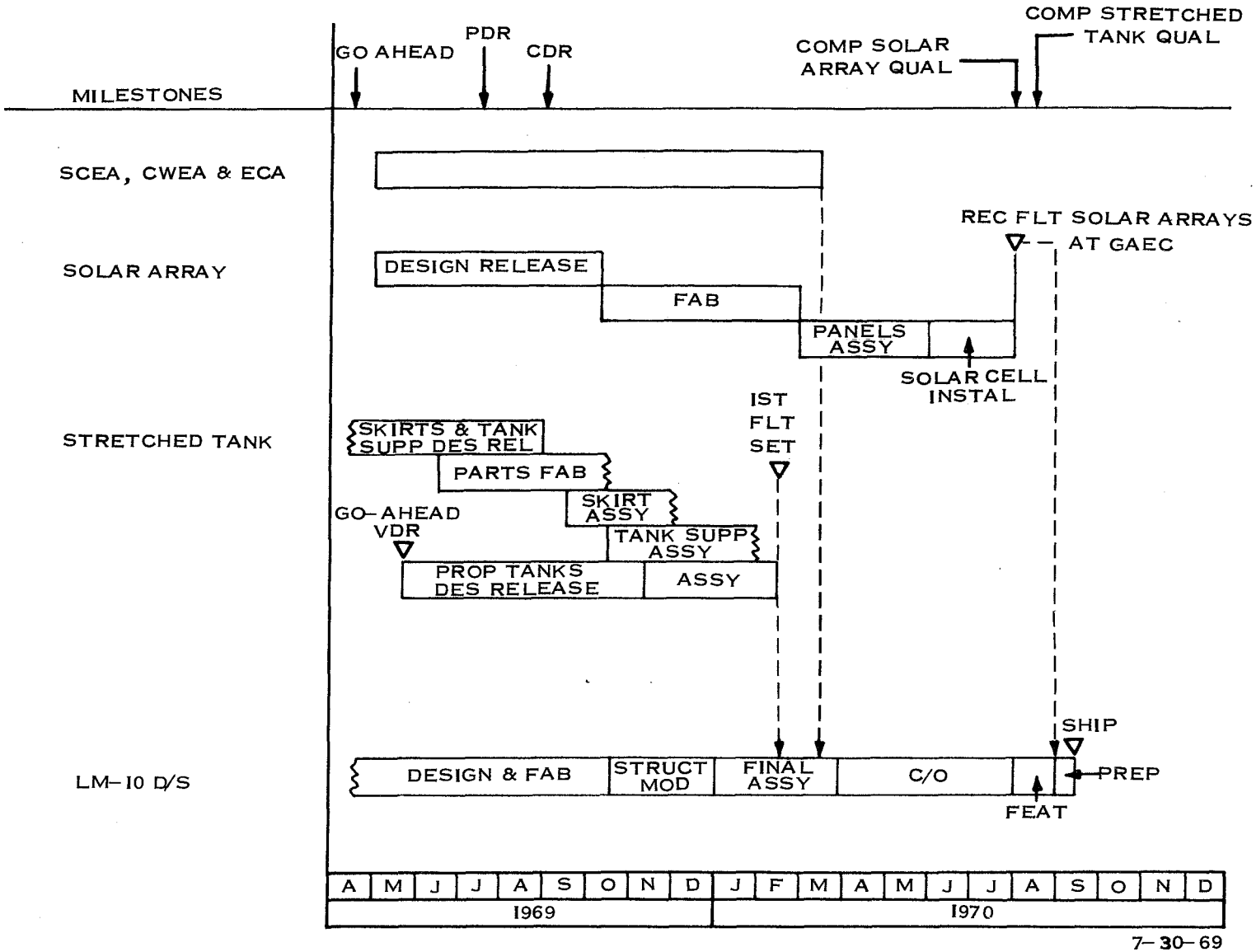


ABOVE SCHEDULE IS FOR D/S WHICH IS PACING

7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

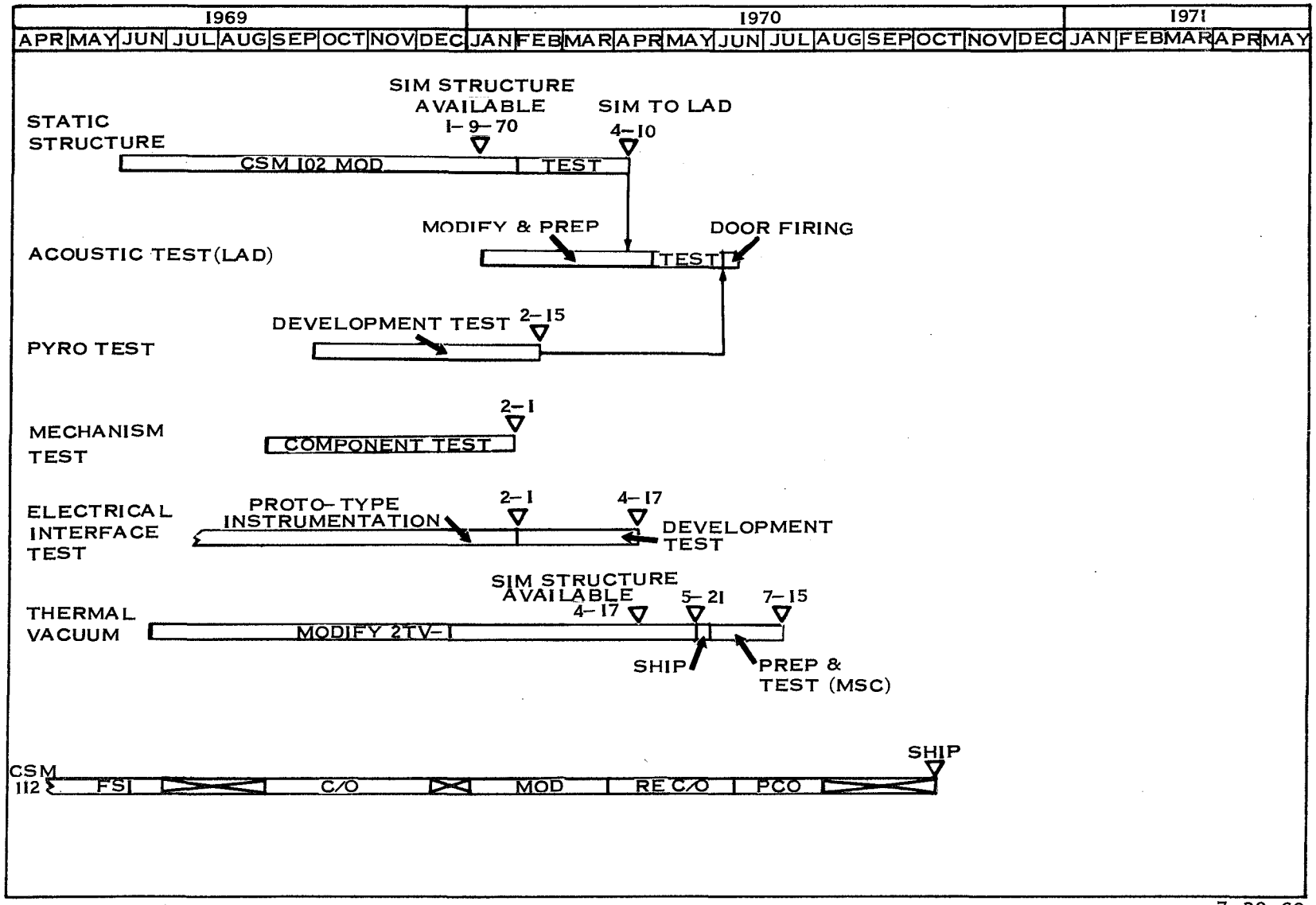
FIRST ARTICLE SCHEDULE – LM-10
(LARGER TANKS PLUS LMMP MODS)



7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

DEVELOPMENT AND CERTIFICATION TEST



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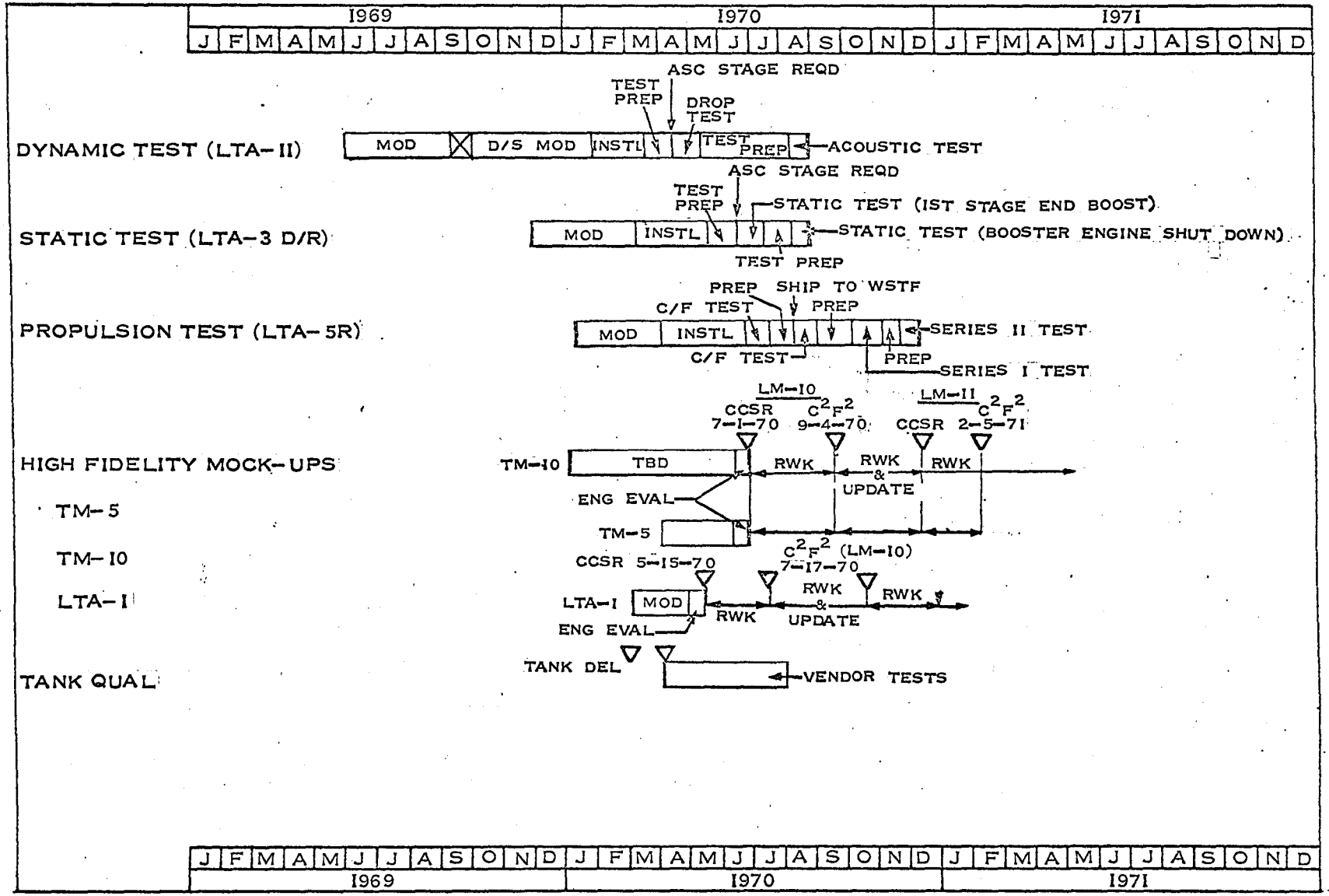
APOLLO LUNAR EXPLORATION MISSIONS
LM GROUND TEST (LARGE TANKS ONLY)



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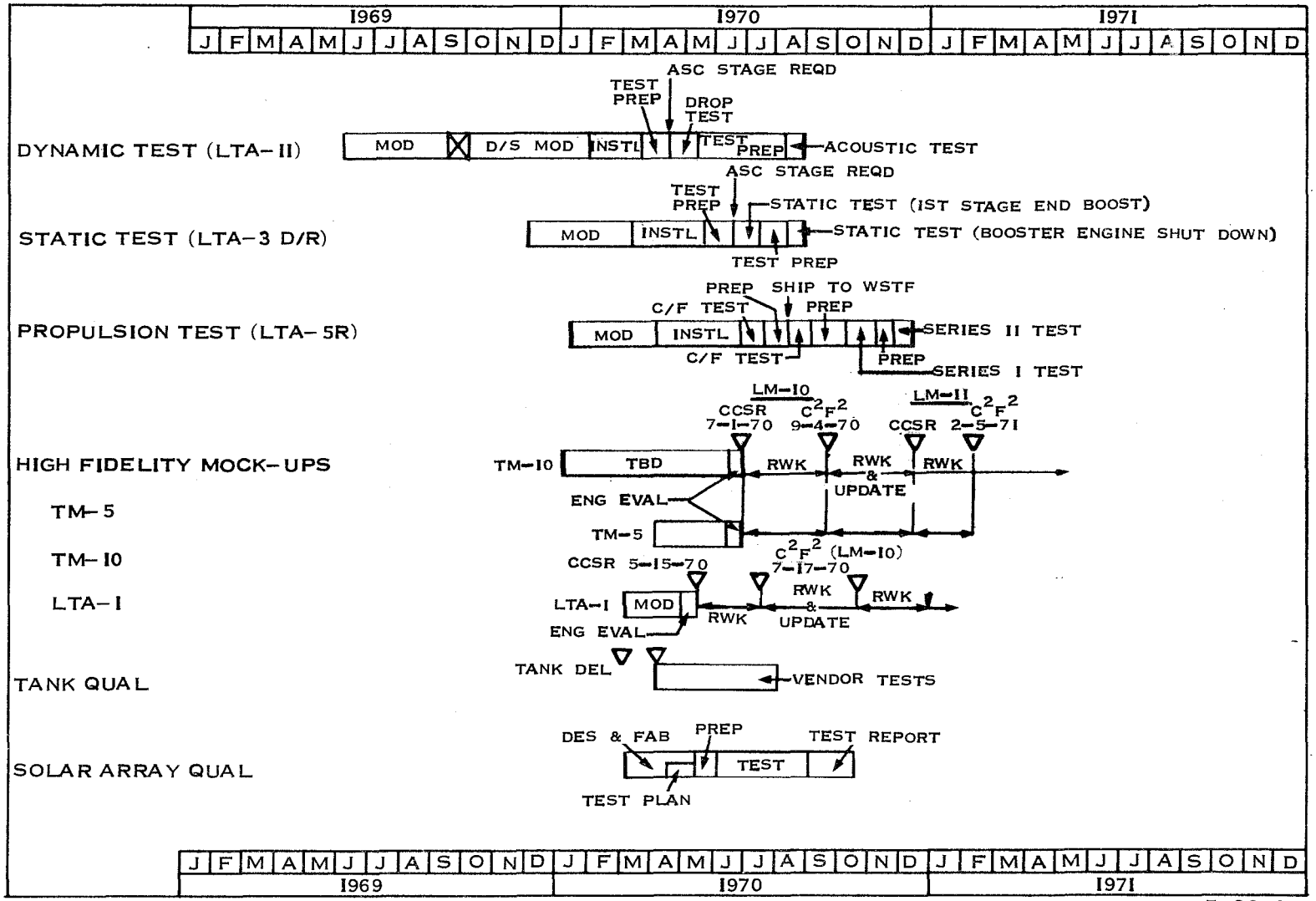
APOLLO LUNAR EXPLORATION MISSIONS

LM GROUND TEST (LARGE TANKS AND LMMP)



7-30-69

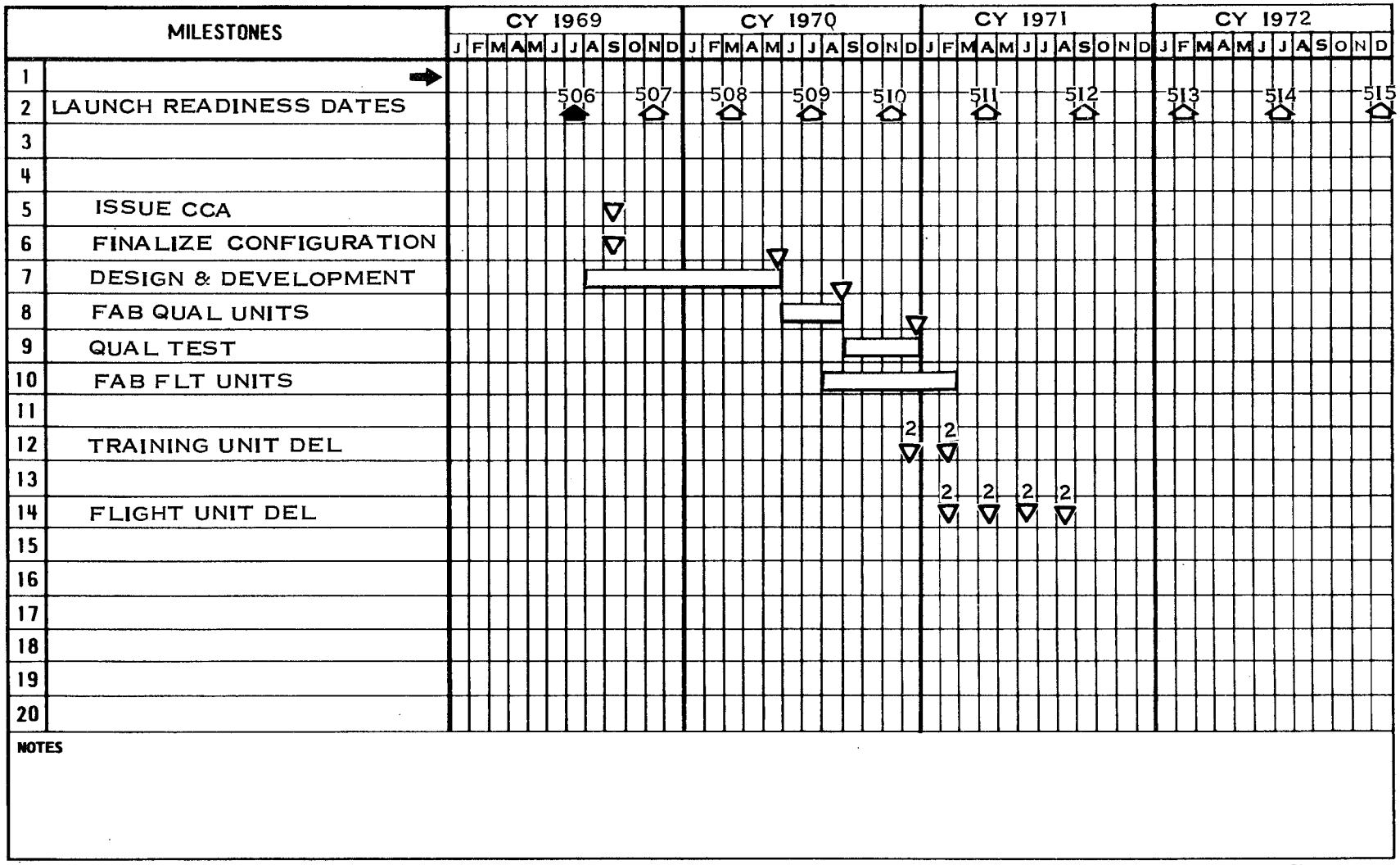
APOLLO LUNAR EXPLORATION MISSIONS
EXTENDED PLSS/SECONDARY LIFE SUPPORT SYSTEM (SLSS)

- PLSS
  - Same as Existing - 6 PLSS except
    - Add larger water tank
    - Increase oxygen storage pressure
- SLSS
  - Same as Current OPS except
    - 1-1$\frac{1}{2}$ hours useful time
    - Includes liquid cooling capability
    - Wet weight 45.9 pounds
    - O_2 stored at 7500 psi

7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

EMU
EXTENDED PLSS/SLSS SCHEDULES



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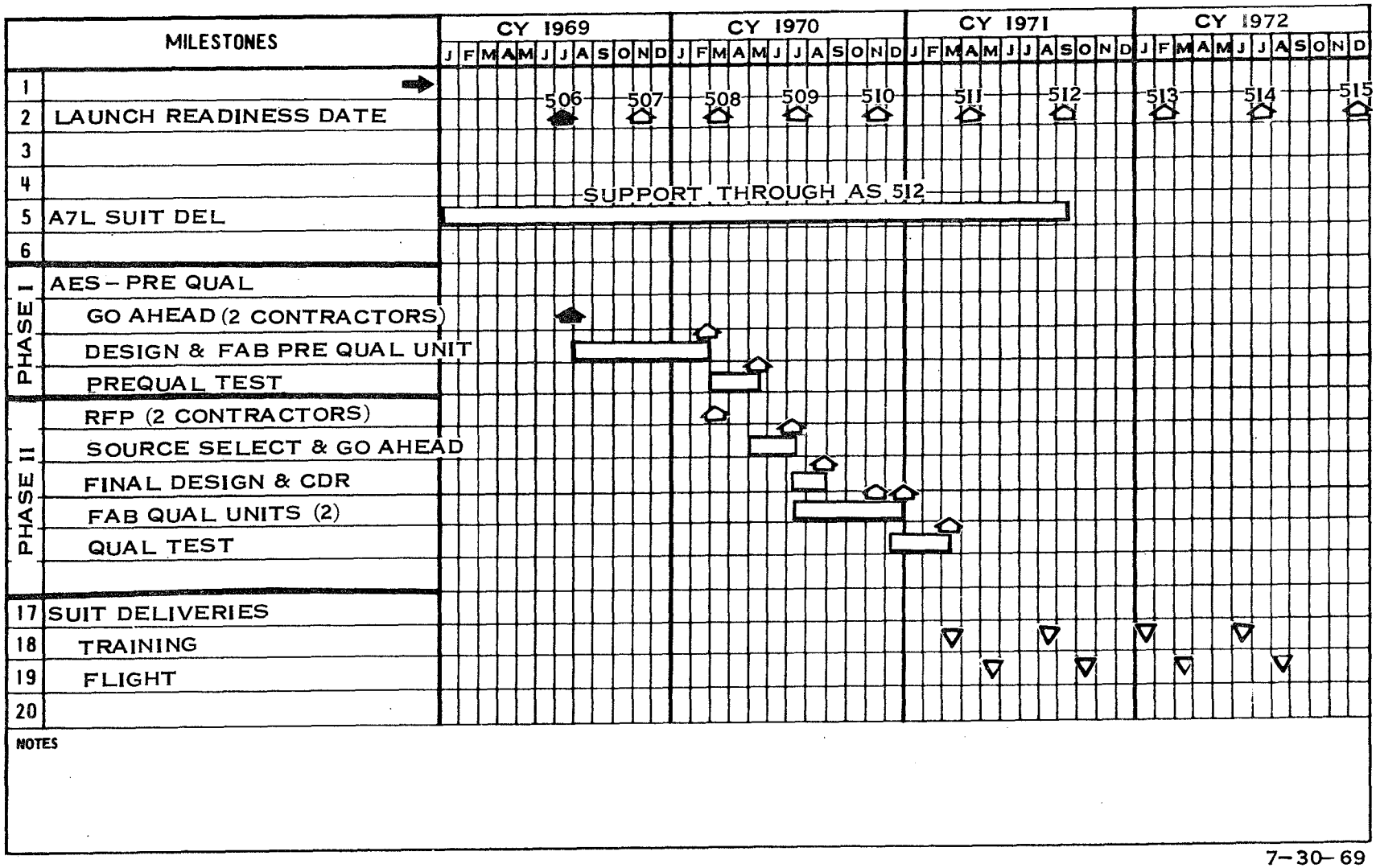
APOLLO LUNAR EXPLORATION MISSIONS

ADVANCED EXTRAVEHICULAR SUIT (AES)



7-30-69

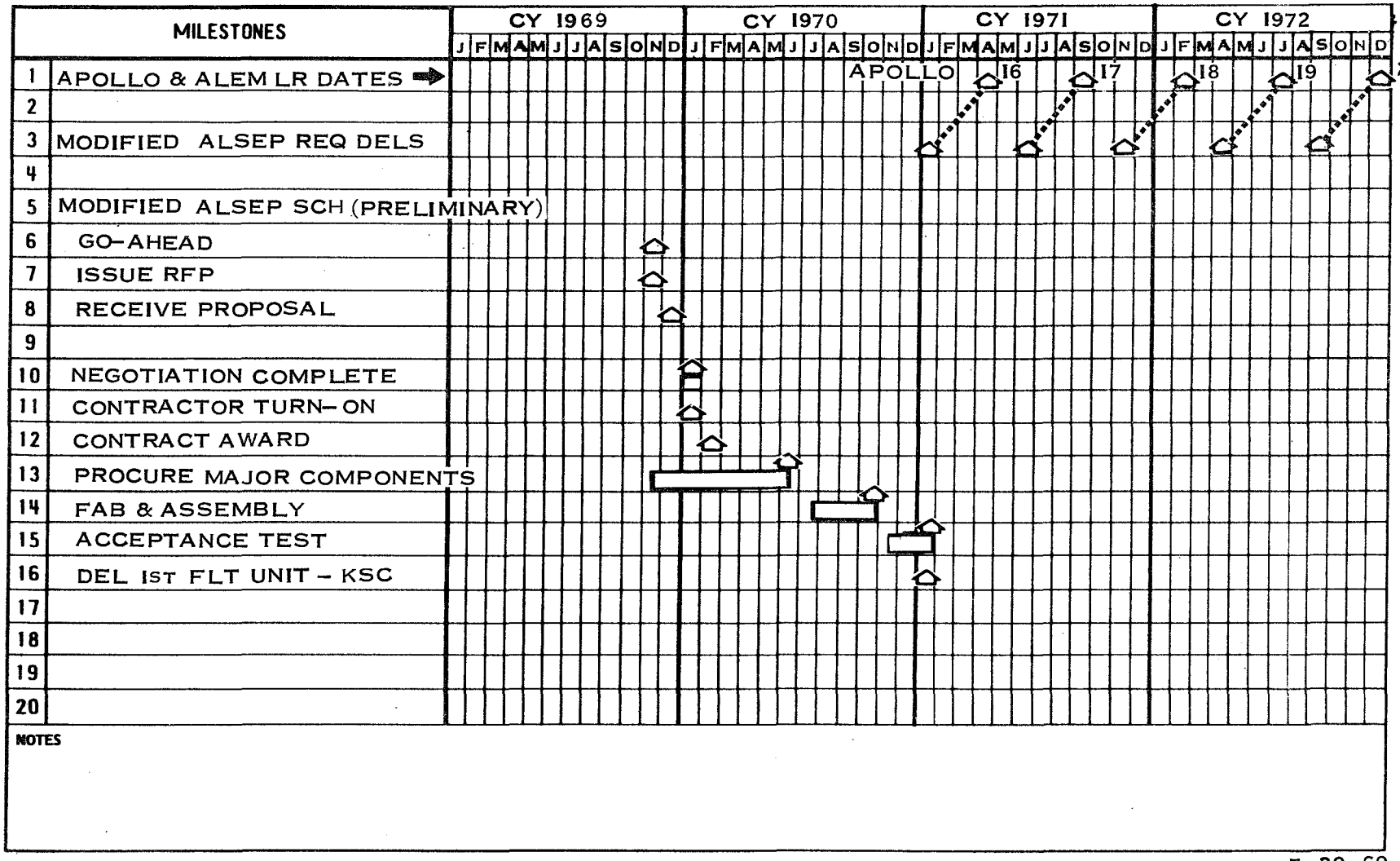
APOLLO LUNAR EXPLORATION MISSIONS

Modified ALSEP Candidate Experiments

- Passive Seismometer
- Lunar Surface Magnetometer
- Cold Cathode Gauge
- Active Seismic
- Water Detector
- Radiometer (Astronomy)
- Cone Penetrometer
- Laser Retro-Reflector
- Lunar Survey Staff
- Sample Return Containers
- Hand Tools
- Stereo Camera
- Electric Field Detector
- Drill (10 Meter)
- Heat Flow Thermal Probe
- Lunar Gravimeter
- Mass Spectrometer (Atmos.)
- Sky Brightness Photometer
- High Z Cosmic Ray
- Engineering Experiments
  - TV Camera
  - Dust Detector
  - Radiometers
- Meteroid Detector

APOLLO LUNAR EXPLORATION MISSIONS

MOD ALSEP



7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

LUNAR ORBIT SCIENCE EXPERIMENTS/MISSION ASSIGNMENT MATRIX

EXPERIMENT	INVESTIGATOR	APOLLO16	APOLLO17	APOLLO18	APOLLO 19	APOLLO20
SUBCOMMITTEE EVALUATION – CATEGORY I:						
X-RAY SPEC	ADLER	X	X	X		
GAMMA-RAY SPEC	ARNOLD	X	X	X		
FAR UV SPEC	FASTIE				X	X
MASS SPEC	HOFFMAN		X	X		
BISTATIC RADAR	HOWARD				X	X
MULTIFREQ MW RAD	JONES					X
IR SCAN RAD	LOW				X	X
24" PAN CAMERA	MASURSKY	X	X	X		
LYMAN ALPHA	POTTER	X				
3" MAPPING CAMERA	SASSER		X	X	X	X
S- BAND TRANSP	SJOGREN	X	X	X	X	X
SUBCOMMITTEE EVALUATION – CATEGORY II:						
ALPHA PARTICLE	GORENSTEIN	X	X	X		
EM SOUNDER "A"	WARD				X	
EXPERIMENTS UNDER SPECIAL STUDY:						
SUBSATELLITE	COLEMAN/ANDERSON					X
IMAGING RADAR	BROWN				X	
EXPERIMENT SUPPORT EQUIPMENT:						
STELLAR REF CAMERA		X	X	X	X	X
LASER ALT			X	X	X	X

7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

Orbital Science Instrumentation Delivery Requirements

Flight Hardware

CSM	Deliver to	Date
112	NR	4/17/70
113	NR	6/12/70
114	NR	12/18/70
115	NR	2/12/71
115A	NR	6/4/71

Functional Prototype

Use	Deliver to	Date
EMI & 2TV-1 Test	NR	3/20/70

Mass Simulators

Use	Deliver to	Date
Acoustic Test	NR	1/9/70

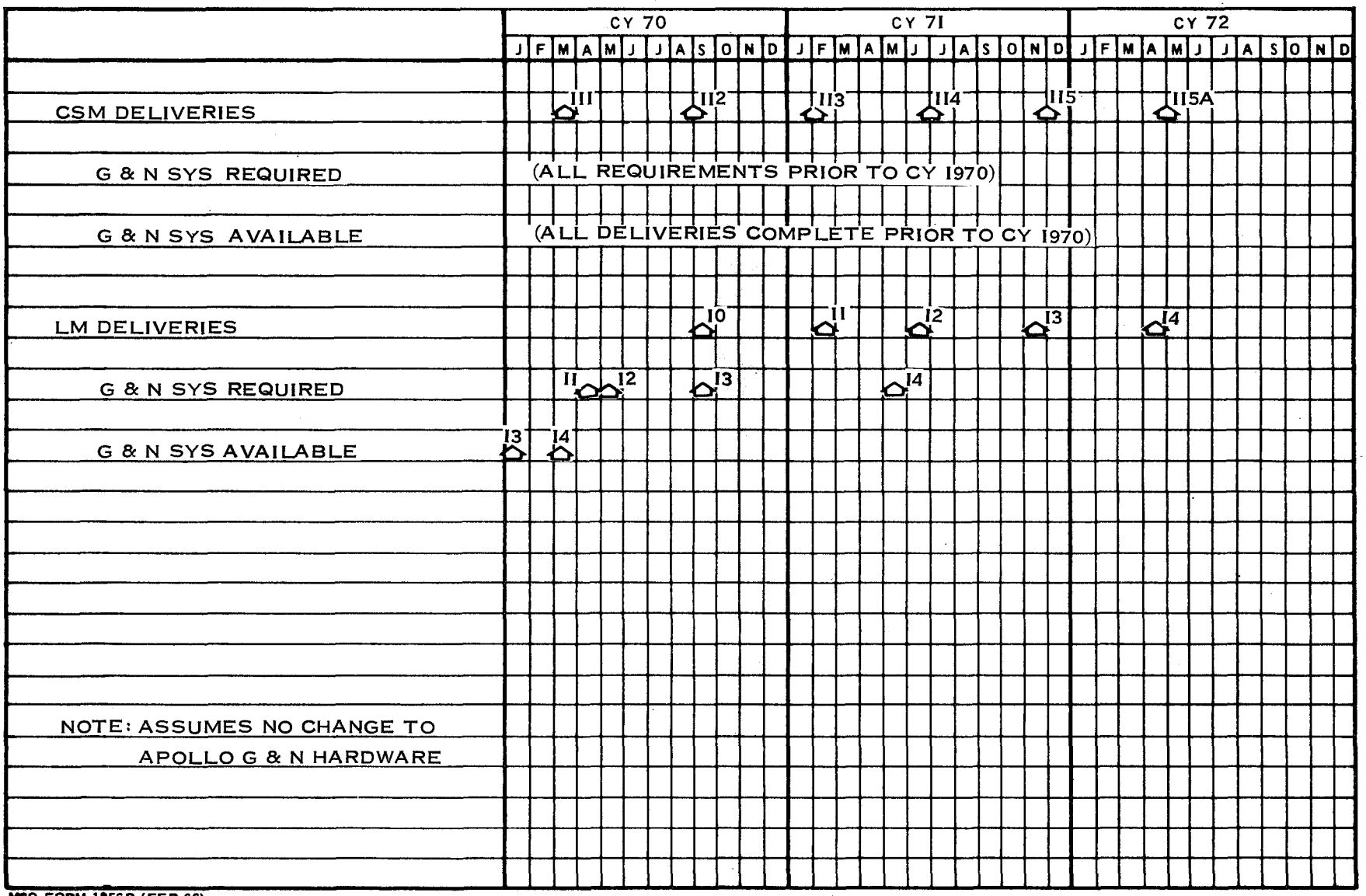
Mock-ups (trainers)

Use	Deliver to	Date*
M-28	NR	8/31/69
MSC-1	MSC	4/30/70
1-g Trainer	MSC	5/31/70
0-g Trainer	MSC	5/15/70
KSC-E	KSC	5/31/70
CMS-1	MSC	8/31/70
CMS-2	KSC	10/30/70
M-18	NR	8/31/69

*Delivery dates are in support of Apollo 16 (CSM 112).

APOLLO LUNAR EXPLORATION MISSIONS

G & N SYSTEMS SCHEDULES



MSC FORM 1956B (FEB 66)

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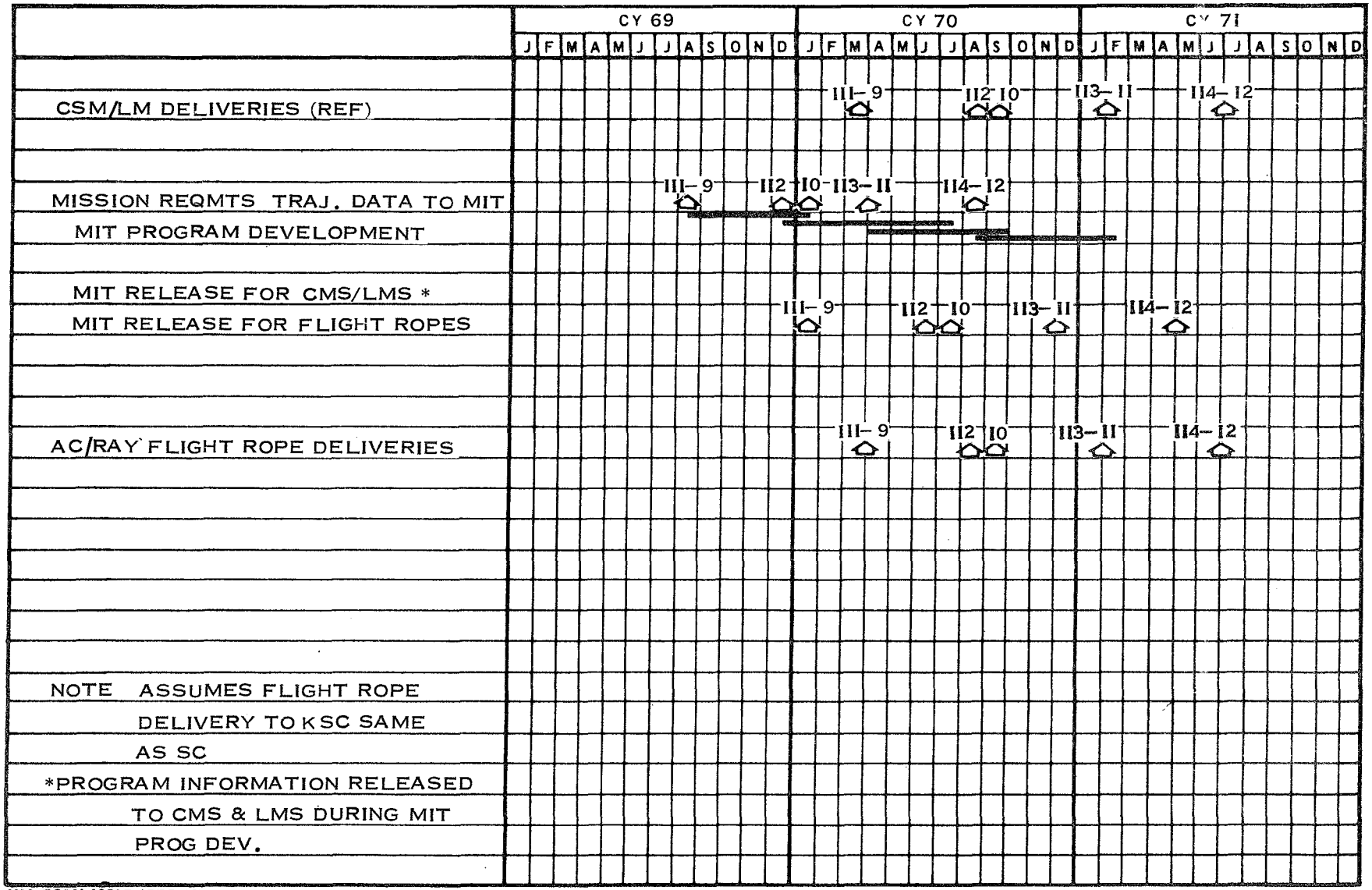
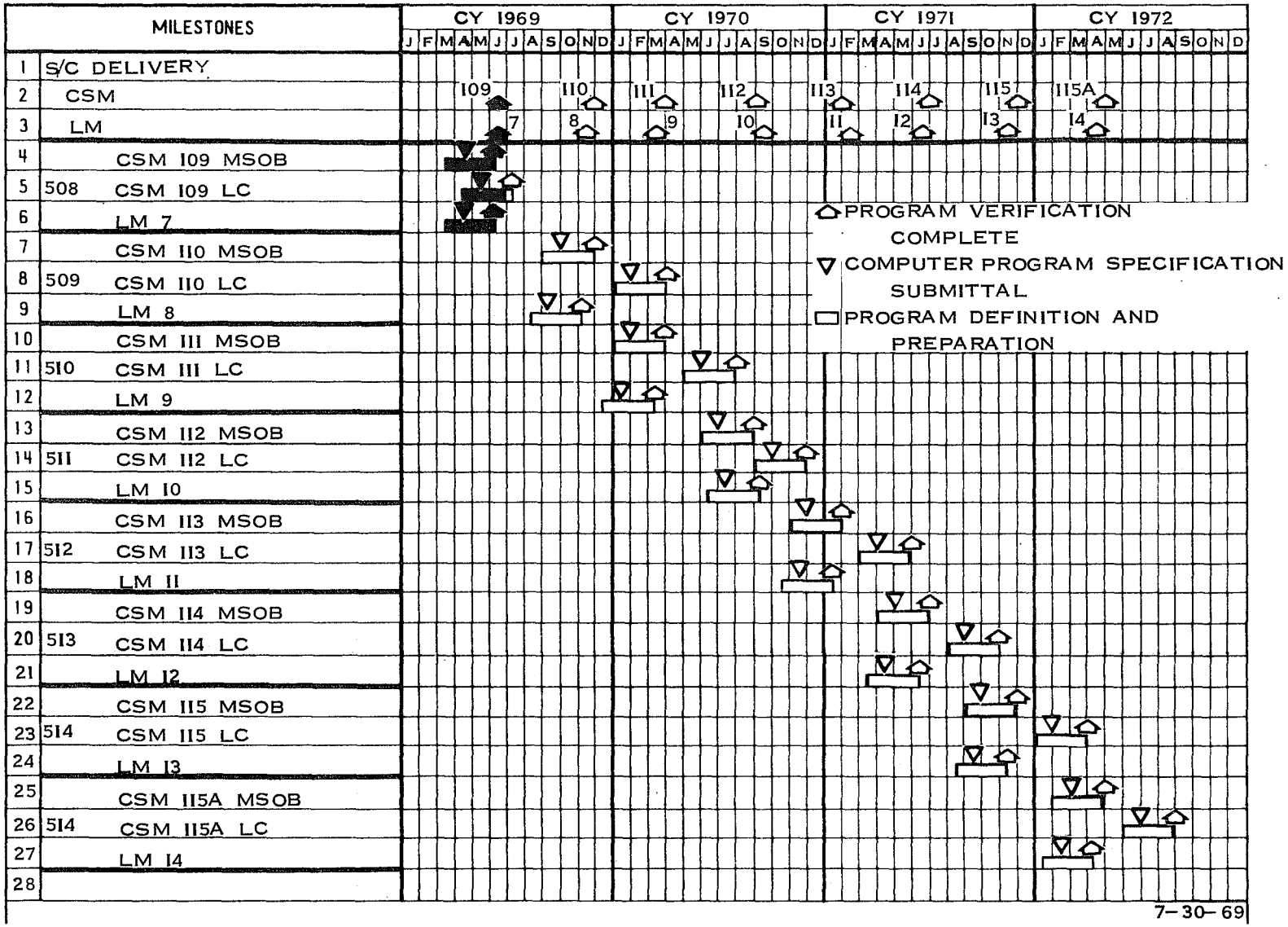
APOLLO LUNAR EXPLORATION MISSIONS

G & N SOFTWARE



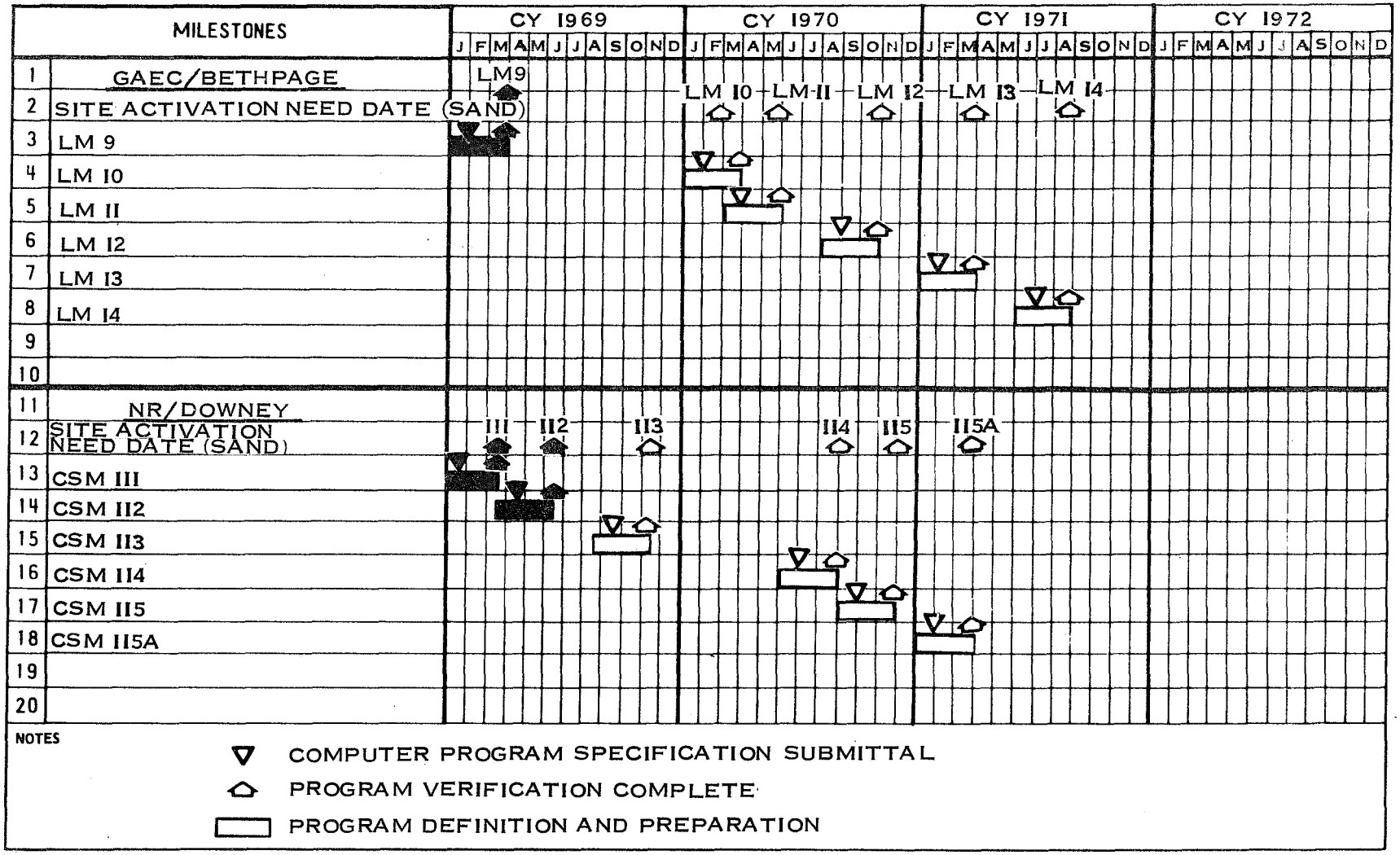
APOLLO LUNAR EXPLORATION MISSIONS

ACE S/C COMPUTER PLAN



APOLLO LUNAR EXPLORATION MISSIONS

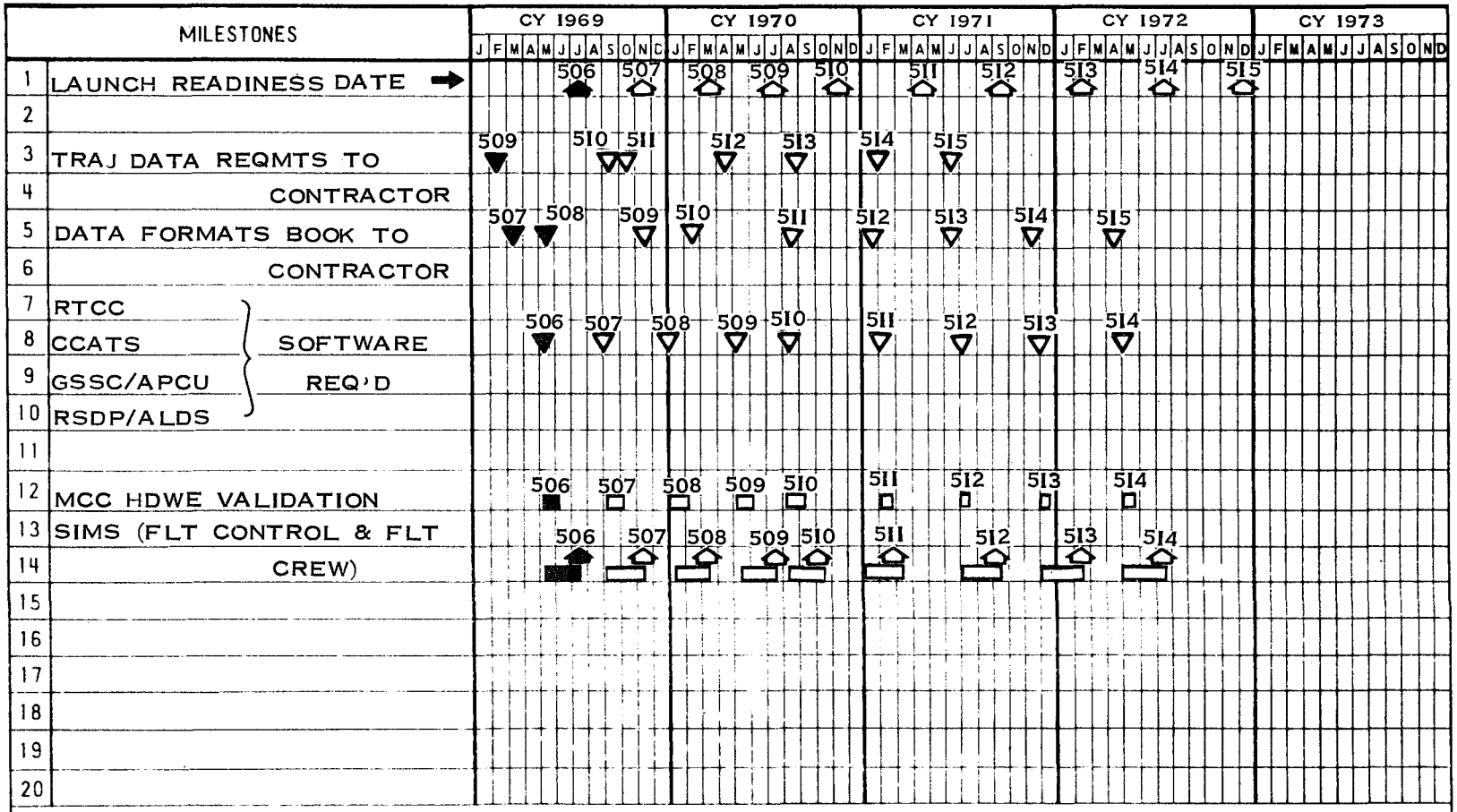
ACE – S/C COMPUTER PLAN



7-30-69

APOLLO LUNAR EXPLORATION MISSIONS

MCC MISSION SUPPORT



NOTES

1. MCC HAS BASIC CAPABILITY TO SUPPORT ALEM AND AAP SIMULTANEOUSLY. POSSIBLY SOME TIME SHARING OF FACILITIES REQUIRED.

NASA FORM 796 DEC. 62, REVISED 9-63

7-30-69

CONTROLLED MILESTONES

MISSION DOCUMENTATION

Mission H-1 (CSM-108/LM-6)

S/C Operational Data Book - Preliminary - LM	03/15/69 A	
S/C Operational Data Book - Preliminary - CSM	11/01/68 A	
S/C Operational Data Book - Final - LM	09/18/69	
S/C Operational Data Book - Final - CSM	09/18/69 A	
Test and Checkout Requirements - Final - LM	07/15/68 A	
Test and Checkout Requirements - Final - CSM	01/17/69 A	
Test Specifications and Criteria - Final - LM	07/24/68 A	
Test Specifications and Criteria - Final - CSM	01/17/69 A	
Apollo Operations Handbook Vol II - Preliminary - LM	06/15/69 A	
Apollo Operations Handbook Vol II - Final - LM	10/10/69	
Apollo Operations Handbook Vol II - Preliminary - CSM	06/16/69 A	
Apollo Operations Handbook Vol II - Final - CSM	10/10/69	
Mission Requirements - Preliminary	04/15/69	05/06/69 A
Mission Requirements - Final	06/15/69	07/18/69 A
Operational Trajectory - Preliminary	05/15/69 A	
Operational Trajectory - Rev 1	07/09/69 A	
Operational Trajectory - Final	09/01/69	
Operational Consumables Analysis - Preliminary	05/01/69 A	
Operational Consumables Analysis - Rev 1	07/11/69 A	
Operational Consumables Analysis - Final	10/01/69	
Flight Operations Plan - Preliminary	06/18/69	07/11/69 A
Flight Operations Plan - Final	TBD	
S/C Operational Abort Plan - Preliminary	07/07/69 A	
S/C Operational Abort Plan - Final	10/01/69	
Alternate Mission Plan - Preliminary	07/11/69 A	
Alternate Mission Plan - Final	10/01/69	
Flight Plan - Reference	05/08/69	04/21/69 A
Flight Plan - Preliminary	09/20/69	
Flight Plan - Final	10/20/69	
Photo Operations Plan - Preliminary	05/18/69 A	
Photo Operations Plan - Final	09/10/69	
EVA Procedures - Reference	04/01/69 A	
EVA Procedures - Final	08/15/69	
Rendezvous Procedures - Preliminary	05/15/69 A	
Rendezvous Procedures - Final	09/10/69	
Ascent/Descent Procedures - Preliminary	05/22/69 A	
Ascent/Descent Procedures - Final	08/01/69	
Lunar Surface Operations - Preliminary	08/30/69	
Lunar Surface Operations - Final	10/03/69	
Reentry Procedures - Preliminary	05/15/69 A	
Reentry Procedures - Final	08/01/69	
Apollo Abort Summary - Preliminary	05/22/69 A	
Apollo Abort Summary - Final	08/01/69	
Launch Mission Rules - Preliminary	08/01/69	

CONTROLLED MILESTONES

MISSION DOCUMENTATION

Mission H-1 (CSM-108/LM-6) (Continued)

Launch Mission Rules - Final	TBD	
Flight Mission Rules - Preliminary	08/15/69	
Flight Mission Rules - Final	TBD	
Measurement Index - Preliminary	06/20/69 A	
Measurement Index - Final	08/07/69	
Post Flight Test Requirements - Preliminary	06/15/69	06/20/69 A
Post Flight Test Requirements - Final	08/01/69	
Mission Evaluation Instructions - Final	08/25/69	