X.5

FINAL ORAL REPORT

ORBITING RESEARCH LABORATORY / LOGISTICS SPACECRAFT CHECKOUT REQUIREMENTS STUDY

MARCH 1965

TRW SPACE TECHNOLOGY LABORATORIES

THOMPSON RAMO WOOLDRIDGE INC.

FLORIDA DIVISION • 7001 NORTH ATLANTIC AVENUE • CAPE CANAVERAL, FLORIDA

INTRODUCTION

This report presents the results of the study of Orbiting Research Laboratory and Logistic Spacecraft Checkout Requirements as they relate to pre-launch operations at MILA. The study was performed jointly by the Florida Division and the Systems Research and Analysis Division of TRW Space Technology Laboratories for NASA under the terms of contract NAS10-1706.

The principal objectives of this study were to establish recommended modes of operation for the assembly, checkout and launch of specified Orbiting Research Laboratories and Logistics Spacecraft at MILA and to determine the resulting impact on KSC resources in terms of facilities, equipment, procedures and personnel.

The study encompassed all planned MILA pre-launch operations relating to Orbiting Research Laboratories, Logistic Spacecraft, crew and cargo. A summary of the study tasks and subtasks is presented in an accompanying chart. Particular emphasis was placed on the subtasks relating to facilities, acceptance checkout equipment (ACE) and scientific equipment (ORL experiments), since new requirements in these areas represented the greatest potential impact on MILA resources.

Various ORL, Logistics Spacecraft, and launch vehicle combinations were studied. The ORL's fall into three basic classes: The Apollo Extensions, the Single Module Space Station (SMSS), and the Multi-Module Space Station (MMSS). Three logistic spacecraft were studied: The Apollo LS, the Modified Apollo LS (MODAP), and the Ballistic LS (BALLOS). Launch vehicle study was confined to the Saturn IB and the Saturn V, and was restricted to spacecraft interface considerations.

LIST OF ABBREVIATIONS

ACE	Acceptance Checkout Equipment
AE	Apollo Extensions
A/S	Ascent Stage
BPC	Boost Protective Cover
BU	Backup
CGM	Cargo Module
CM	Command Module
CSM	Command & Service Module (Mated)
D/S	Descent Stage
ECS	Environmental Control System
EDS	Emergency Detection System
EIF	Experiment Integration Function
EIT	Experiment Integration & Test
ELS	Earth Landing System
FHS	Forward Heat Shield
G&N	Guidance and Navigation
ICA	Integrated Checkout Area
LC	Launch Complex
LEM	Lunar Excursion Module
LES	Launch Escape System
LET	Launch Escape Tower
LM(D)	Laboratory Module (Dependent)
LM(I)	Laboratory Module (Independent)
LS	Logistics Spacecraft
L/V	Launch Vehicle
MMSS	Multi-Module Space Station
MODAP	Modified Apollo
MORL	Manned Orbital Research Lab (DAC)
MOSS	Manned Orbital Space Station
NE	Nozzle Extension
NS	Nozzle Simulator
O&C	Operations & Checkout (Facility)
OFTL	Ordnance Field Test Lab
ORL	Orbital Research Laboratory
OSF	Ordnance Storage Facility
PIB	Pyrotechnic Installation Bldg
RCS	Reaction Control System
RF	Radar-Boresight Facility
S/C	Spacecraft
SCS	Stabilization Control System
SLA	Spacecraft LEM Adapter
SM	Service Module
SMSS	Single-Module Space Station
SPS	Service Propulsion System
STF	Static Test Facility
S/V	Space Vehicle (L/V + S/C)
SVP	Service Pack
S-IB	Saturn I-B
S-V	Saturn V
TVA	Thrust Vector Alignment
W&B	Weight and Balance

STUDY OBJECTIVES

1. DETERMINE THE EFFECT OF ORL/LS ON MILA OPERATIONS
2. PROVIDE METHOD FOR EVALUATING FUTURE REQUIREMENTS

STUDY GROUND RULES

1. ORL/LS-NO INTERFERENCE WITH LUNAR APOLLO
2. MAXIMUM USE OF EXISTING FACILITIES AND EQUIPMENT
3. PRELAUNCH OPERATIONS ONLY (EXCEPT REFURBISHMENT & RESUPPLY)
4. ORL/LS & LUNAR APOLLO ONLY
5. SPACECRAFT & RELATED ACTIVITIES ONLY

LAUNCH SCHEDULE

The potential manned space flight schedule, revised 28 December 1964, was issued by NASA Headquarters for a study baseline. To facilitate analysis of the impact of this program on MILA resources, certain representative time periods have been selected from the baseline schedule; during these periods, significant step function changes occur in ORL activities.

Case I represents a change in launch rate of Apollo-type spacecraft, from three-month to two-month intervals. Also, the AE configuration (Apollo X-5) is introduced into the program during this period.

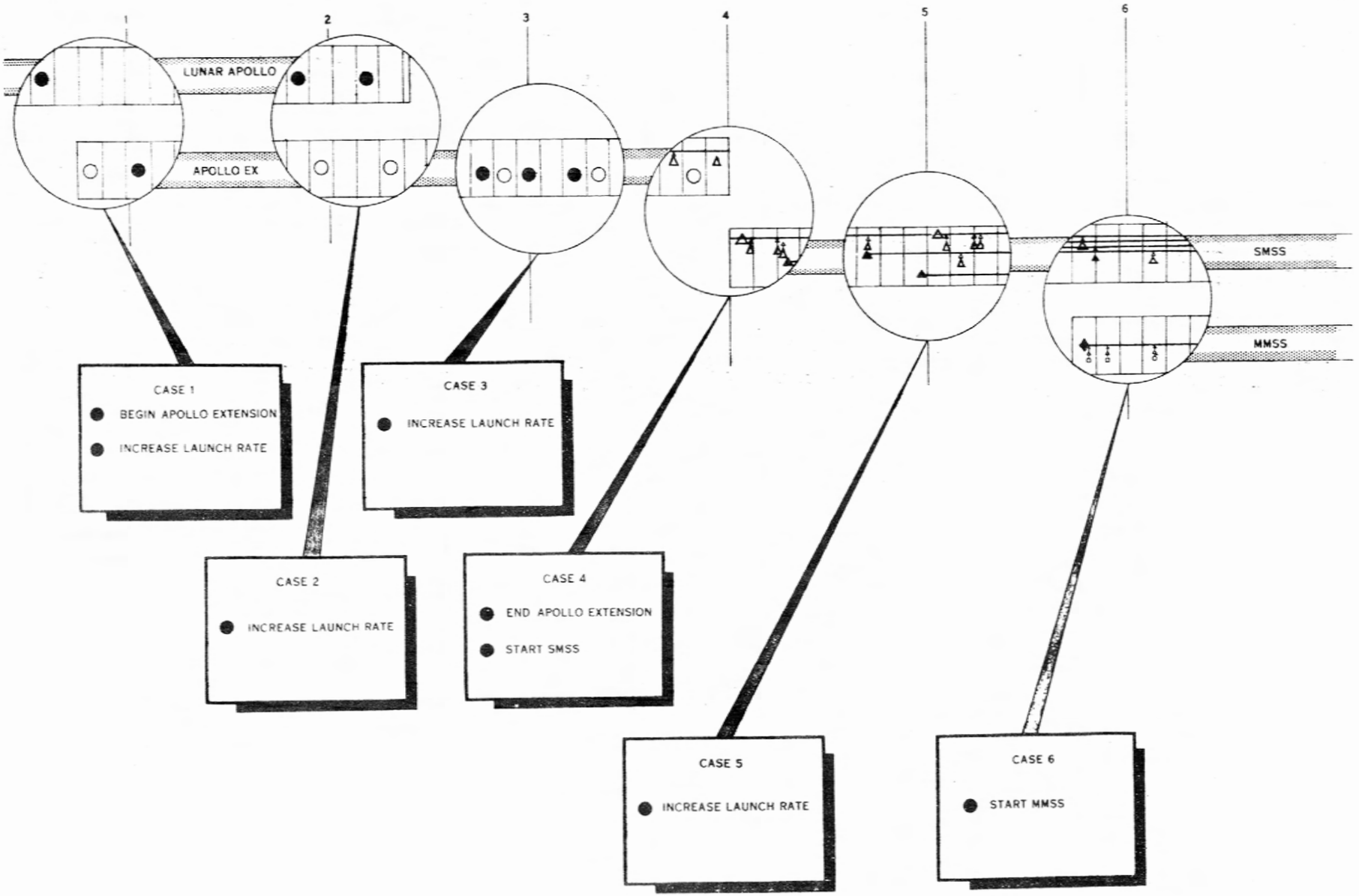
Case II shows two Apollo-type spacecraft (Lunar Apollo and X-6) launched at one-month intervals.

In Case III, three Apollo-type spacecraft (Lunar Apollo and X-6) are launched at one-month intervals.

In Case IV, the SMSS and the three-six man Logistic Spacecraft are introduced into the program, concurrently with the AE (Apollo X-6). AE resupply is also shown. Backup logistic spacecraft are shown as required and the SMSS/LS launch sequence is in accordance with the DAC MORL study. The SMSS launched by a Saturn V is manned at launch, with an Apollo Command Module installed in the hangar area.

Case V shows three SMSS's launched in a four-month period. Two of these are manned launches, utilizing a Saturn V. The third is a Saturn IB unmanned launch, which is then manned and supported in accordance with the DAC MORL Study. Logistic spacecraft with appropriate backup are indicated.

During the time period represented by Case VI, four SMSS's are in orbit, resupplied by the three-six man LS. The Multi-Module Space Station is launched and initial manning is accomplished by the BALLOS. Backup logistic spacecraft are provided in all cases.



SELECTION OF CASES FROM PROGRAM SCHEDULE

SELECTED CASES
FROM
PROGRAM LAUNCH SCHEDULE

SPACECRAFT	CALENDAR MONTHS								
	1	2	3	4	5	6	7	8	9
LUNAR APOLLO APOLLO EX. (X-5)	▲		△		▲		▲		

CASE I

SPACECRAFT	CALENDAR MONTHS								
	1	2	3	4	5	6	7	8	9
LUNAR APOLLO APOLLO EX. (X-6)	▲	△		▲	△				

CASE II

SPACECRAFT	CALENDAR MONTHS								
	1	2	3	4	5	6	7	8	9
AES (LUNAR) APOLLO EX. (X-6)	▲	△	▲		▲	△		△	▲

CASE III

SPACECRAFT	CALENDAR MONTHS								
	1	2	3	4	5	6	7	8	9
APOLLO EX. (X-6) 3-6 MAN LS SMSS	△		△ ● - - -	▲	△	△ ● - - -	- - -	△ ▲	- - -

CASE IV

SPACECRAFT	CALENDAR MONTHS								
	1	2	3	4	5	6	7	8	9
3-6 MAN LS SMSS	△ ▲		▲	△	△ ● - - -	- - -	- - -	- - -	△ - - -

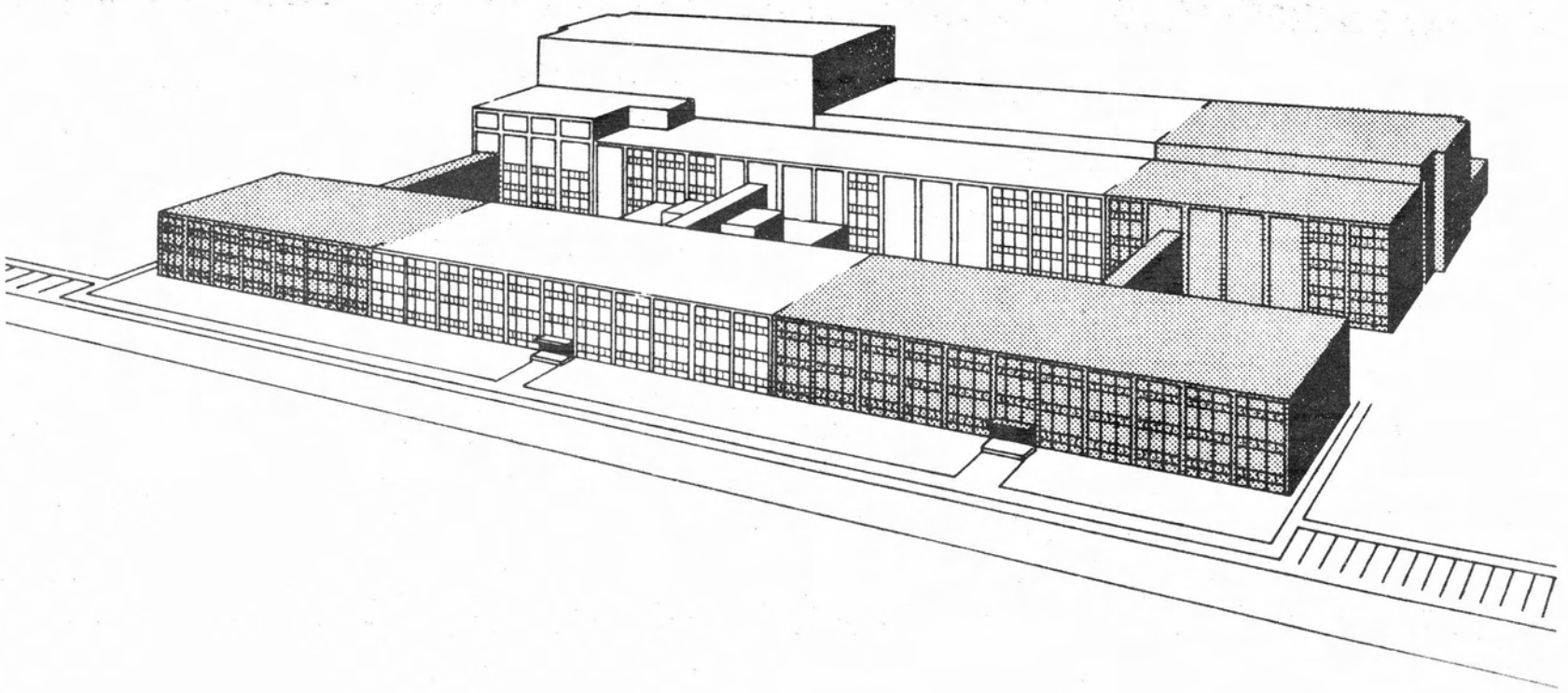
CASE V

SPACECRAFT	CALENDAR MONTHS								
	1	2	3	4	5	6	7	8	9
3-6 MAN LS 3-6 MAN LS MMSS BALLOS	△ - - -	- - -	▲ - - -	- - -	△ - - - ▲ △	- - -	- - -	▲ - - -	△ - - -

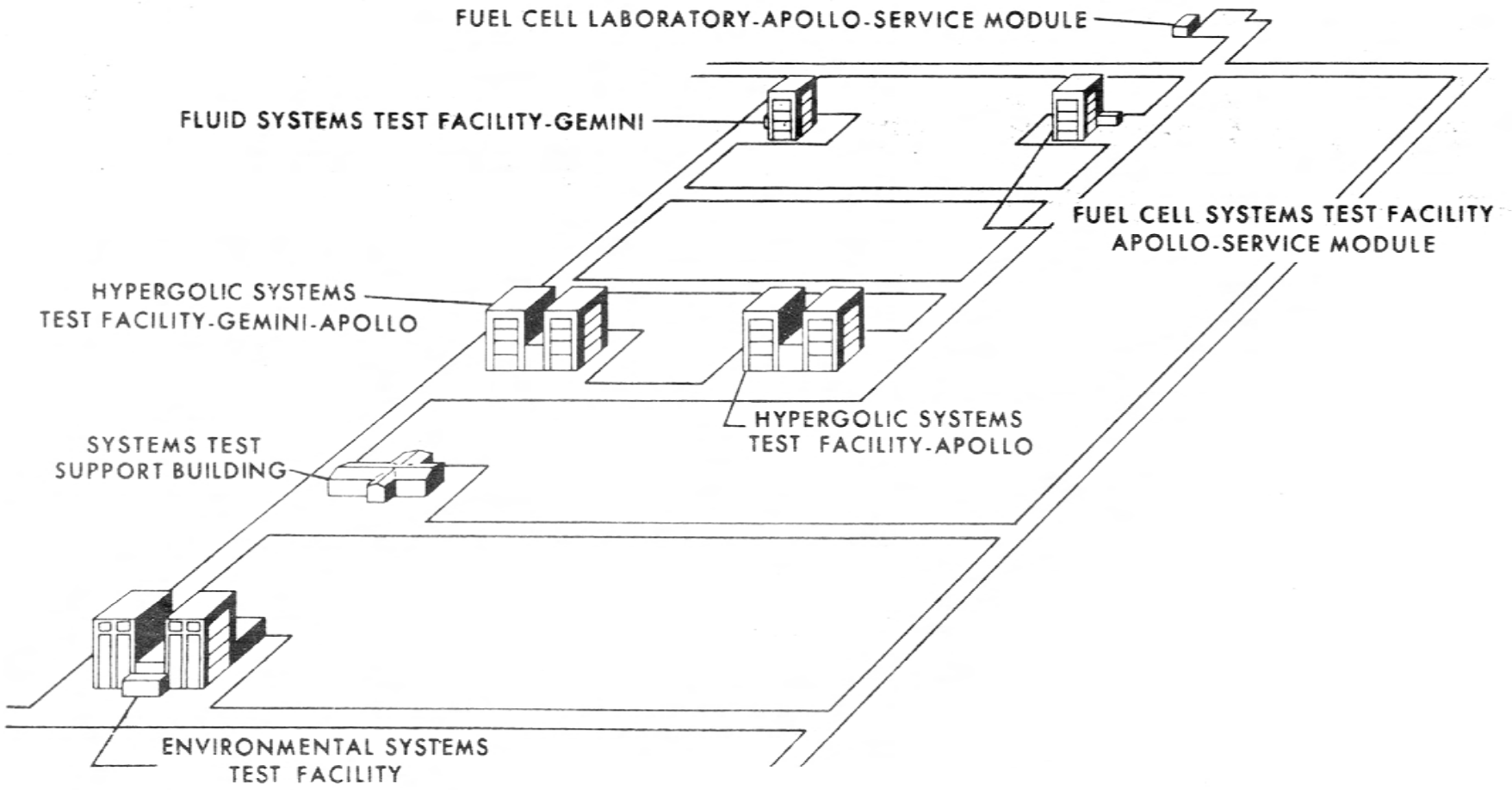
CASE VI

△ S-IB LAUNCH
▲ S-V LAUNCH
● BACKUP LS READY
— — BACKUP/EMERGENCY LS ON PAD

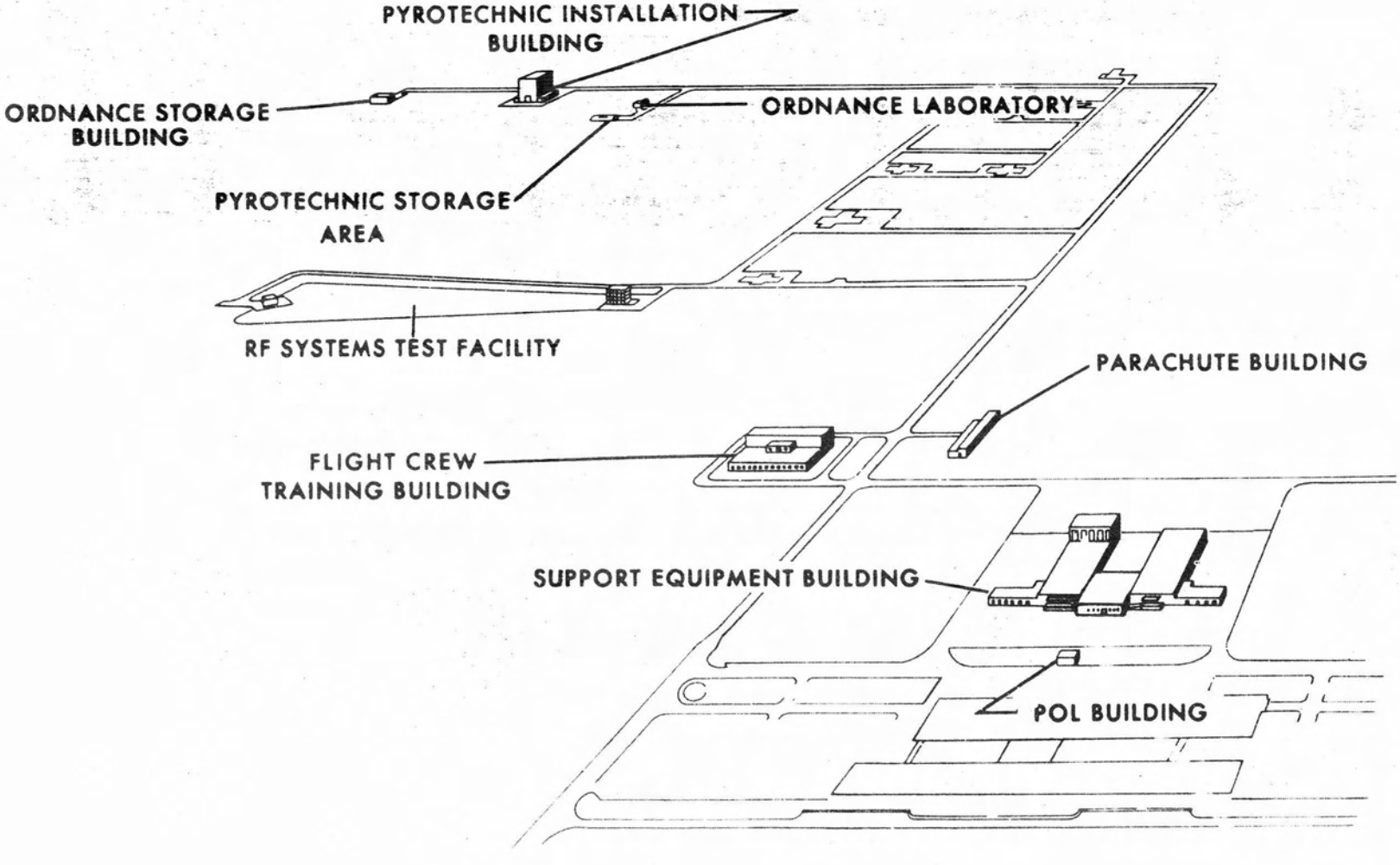
OPERATIONS AND CHECKOUT BUILDING



FLUID TEST COMPLEX



OTHER FACILITIES



STUDY CONFIGURATIONS

Apollo Extensions

Several configurations of the Apollo Extensions were selected as study models, to be used in the development of recommended modes of operation and for impact analysis.

The minimum mod Apollo was selected as the first study model and was designated Apollo X-1. A two-man crew was assumed, since this possible configuration represented a significant change from Lunar Apollo.

Both a dependent LEM shell and a dependent new Laboratory Module were considered for the second study model, designated Apollo X-2. The dependent Laboratory Module was selected, since it represented the major change from Lunar Apollo, and since greater impact on KSC resources was indicated.

The independent LEM laboratory was considered in a subsequent model, designated Apollo X-5. Ascent stage propulsion was assumed for this model, to provide a worst case basis for facilities and checkout equipment utilization.

The independent LEM laboratory with ascent stage propulsion removed combined with a modified LEM descent stage was established as another study model, designated Apollo X-6.

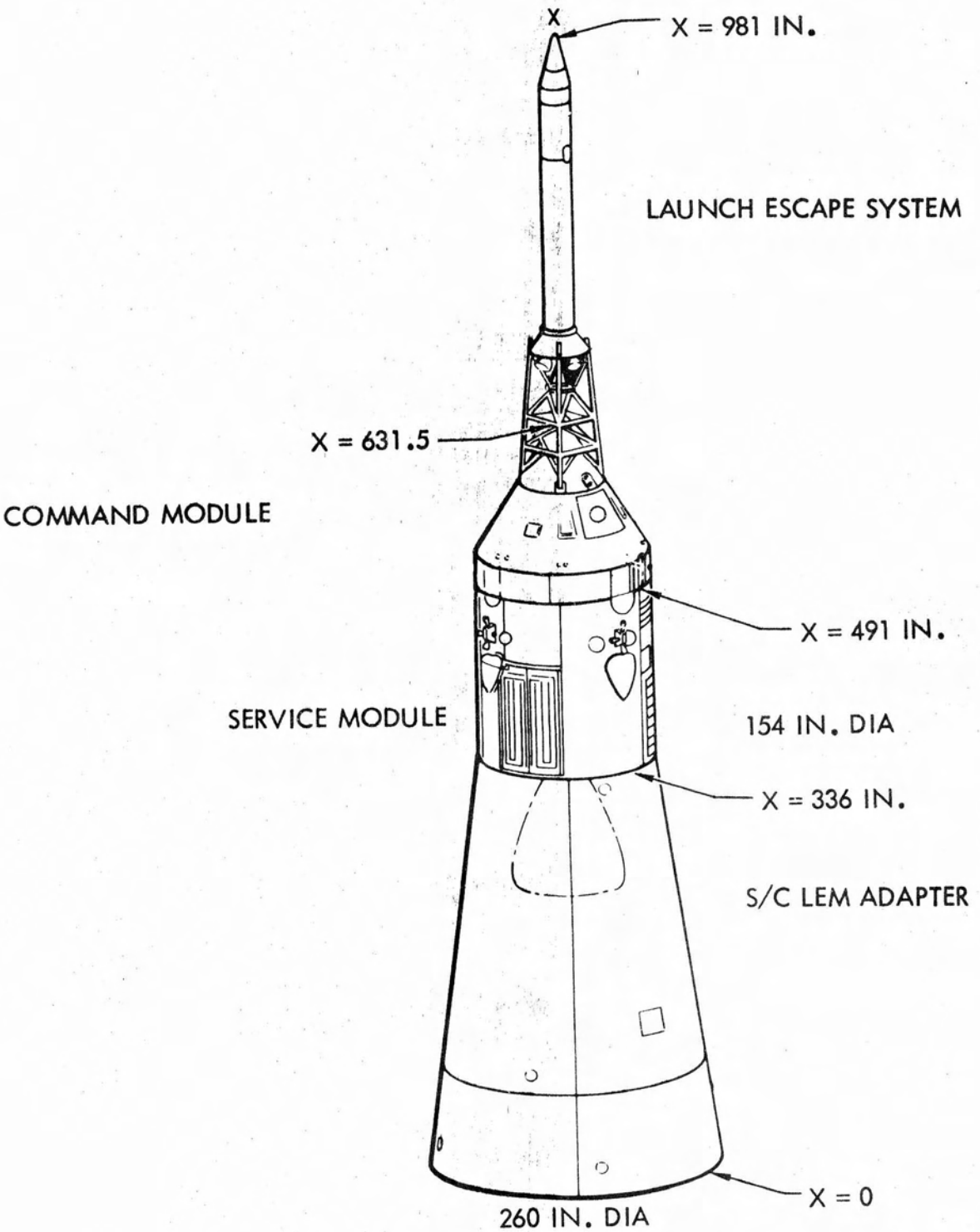
To complete the study models for Apollo Extensions, an Apollo CSM with both a dependent and independent Laboratory Module was selected. This was designated Apollo X-4.

Single Module Space Station (SMSS)

The Langley Research Center/DAC Manned Orbital Research Laboratory (MORL) was selected as a study model for this class space station. Both the Apollo and the Modified Apollo (MODAP) Logistic Spacecraft were considered in connection with the SMSS.

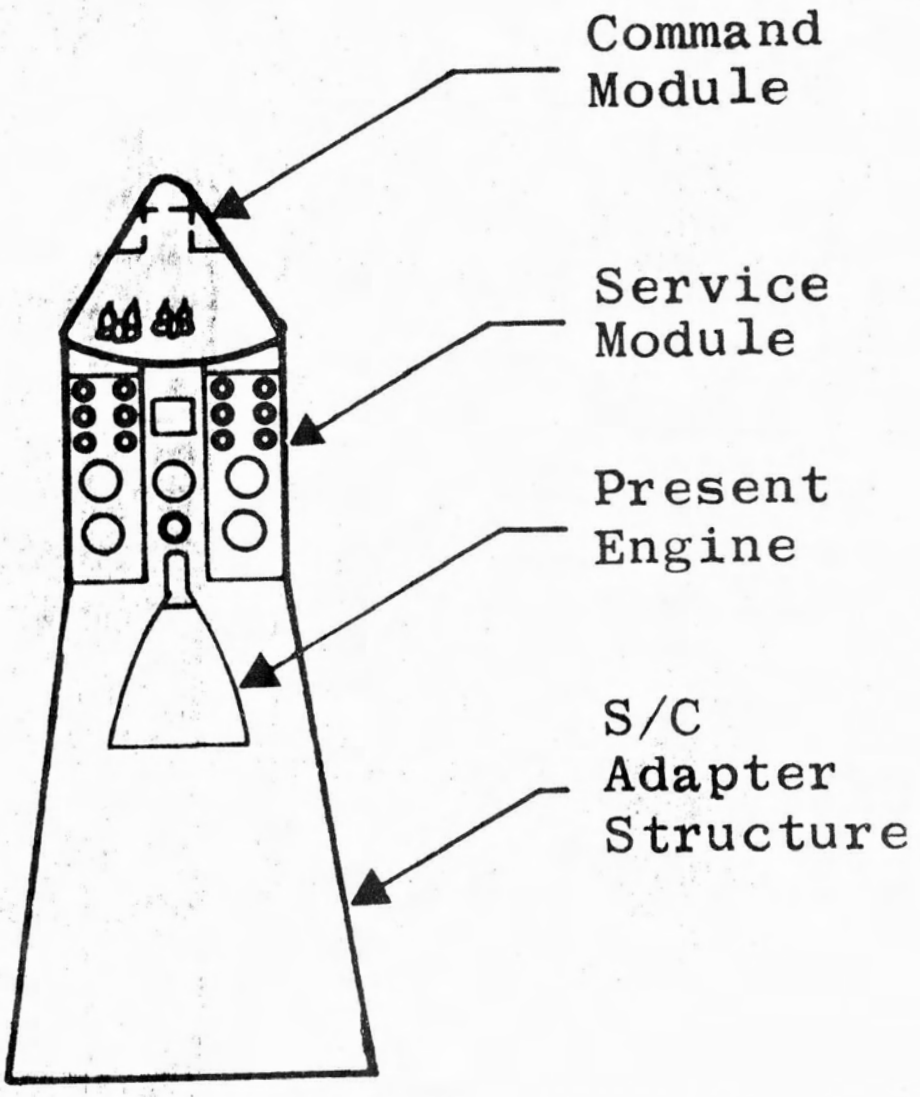
Multi-Module Space Station (MMSS)

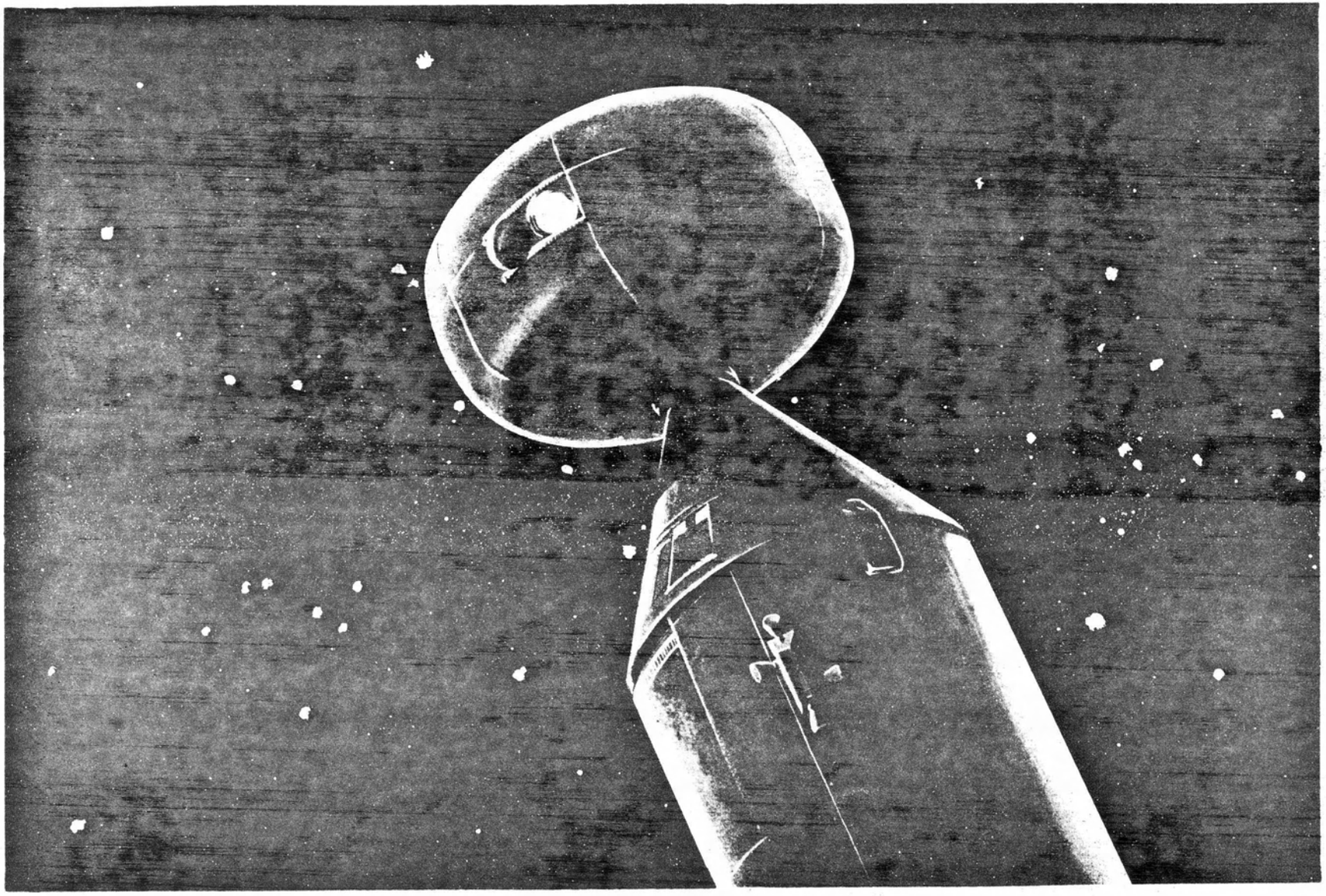
The study model selected was based on the Lockheed Study: three-arm radial segmented elements surrounding a central hub. This ORL is manned and supported by the Ballistic Logistic Spacecraft (BALLOS).



Apollo X-1 Launch Configuration

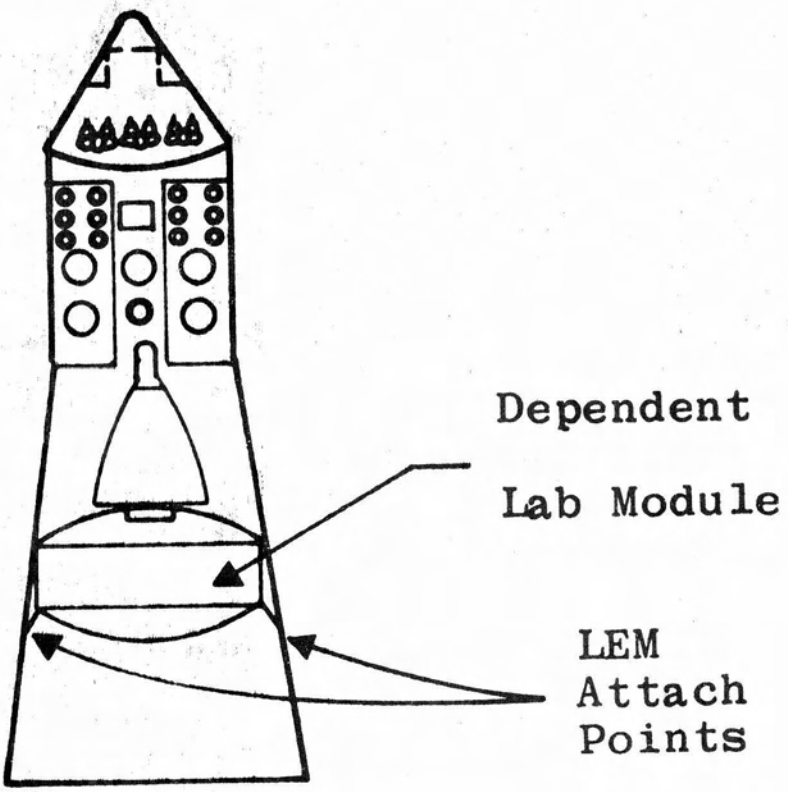
X-1
(2 man)


Command Module
Service Module
Present Engine
S/C Adapter Structure

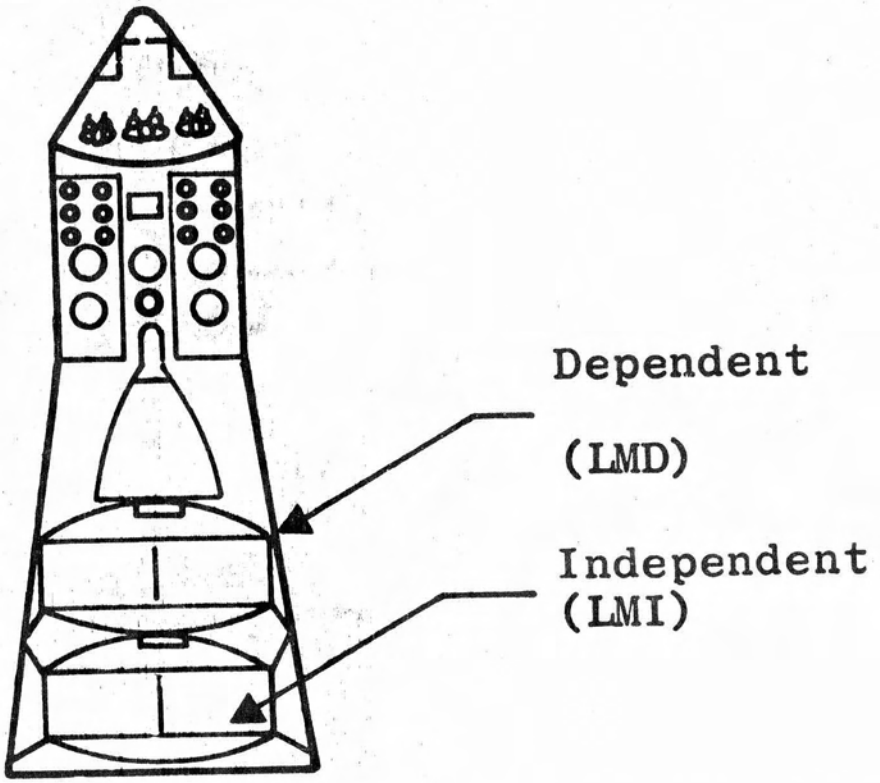


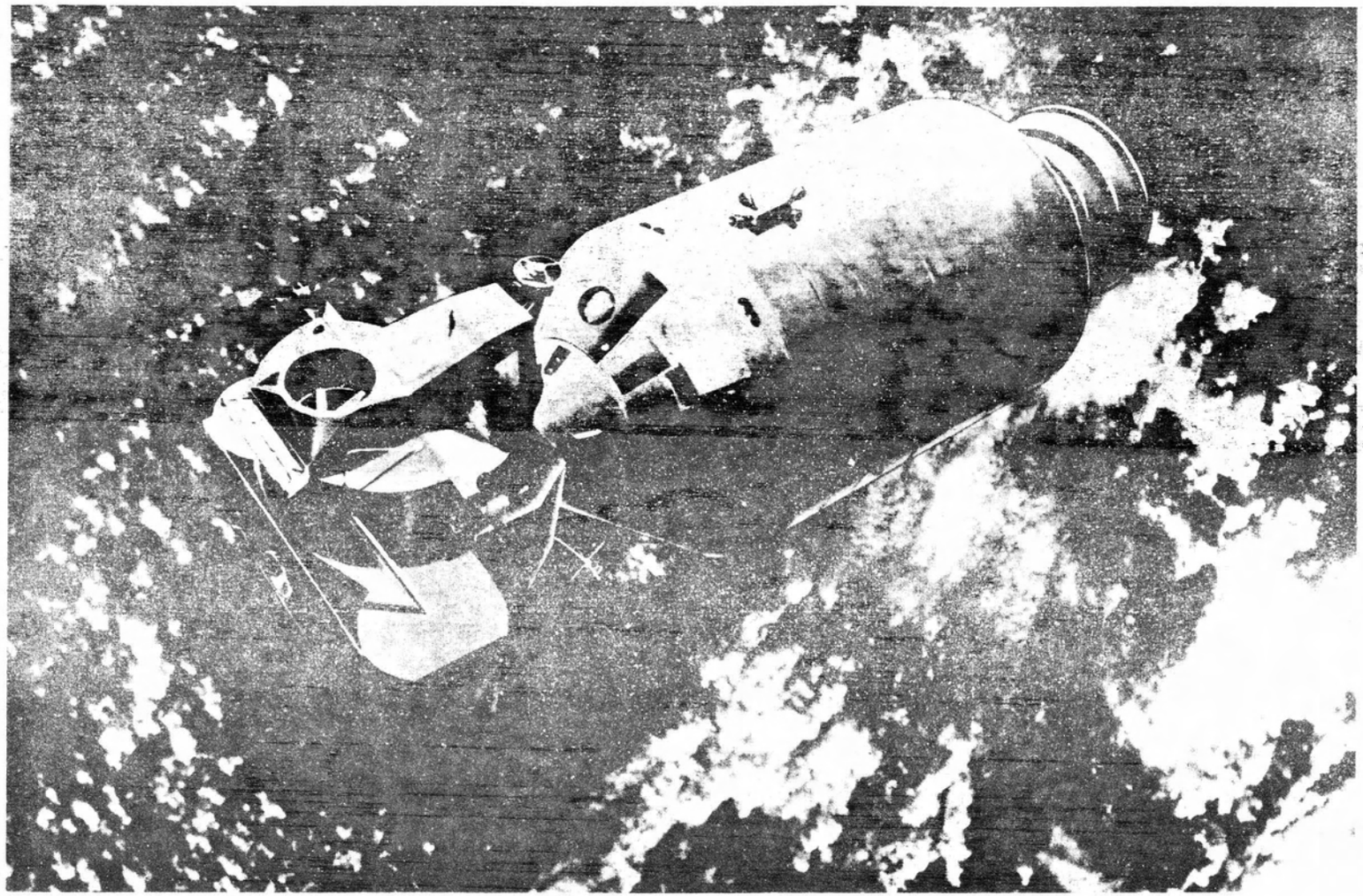
Apollo X-2 Configuration—Modified Command Module
and Dependent Laboratory Module

X-2
(3 man)



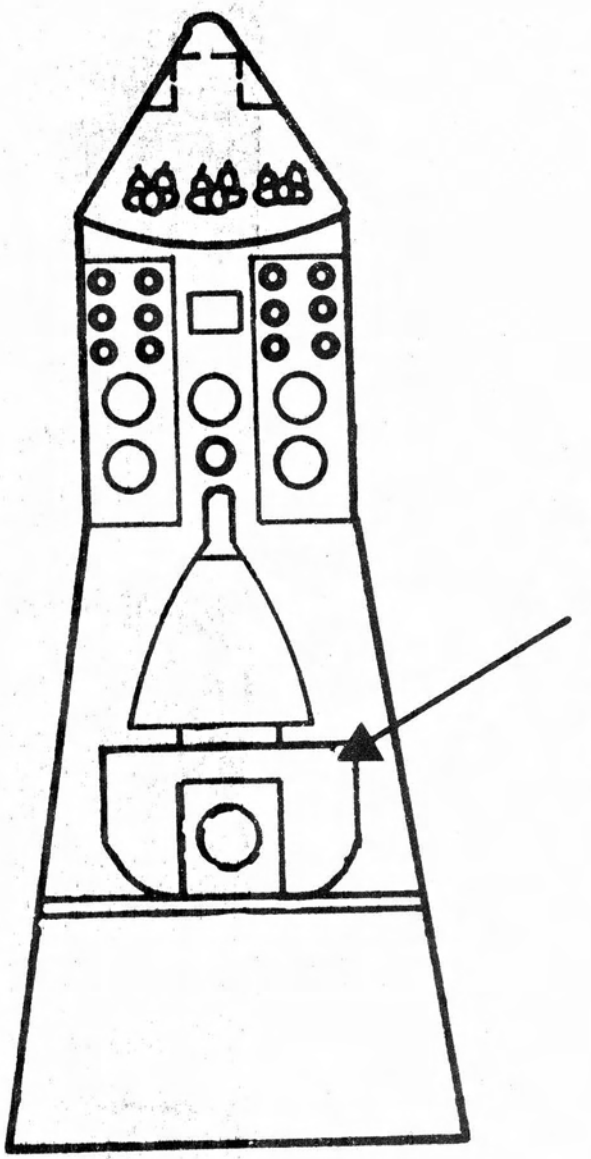
X-4
(3 man)



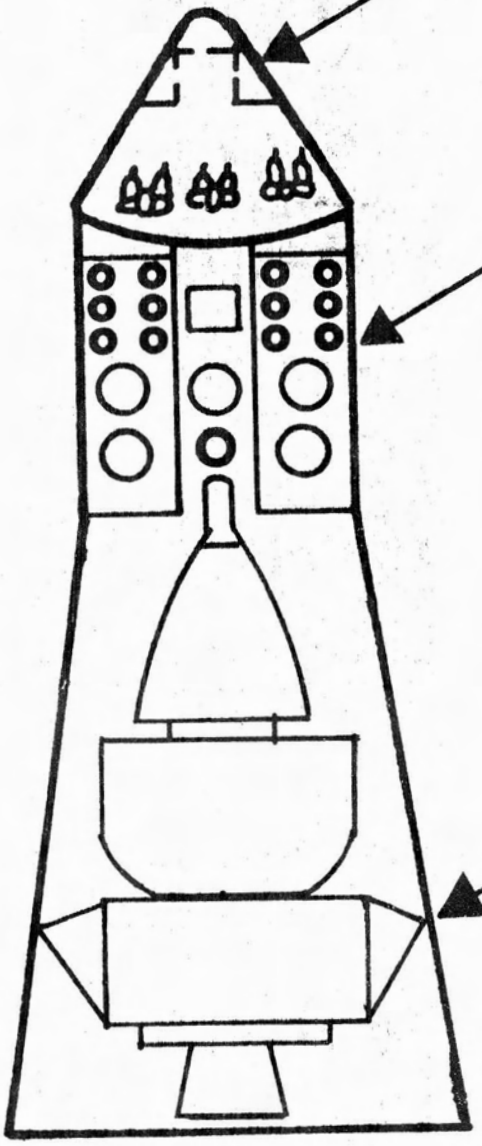


Apollo X-5 Configuration — Modified Command Module
and Modified LEM Ascent Stage

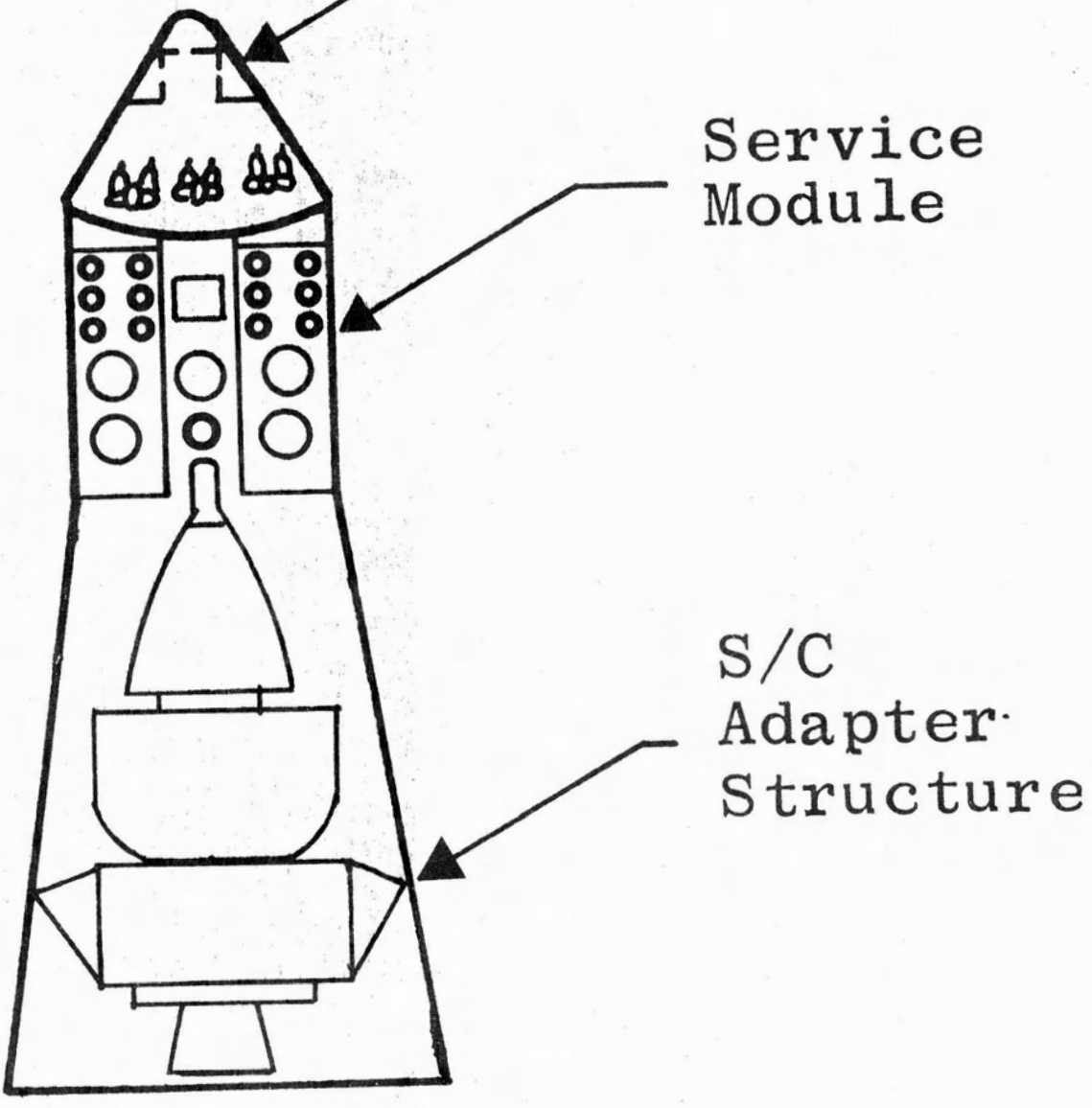
X-5
(3 man)

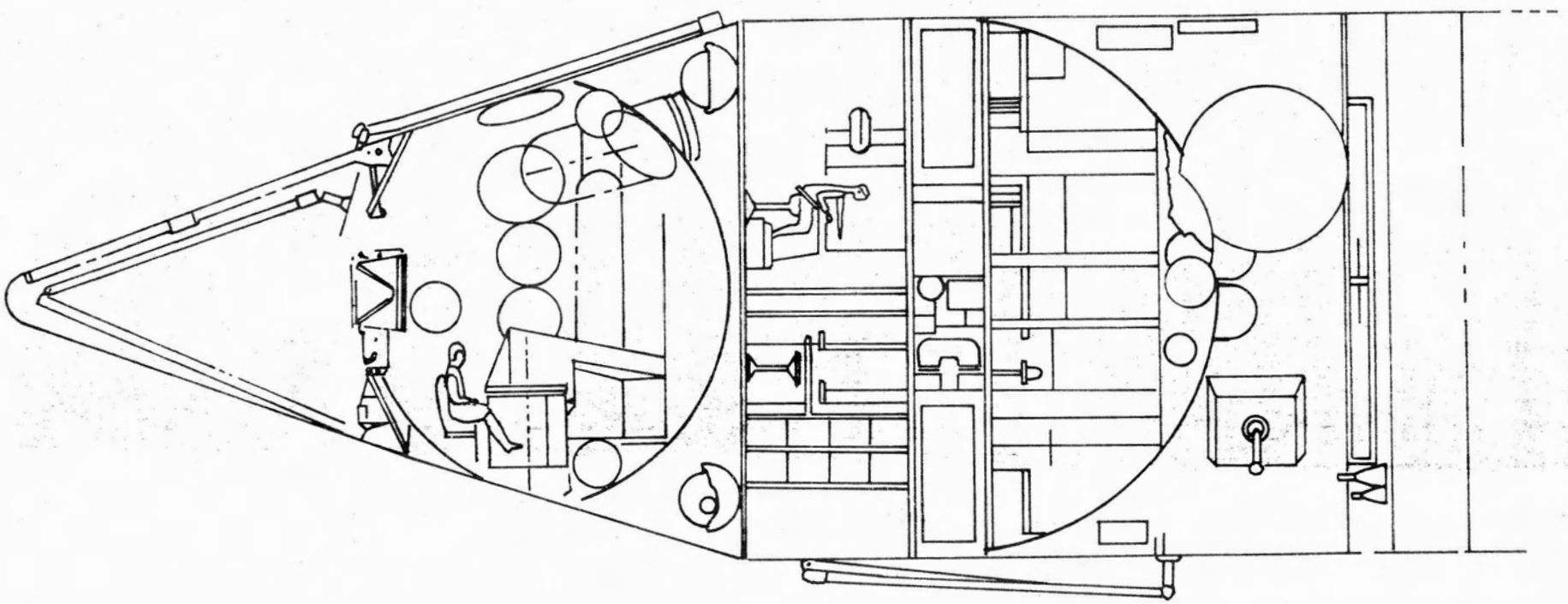


X-6
(3 man)

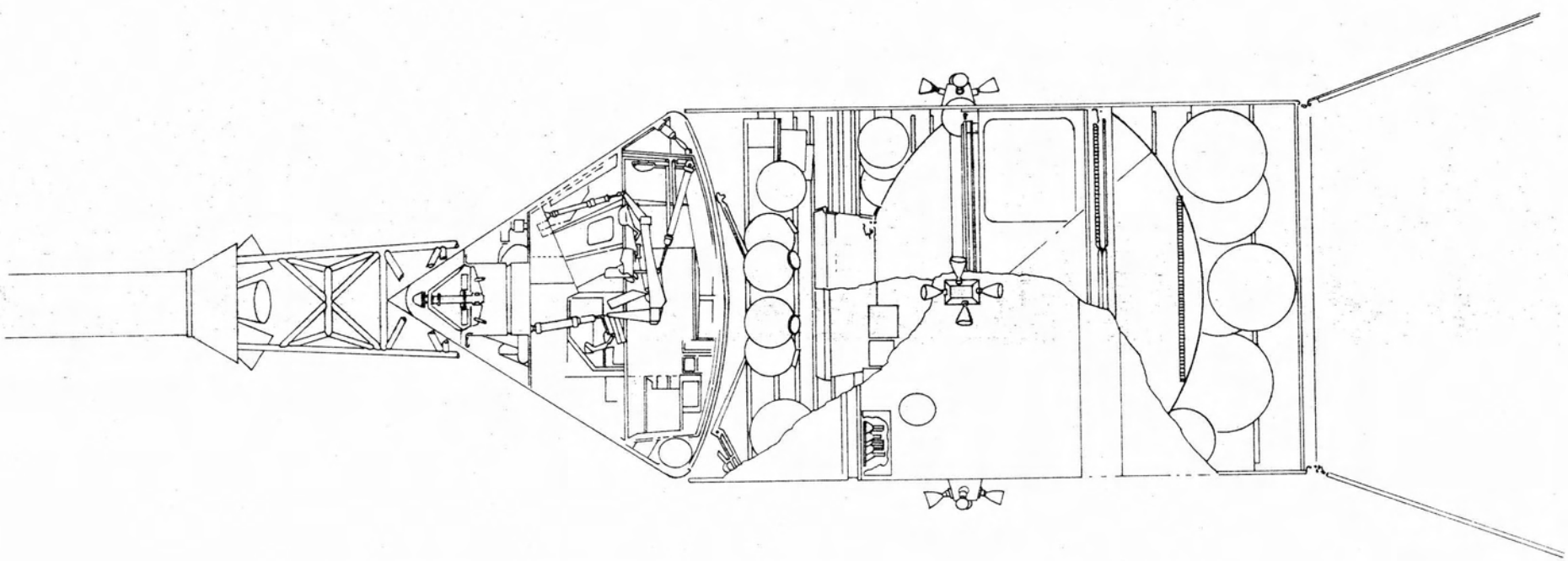


X-6
(3 man)

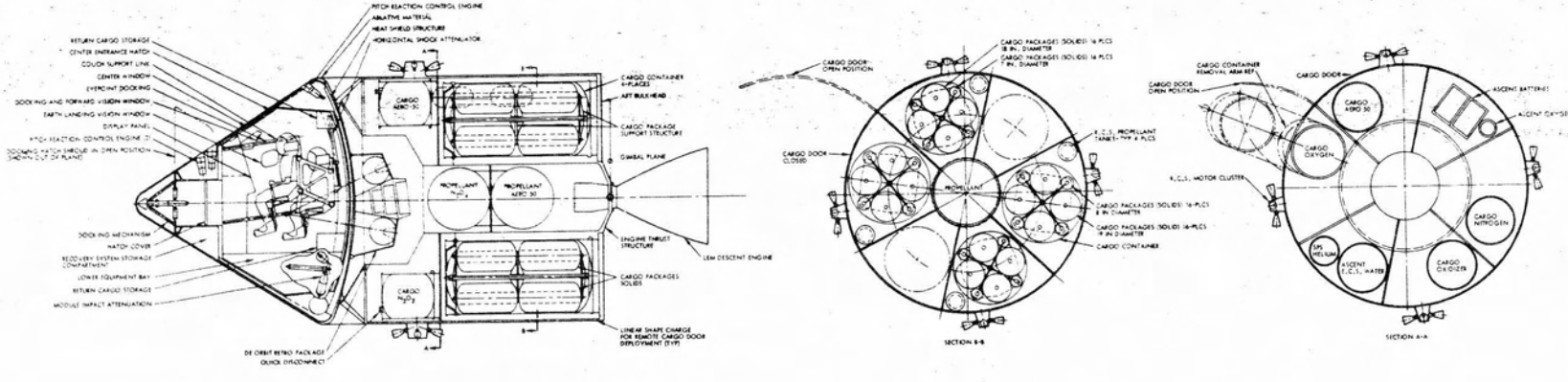




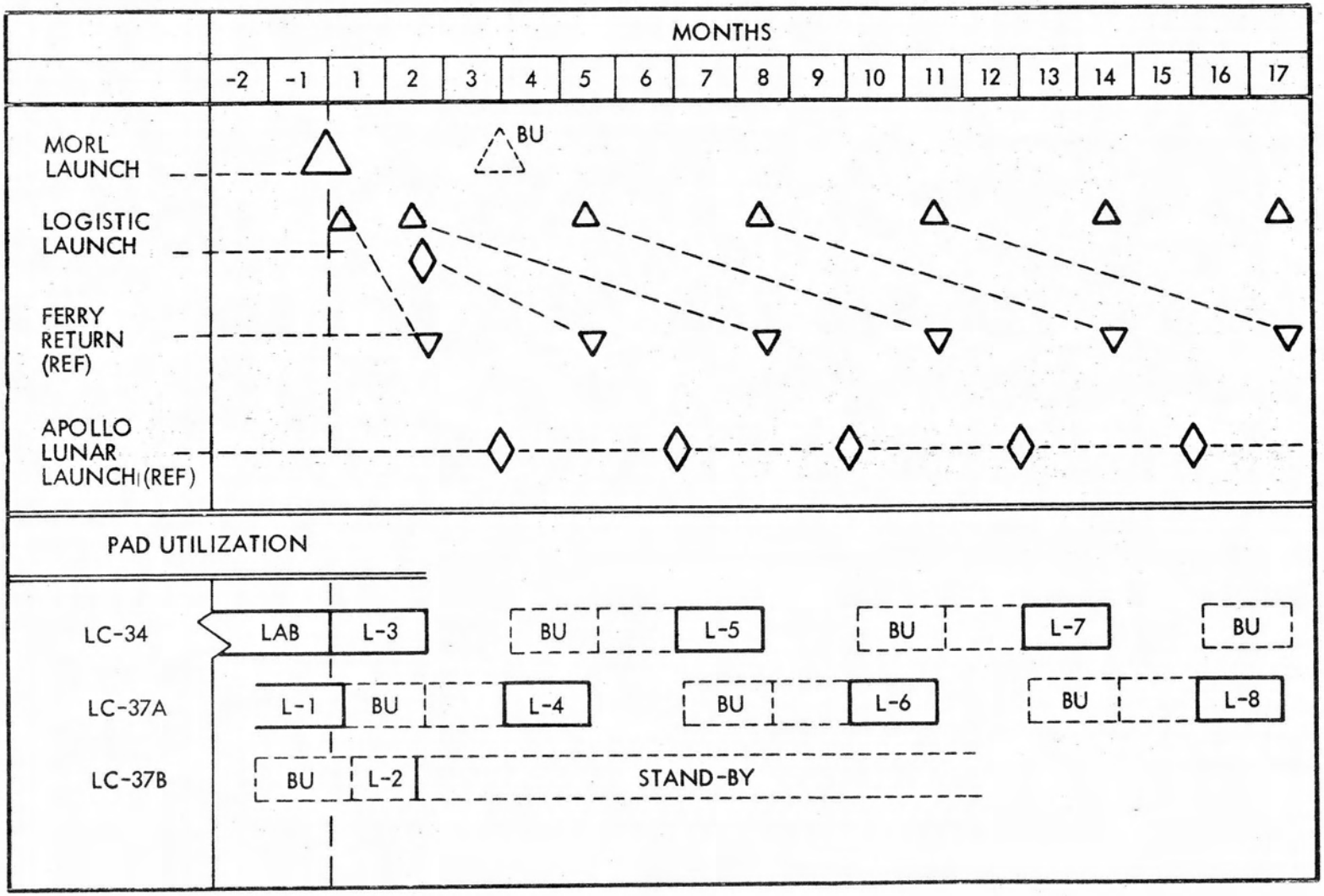
SINGLE MODULE SPACE STATION



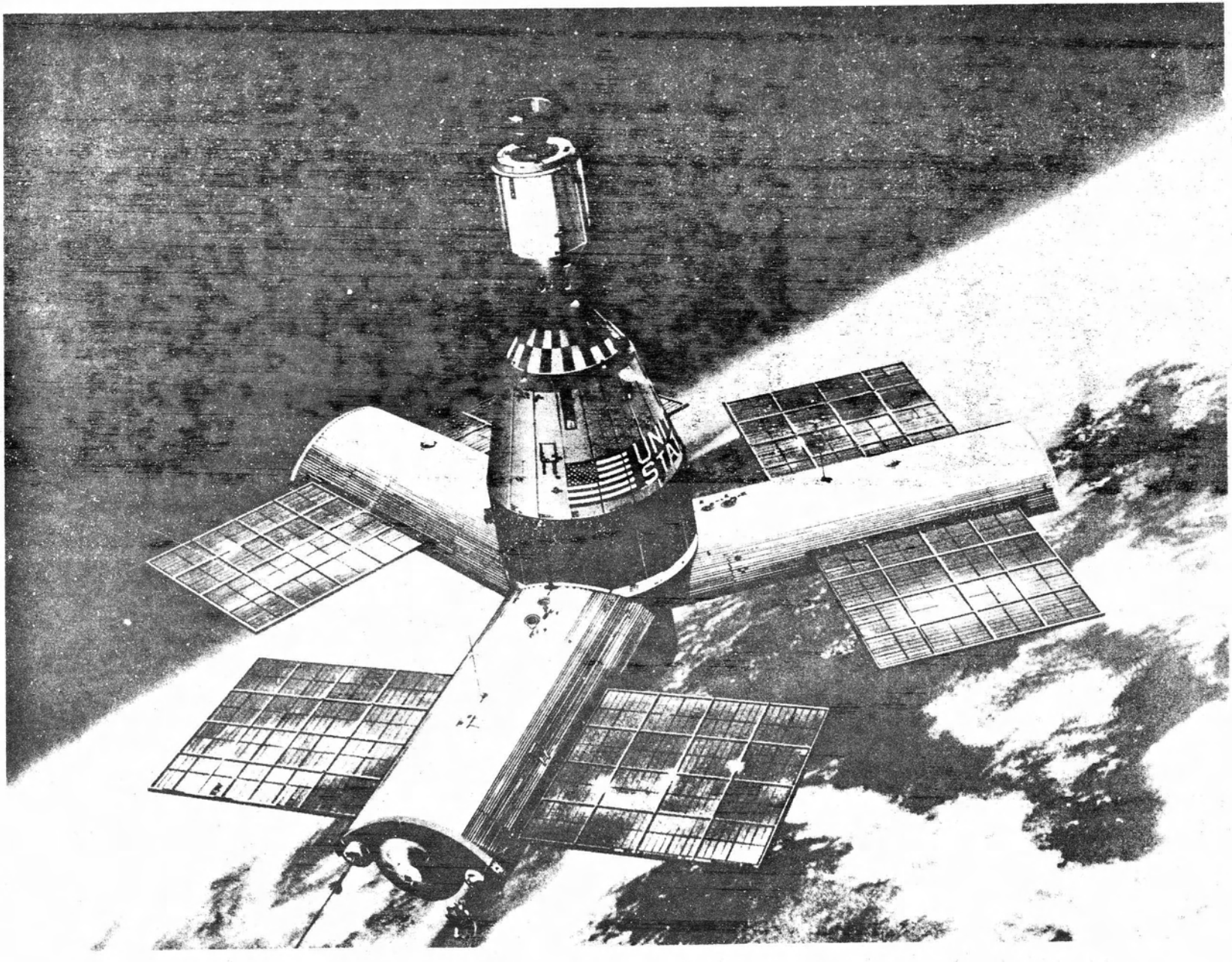
APOLLO LOGISTICS VEHICLE FOR SMSS



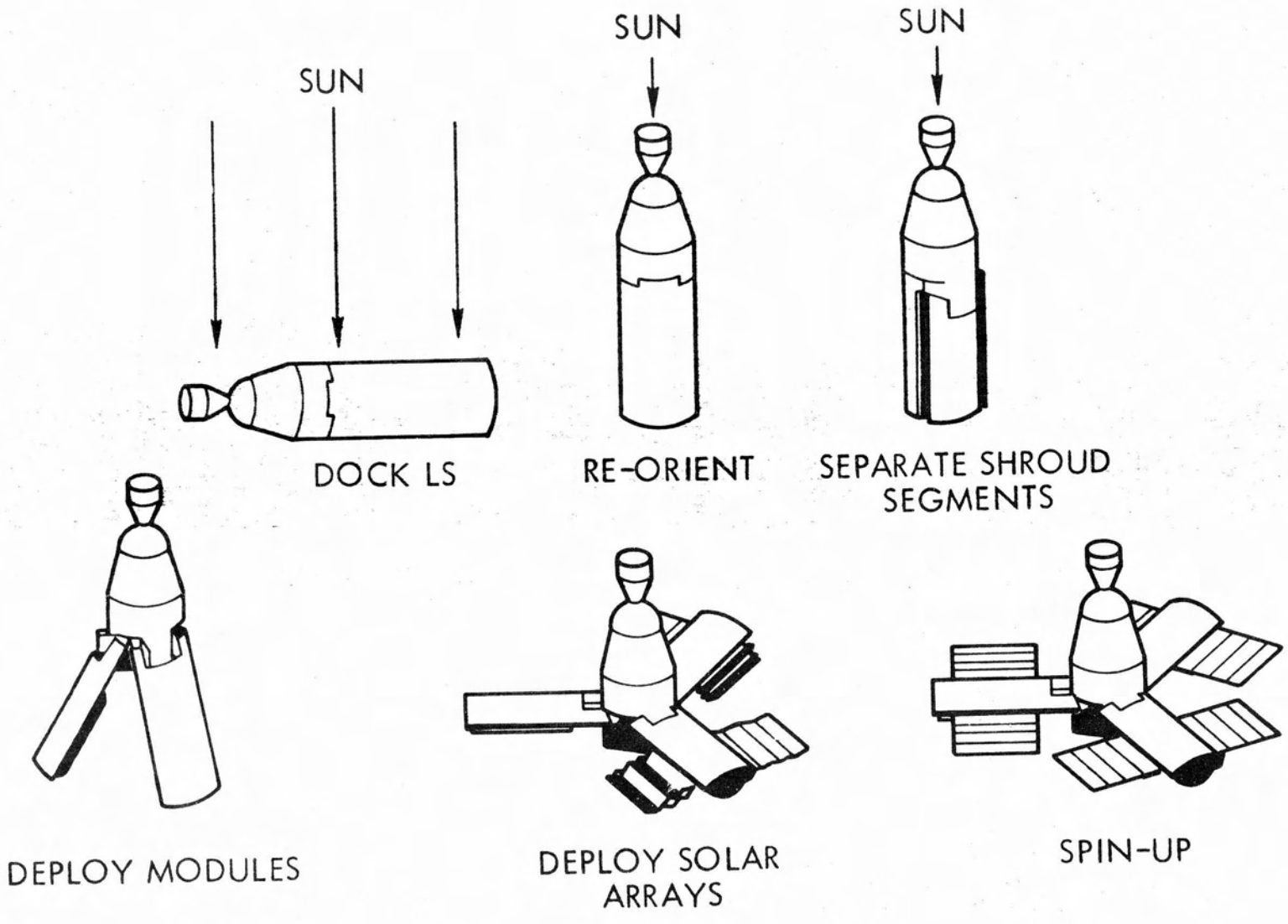
Modified Apollo (MODAP)
Cargo/Crew Modules



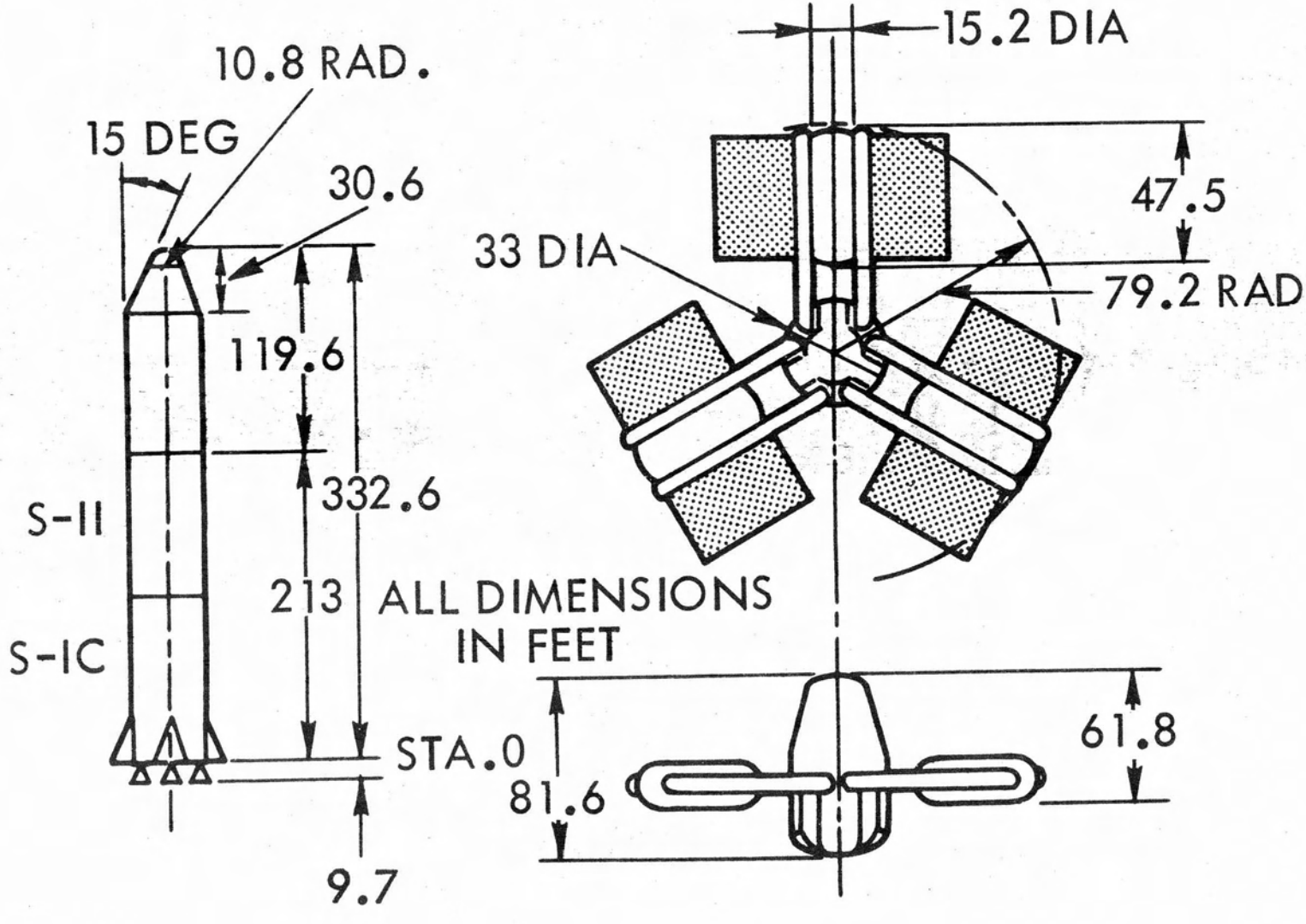
SMSS/Apollo LS Program Schedule



Multi-Module Space Station

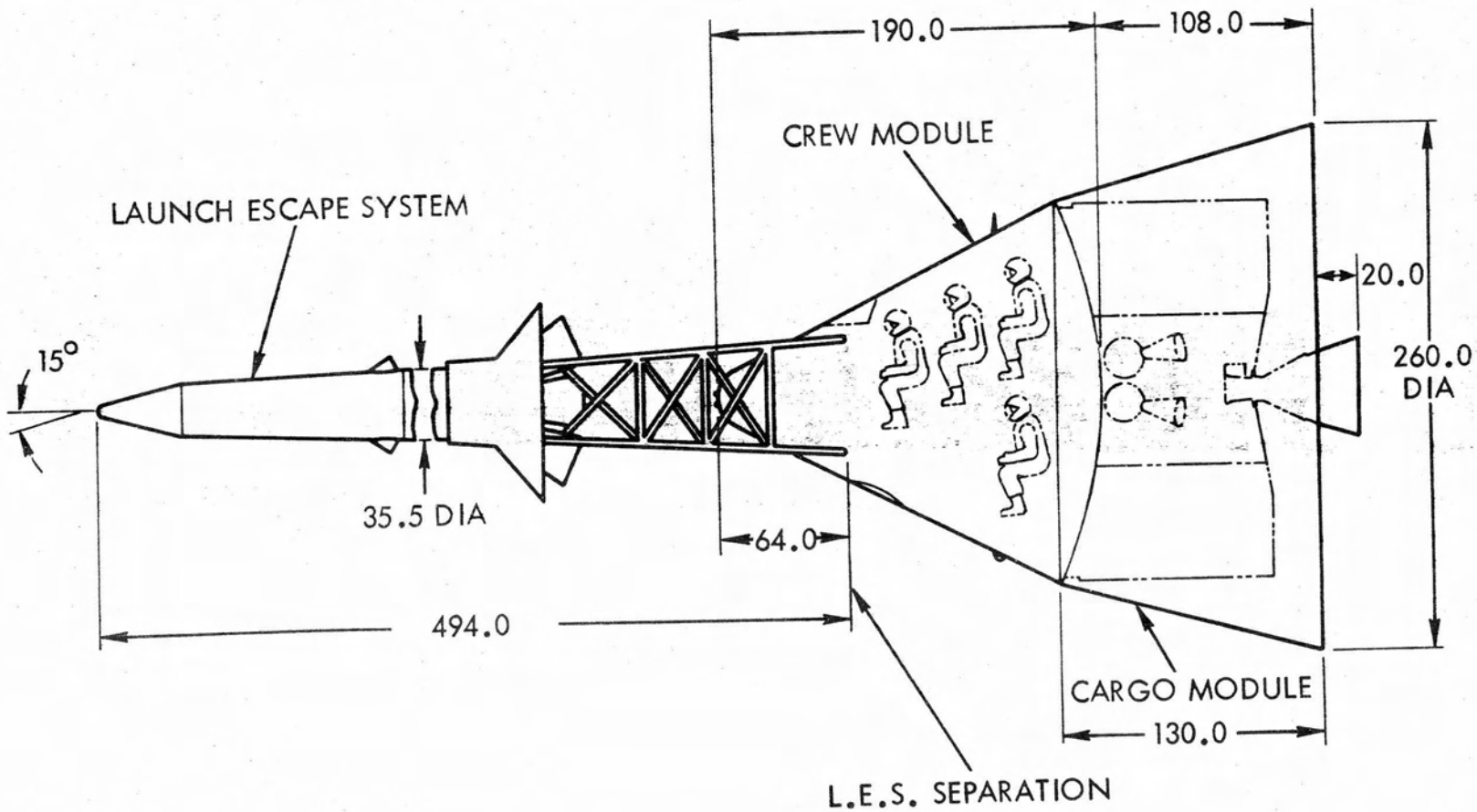


Deployment Sequence

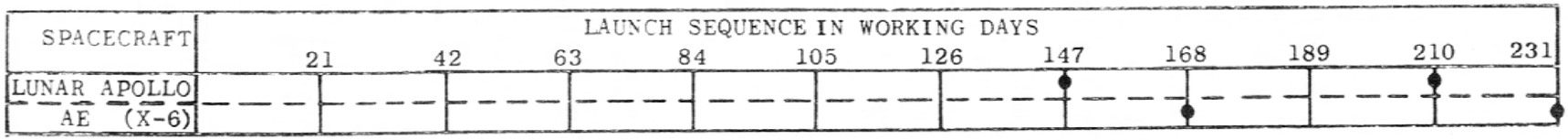


General Arrangement of MMSS

GENERAL ARRANGEMENT

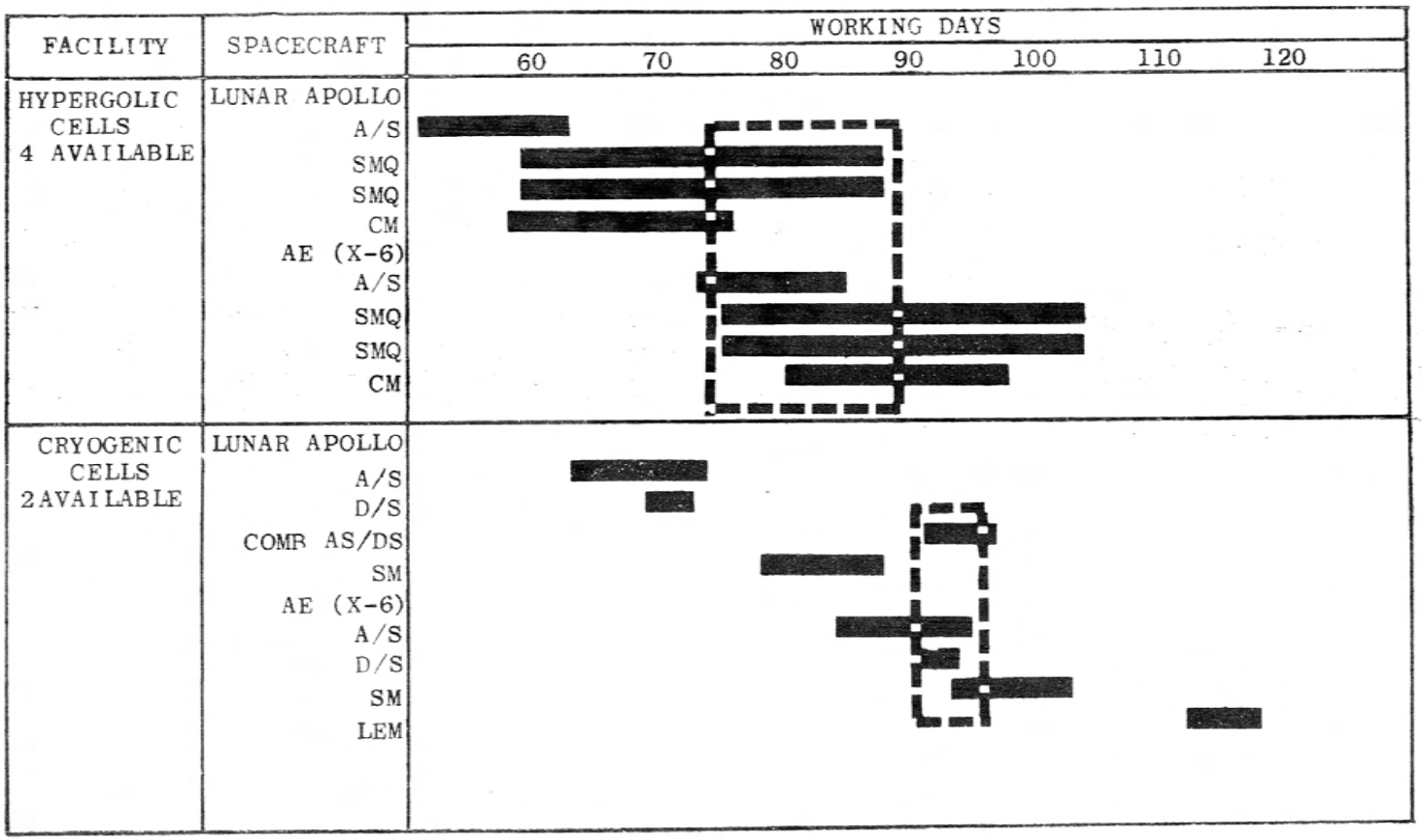


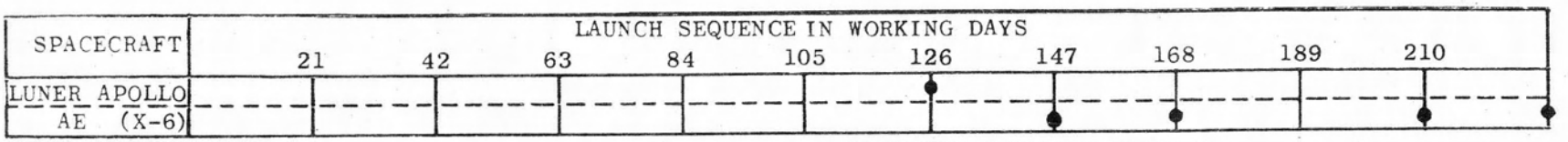
Twelve-Man Ballistic LS — General Arrangement



FACILITY OVERLOAD PERIODS

CASE II



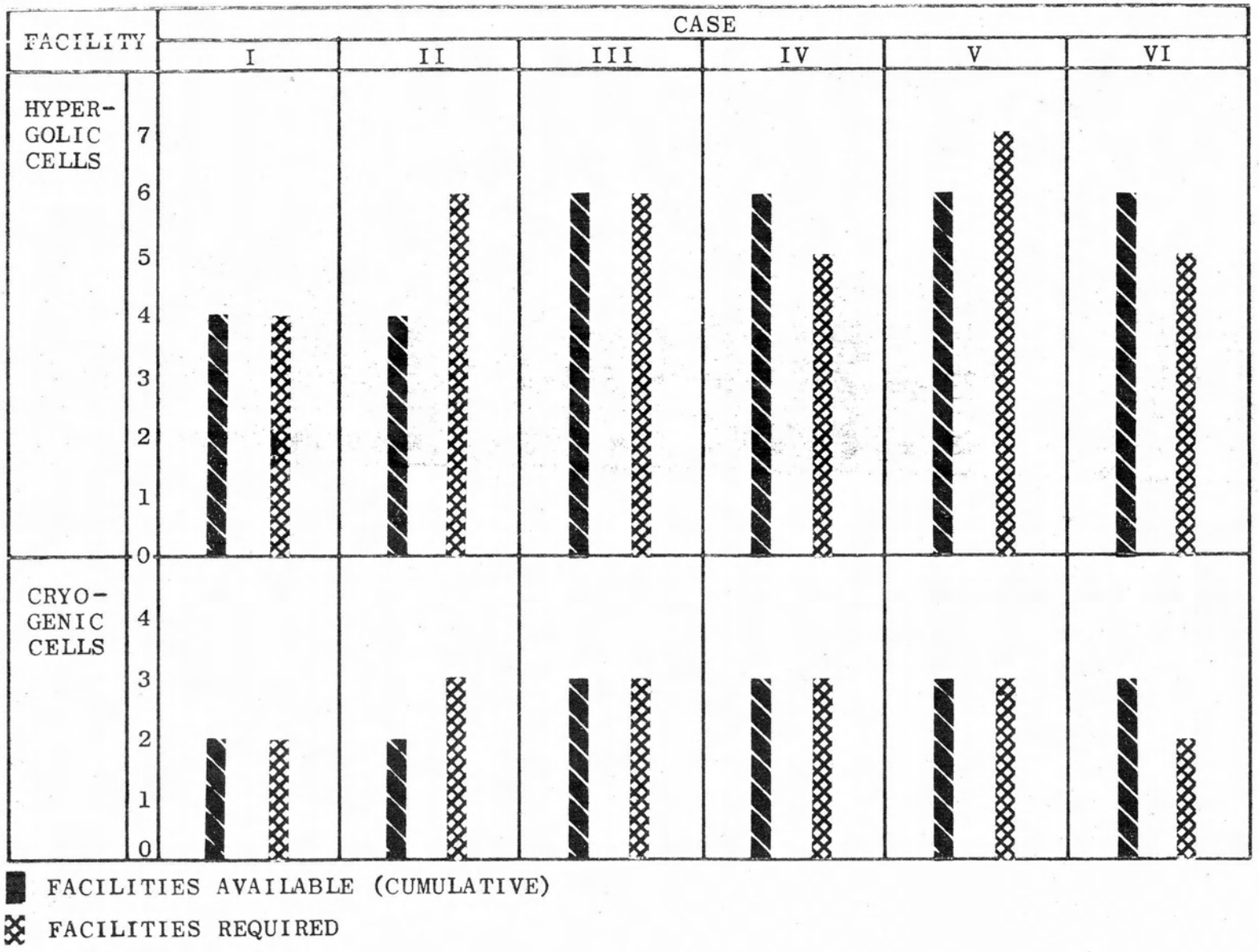


FACILITY OVERLOAD PERIODS

CASE III

FACILITY	SPACECRAFT	WORKING DAYS 40 50 60 70 80 90 100
STATIC TEST CELLS 2AVAILABLE	LUNAR APOLLO A/S SM AE (X-6) D/S SM	
HYPERGOLIC CELLS 4AVAILABLE	LUNAR APOLLO SMQ SMQ CM AE (X-6) A/S SMQ SMQ CM	
CRYOGENIC CELLS 2AVAILABLE	LUNAR APOLLO A/S D/S COMB. A/S&D/S SM AE (X-6) A/S D/S LEM SM	

FLUID TEST COMPLEX FACILITIES REQUIREMENTS



CM PREPARATION

DEGRADATION INSPECTION

COMPLETE DISASSEMBLY

REFURBISHMENT

Electrical
Mechanical
Structural

REASSEMBLY

INSPECTION

S/C CHECKOUT FLOW

CREW MODULE REFURBISHMENT OPERATIONS

BALLOS Refurbishment

Estimated Net Savings

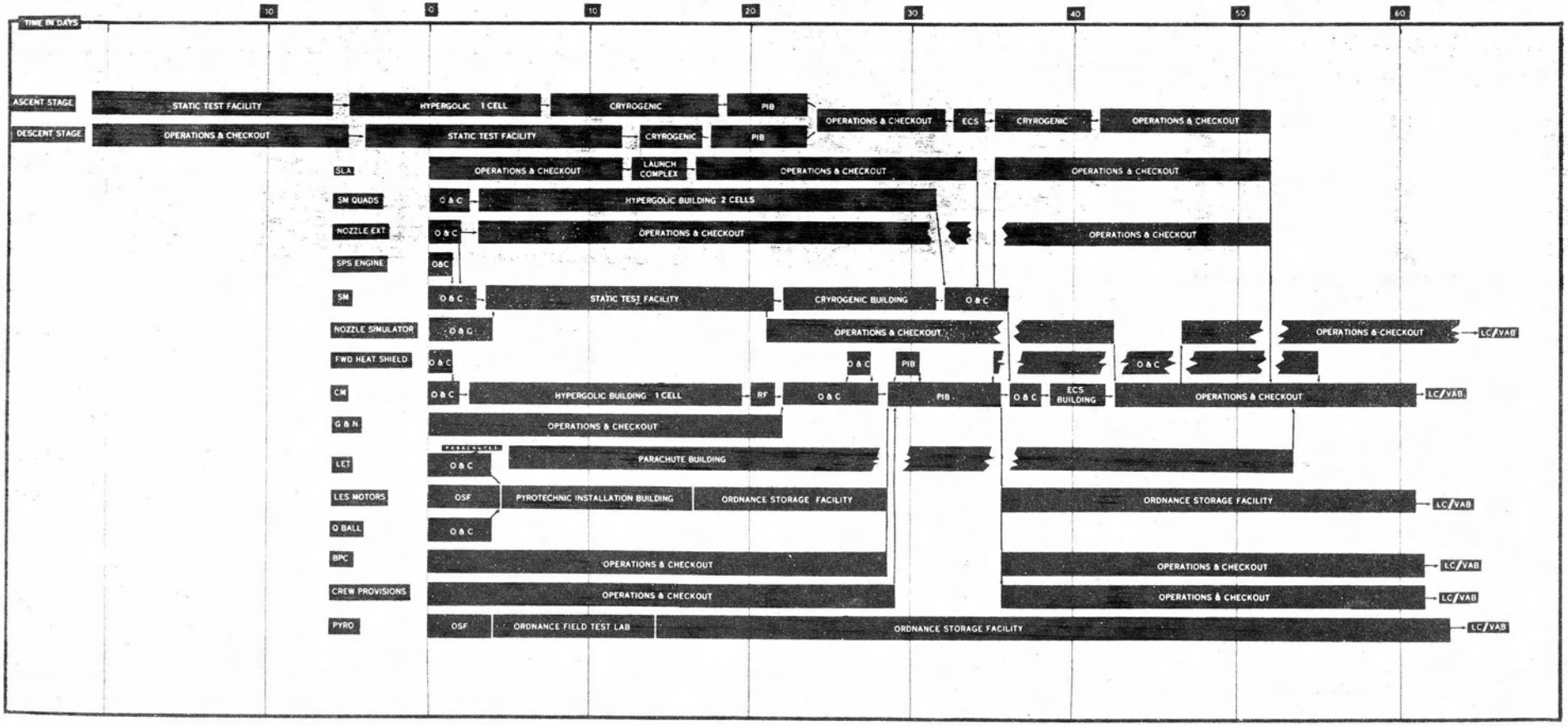
	Million Dollars	
15 new CM's @ $11.1 million each		$166.5
Reuse Concept Costs:		
CM refurbishment	73.6	
Refurbishment facility resources	2.0	
Reuse RD&T	30.7	
Reuse flight test verification	34.5	
Potential savings by refurbishment		140.8
Net		$ 25.7

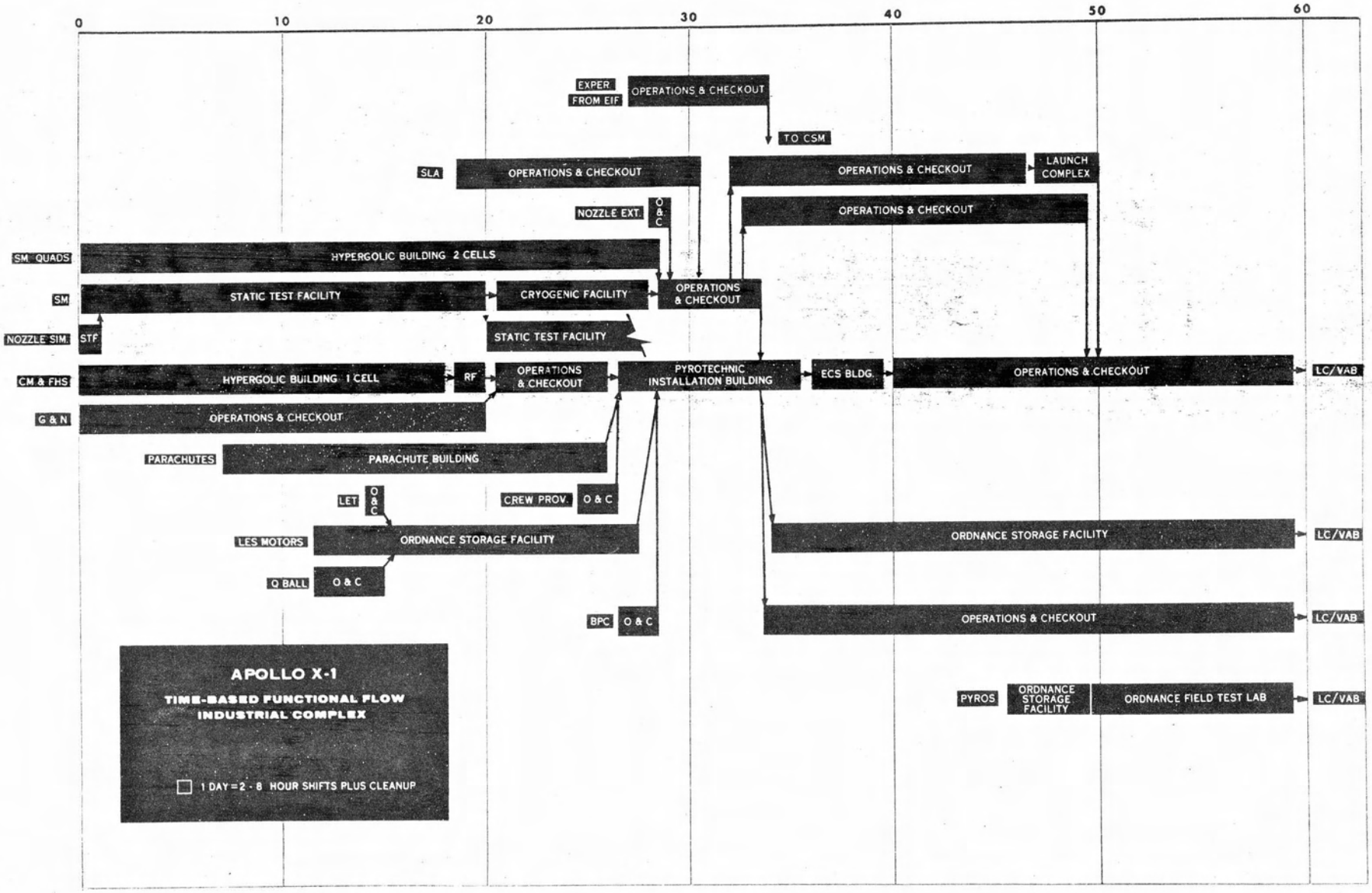
RECOMMENDED MODES OF OPERATION

As a product of the subtask and task analyses and of the optimization and tradeoff studies, recommended modes of operation were developed for each of the study configurations.

The time-based functional flow diagrams representing the recommended mode of operation for the assembly, checkout and launch of the various study configurations are a composite of functional flow and time line diagrams. The time scale on these diagrams is read horizontally and is in working days. A two-shift operation is assumed with third shift cleanup. No contingencies are considered. Major spacecraft elements are identified vertically and the operations relating to a given module may be identified by locating the module on the vertical listing and following it through horizontally. Similarly, facility utilization at any given time may be established by reading facility and spacecraft elements vertically.

APOLLO AIRFRAME 011 & LEM
TIME-BASED FUNCTIONAL FLOW
INDUSTRIAL COMPLEX

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EXPER
FROM EIF
OPERATIONS & CHECKOUT
TO CSM
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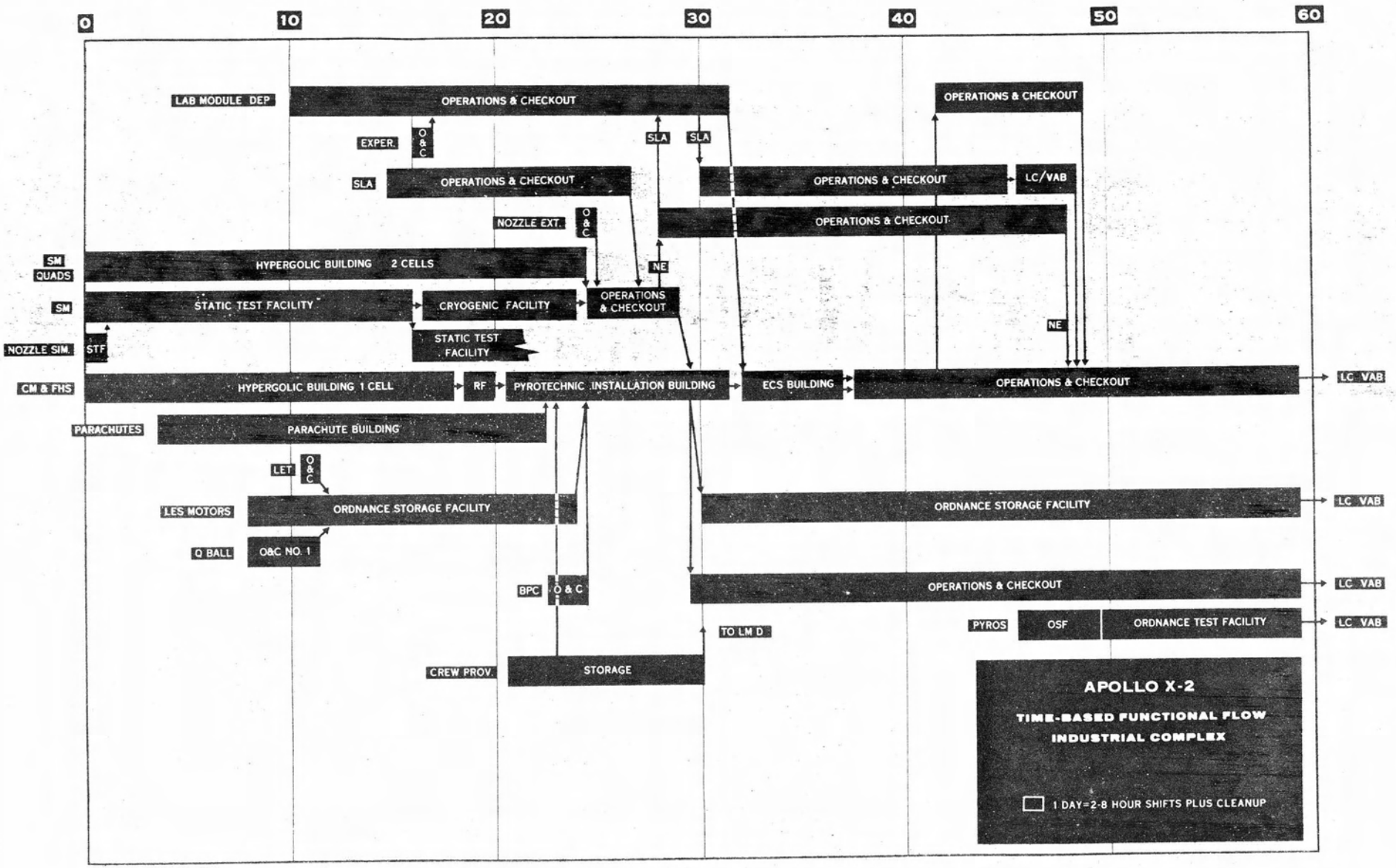
OPERATIONS & CHECKOUT
OPERATIONS & CHECKOUT
LAUNCH COMPLEX
NOZZLE EXT.
O & C
OPERATIONS & CHECKOUT
SM QUADS
HYPERGOLIC BUILDING 2 CELLS
SM
STATIC TEST FACILITY
CRYOGENIC FACILITY
OPERATIONS & CHECKOUT
NOZZLE SIM.
STF
STATIC TEST FACILITY
CM & FHS
HYPERGOLIC BUILDING 1 CELL
RF
OPERATIONS & CHECKOUT
PYROTECHNIC INSTALLATION BUILDING
ECS BLDG.
OPERATIONS & CHECKOUT
LC/VAB
G & N
OPERATIONS & CHECKOUT
PARACHUTES
PARACHUTE BUILDING
LET
O & C
CREW PROV.
O & C
LES MOTORS
ORDNANCE STORAGE FACILITY
ORDNANCE STORAGE FACILITY
LC/VAB
Q BALL
O & C
BPC
O & C
OPERATIONS & CHECKOUT
LC/VAB
APOLLO X-1
TIME-BASED FUNCTIONAL FLOW
INDUSTRIAL COMPLEX
1 DAY = 2 - 8 HOUR SHIFTS PLUS CLEANUP
PYROS
ORDNANCE STORAGE FACILITY
ORDNANCE FIELD TEST LAB
LC/VAB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LAB MODULE DEP
OPERATIONS & CHECKOUT
OPERATIONS & CHECKOUT
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HYPERGOLIC BUILDING 2 CELLS
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STATIC TEST FACILITY
CRYOGENIC FACILITY
OPERATIONS & CHECKOUT
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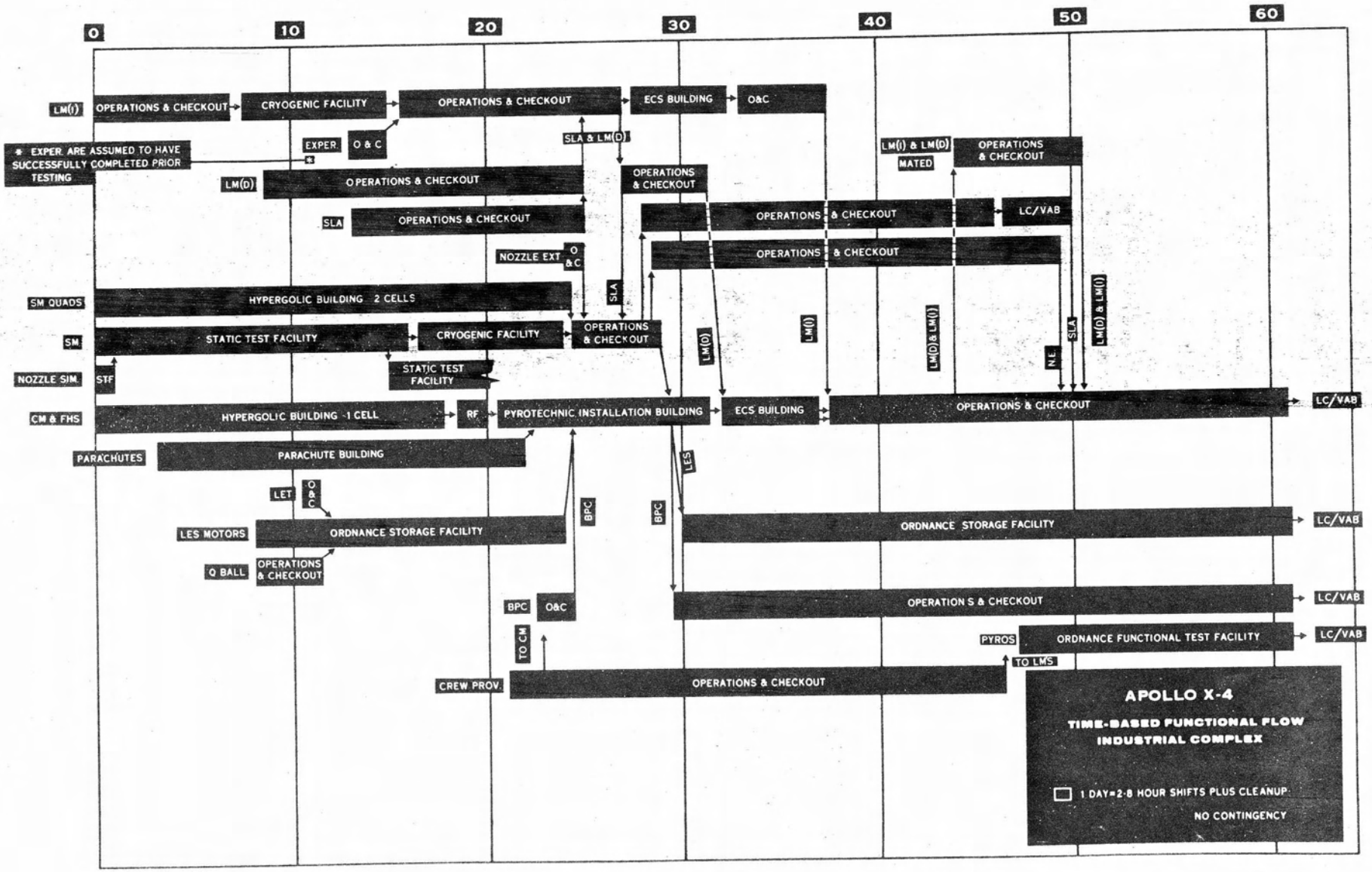
NOZZLE SIM.
STF
STATIC TEST FACILITY
CM & FHS
HYPERGOLIC BUILDING 1 CELL
RF
PYROTECHNIC INSTALLATION BUILDING
ECS BUILDING
OPERATIONS & CHECKOUT
LC VAB
PARACHUTES
PARACHUTE BUILDING
LET
O & C
LES MOTORS
ORDNANCE STORAGE FACILITY
ORDNANCE STORAGE FACILITY
LC VAB
Q BALL
O&C NO. 1
BPC
O & C
OPERATIONS & CHECKOUT
LC VAB
TO LM D
PYROS
OSF
ORDNANCE TEST FACILITY
LC VAB
CREW PROV.
STORAGE
APOLLO X-2
TIME-BASED FUNCTIONAL FLOW
INDUSTRIAL COMPLEX
1 DAY=2-8 HOUR SHIFTS PLUS CLEANUP


0
10
20
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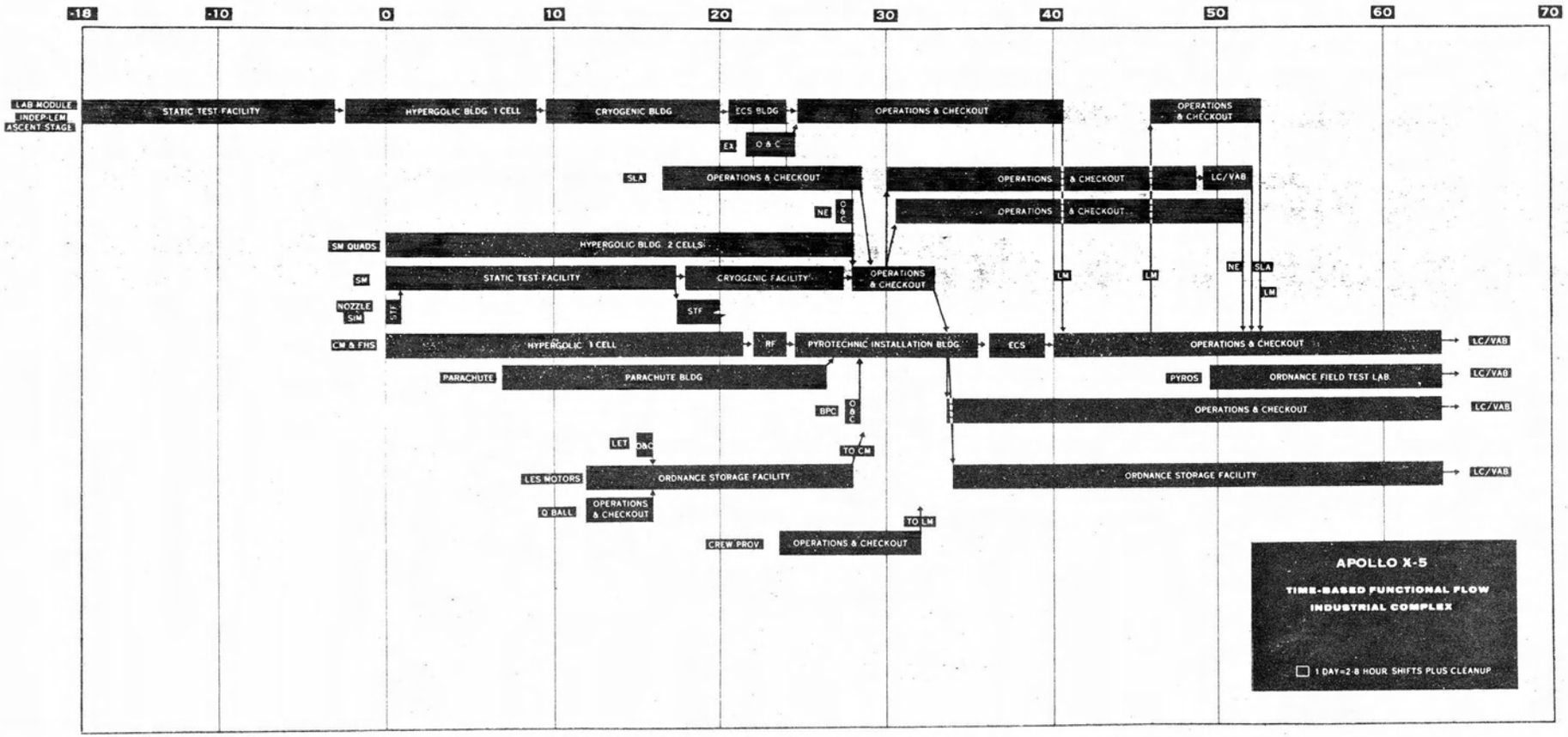
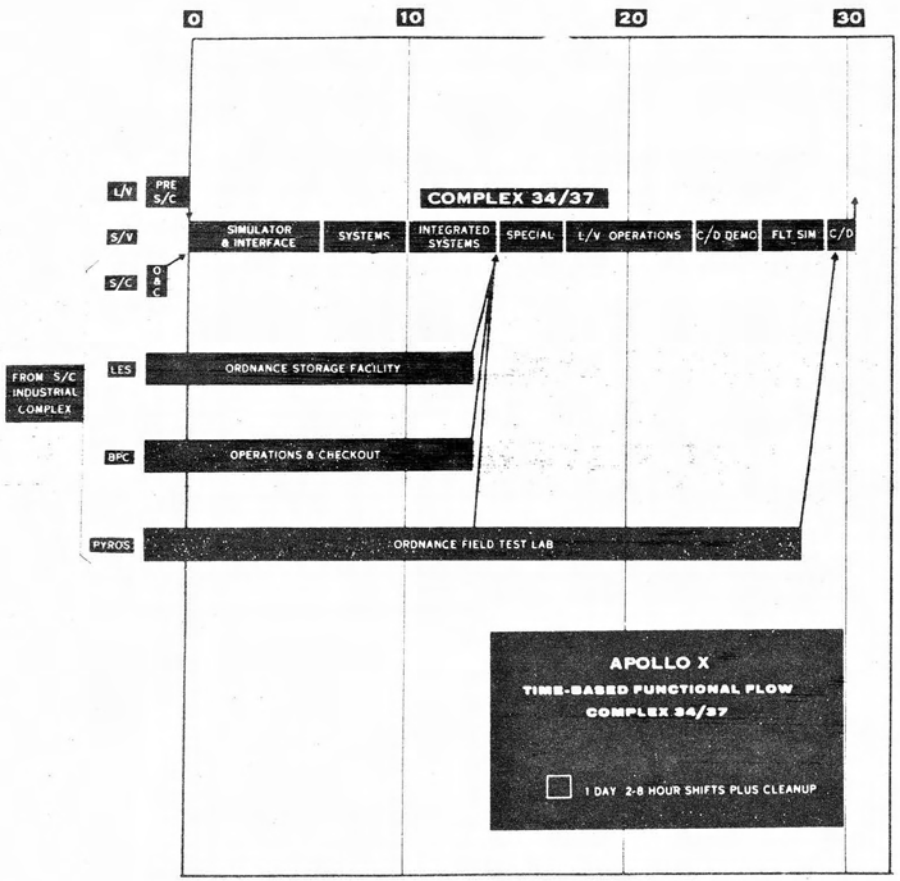
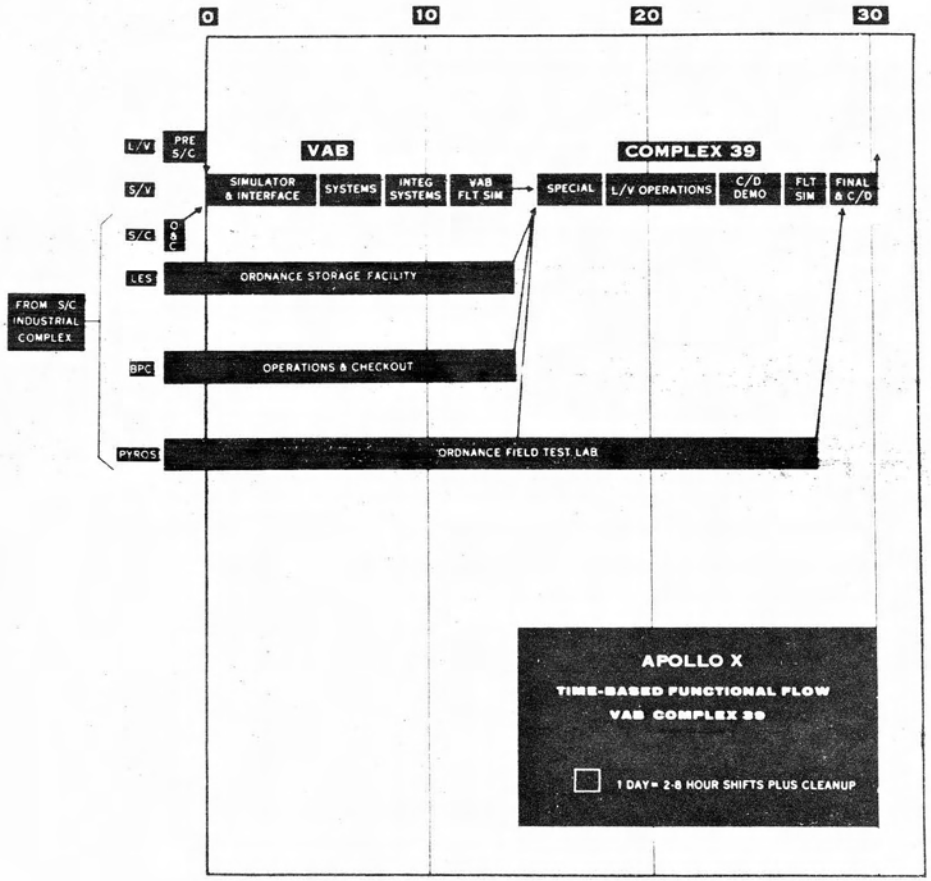
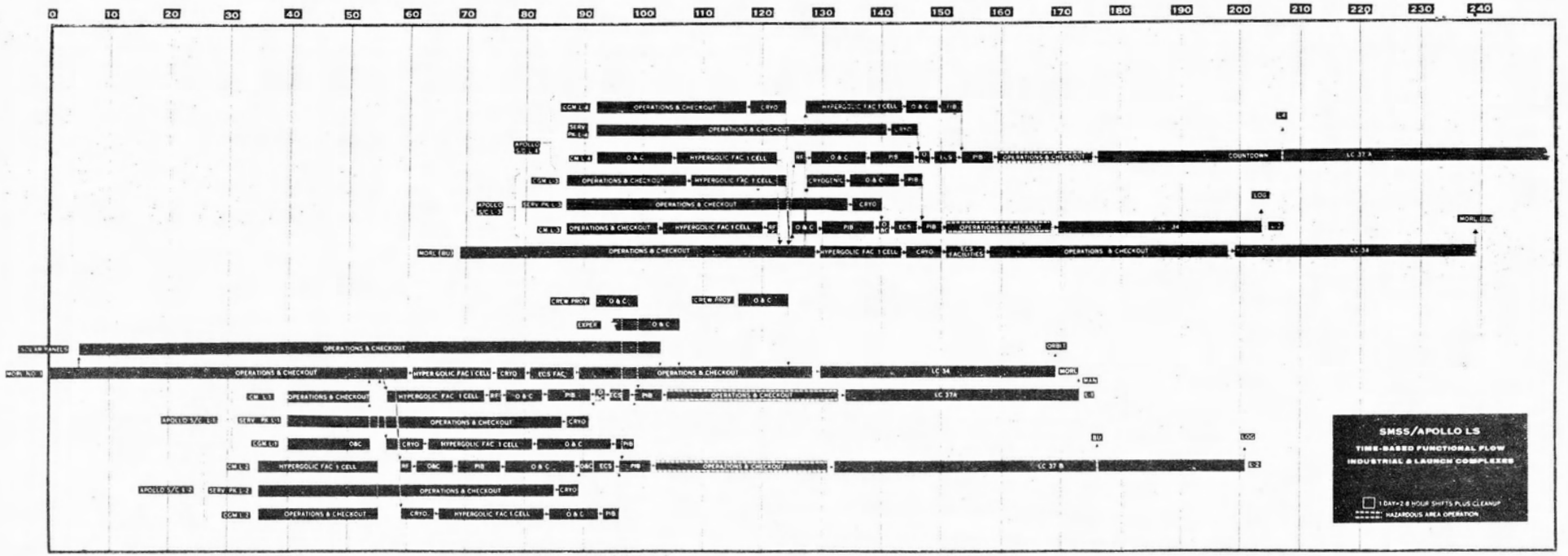
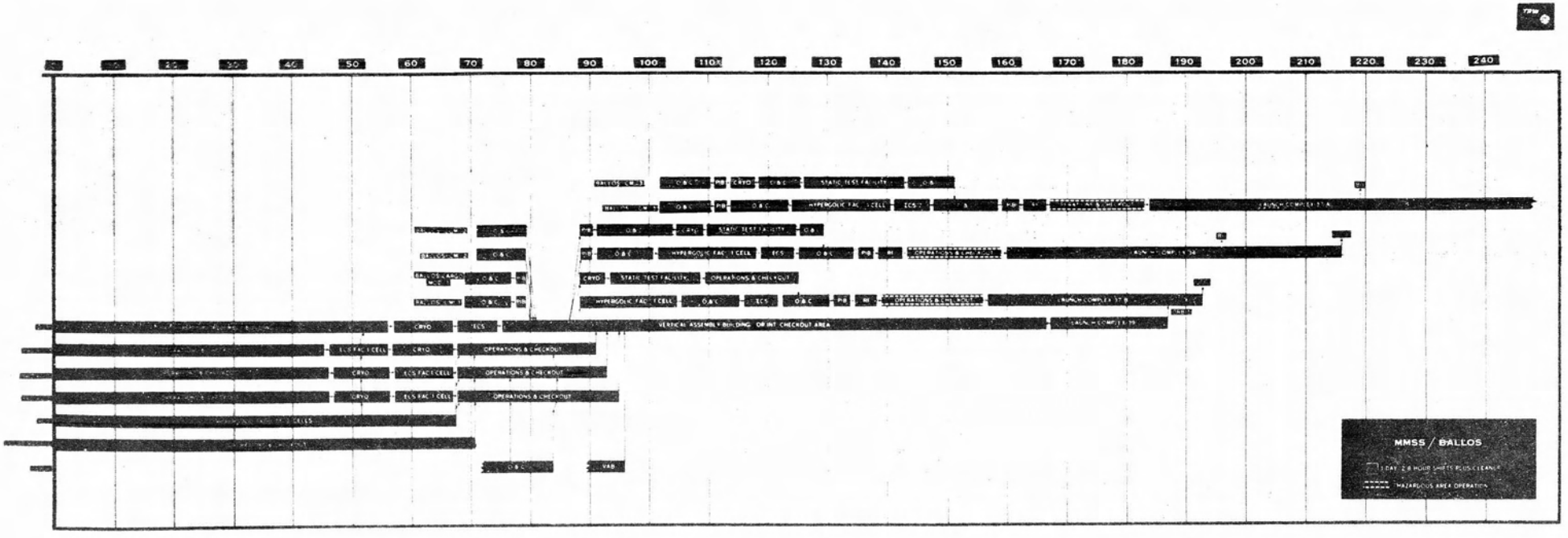
50
60
LM(I)
OPERATIONS & CHECKOUT
CRYOGENIC FACILITY
OPERATIONS & CHECKOUT
ECS BUILDING
O&C
* EXPER. ARE ASSUMED TO HAVE SUCCESSFULLY COMPLETED PRIOR TESTING
EXPER.
O & C
SLA & LM(D)
LM(D)
OPERATIONS & CHECKOUT
OPERATIONS & CHECKOUT
LM(I) & LM(D) MATED
OPERATIONS & CHECKOUT
SLA
OPERATIONS & CHECKOUT
OPERATIONS & CHECKOUT
LC/VAB
NOZZLE EXT
O & C
OPERATIONS & CHECKOUT
SM QUADS
HYPERGOLIC BUILDING 2 CELLS
SLA
SM
STATIC TEST FACILITY
CRYOGENIC FACILITY
OPERATIONS & CHECKOUT
LM(D)
LM(I)
LM(D) & LM(I)
N.E.
SLA
LM(D) & LM(I)
NOZZLE SIM.
STF
STATIC TEST FACILITY
CM & FHS
HYPERGOLIC BUILDING -1 CELL
RF
PYROTECHNIC INSTALLATION BUILDING
ECS BUILDING
OPERATIONS & CHECKOUT
LC/VAB
PARACHUTES
PARACHUTE BUILDING
LES
LET
O & C
BPC
BPC
LES MOTORS
ORDNANCE STORAGE FACILITY
ORDNANCE STORAGE FACILITY
LC/VAB
Q BALL
OPERATIONS & CHECKOUT
BPC
O&C
OPERATIONS & CHECKOUT
LC/VAB
TO CM
PYROS
ORDNANCE FUNCTIONAL TEST FACILITY
LC/VAB
TO LMS
CREW PROV.
OPERATIONS & CHECKOUT
APOLLO X-4
TIME-BASED FUNCTIONAL FLOW
INDUSTRIAL COMPLEX
1 DAY=2-8 HOUR SHIFTS PLUS CLEANUP
NO CONTINGENCY

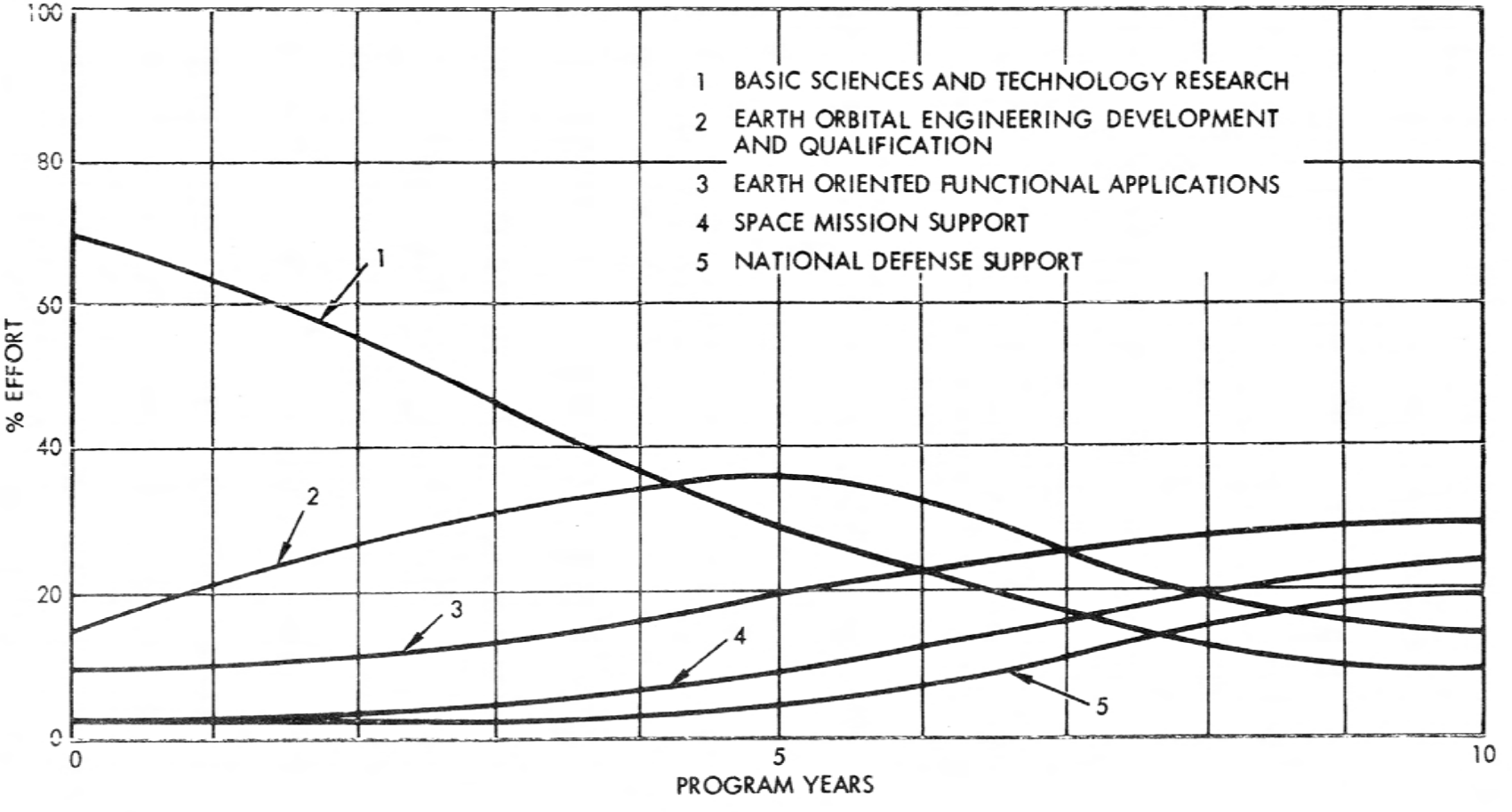

-18
-10
0
10
20
30
40
50
60
70
LAB MODULE
INDEP-LEM ASCENT STAGE
STATIC TEST FACILITY
HYPERGOLIC BLDG 1 CELL
CRYOGENIC BLDG
ECS BLDG
OPERATIONS & CHECKOUT
OPERATIONS & CHECKOUT
EX
O & C
SLA
OPERATIONS & CHECKOUT
OPERATIONS & CHECKOUT
LC/VAB
NE
O & C
OPERATIONS & CHECKOUT
SM QUADS
HYPERGOLIC BLDG 2 CELLS
SM
STATIC TEST FACILITY
CRYOGENIC FACILITY
OPERATIONS & CHECKOUT
LM
LM
NE
SLA
LM
NOZZLE SIM
STF
STF
CM & FHS
HYPERGOLIC 3 CELL
RF
PYROTECHNIC INSTALLATION BLDG
ECS
OPERATIONS & CHECKOUT
LC/VAB
PARACHUTE
PARACHUTE BLDG
PYROS
ORDNANCE FIELD TEST LAB
LC/VAB
BPC
O & C
OPERATIONS & CHECKOUT
LC/VAB
LET
D&C
TO CM
LES MOTORS
ORDNANCE STORAGE FACILITY
ORDNANCE STORAGE FACILITY
LC/VAB
Q BALL
OPERATIONS & CHECKOUT
TO LM
CREW PROV
OPERATIONS & CHECKOUT
APOLLO X-5
TIME-BASED FUNCTIONAL FLOW
INDUSTRIAL COMPLEX
1 DAY=2-8 HOUR SHIFTS PLUS CLEANUP


0
10
20
30
L/V
PRE S/C
COMPLEX 34/37
S/V
SIMULATOR & INTERFACE
SYSTEMS
INTEGRATED SYSTEMS
SPECIAL
L/V OPERATIONS
C/D DEMO
FLT SIM
C/D
S/C
O & C
FROM S/C INDUSTRIAL COMPLEX
LES
ORDNANCE STORAGE FACILITY
BPC
OPERATIONS & CHECKOUT
PYROS
ORDNANCE FIELD TEST LAB
APOLLO X
TIME-BASED FUNCTIONAL FLOW
COMPLEX 34/37
1 DAY 2-8 HOUR SHIFTS PLUS CLEANUP

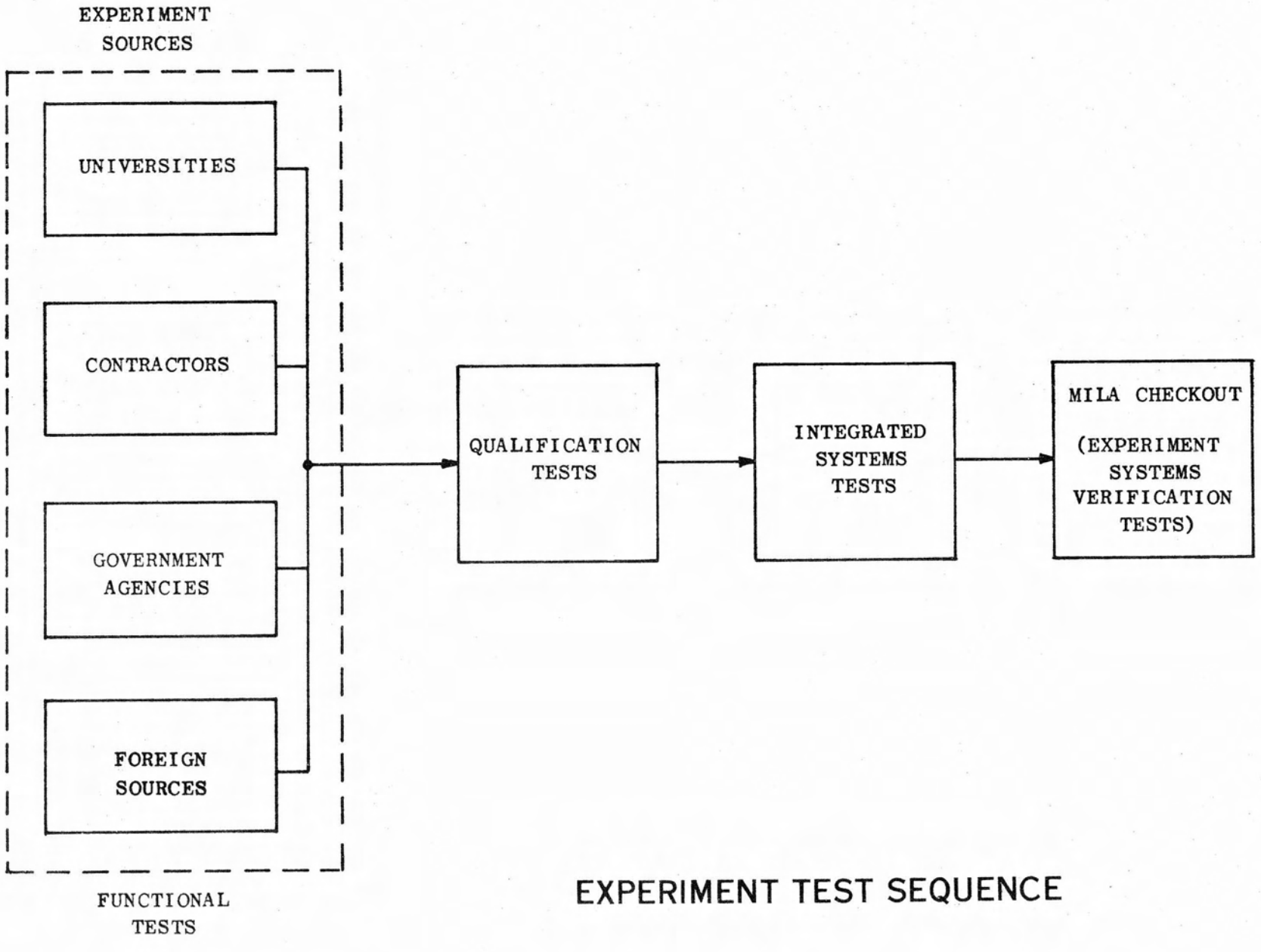

0
10
20
30
L/V
PRE S/C
VAB
COMPLEX 39
S/V
SIMULATOR & INTERFACE
SYSTEMS
INTEG SYSTEMS
VAB FLT SIM
SPECIAL
L/V OPERATIONS
C/D DEMO
FLT SIM
FINAL & C/D
S/C
O & C
LES
ORDNANCE STORAGE FACILITY
FROM S/C INDUSTRIAL COMPLEX
BPC
OPERATIONS & CHECKOUT
PYROS
ORDNANCE FIELD TEST LAB
APOLLO X
TIME-BASED FUNCTIONAL FLOW
VAB COMPLEX 39
1 DAY= 2-8 HOUR SHIFTS PLUS CLEANUP


0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
OPERATIONS & CHECKOUT
CRYO
HYPERGOLIC FAC 1 CELL
O & C
PIB
COUNTDOWN
LC 37 A
LC 34
LC 37B
CRYOGENIC
ECS
ECS FACILITIES
OPERATIONS & CHECKOUT
HYPERGOLIC FAC 1 CELL
OBC
CREW PROV
EXPER
ORBIT
MORL
LOS
AOS
MAN
SMSS/APOLLO LS
TIME-BASED FUNCTIONAL FLOW
INDUSTRIAL & LAUNCH COMPLEXES
1 DAY=2 8 HOUR SHIFTS PLUS CLEANUP
HAZARDOUS AREA OPERATION


-10
0
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
CRYO
ECS
VERTICAL ASSEMBLY BUILDING ORBIT CHECKOUT AREA
OPERATIONS & CHECKOUT
VAB
MMSS / BALLOS
1 DAY, 2-8 HOUR SHIFTS PLUS CLEANUP
HAZARDOUS AREA OPERATION



Distribution of Utilization Effort Within ORL Program

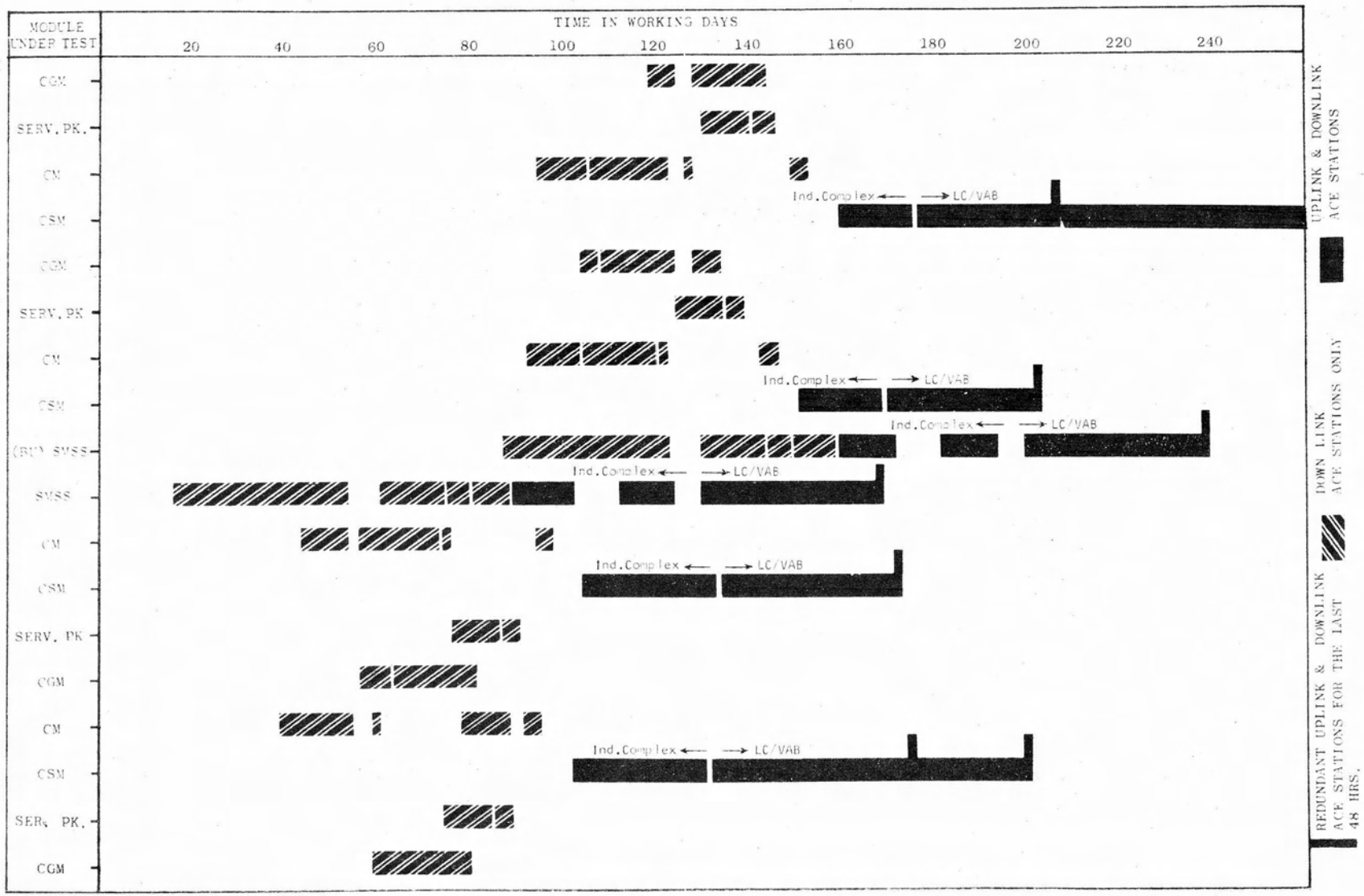


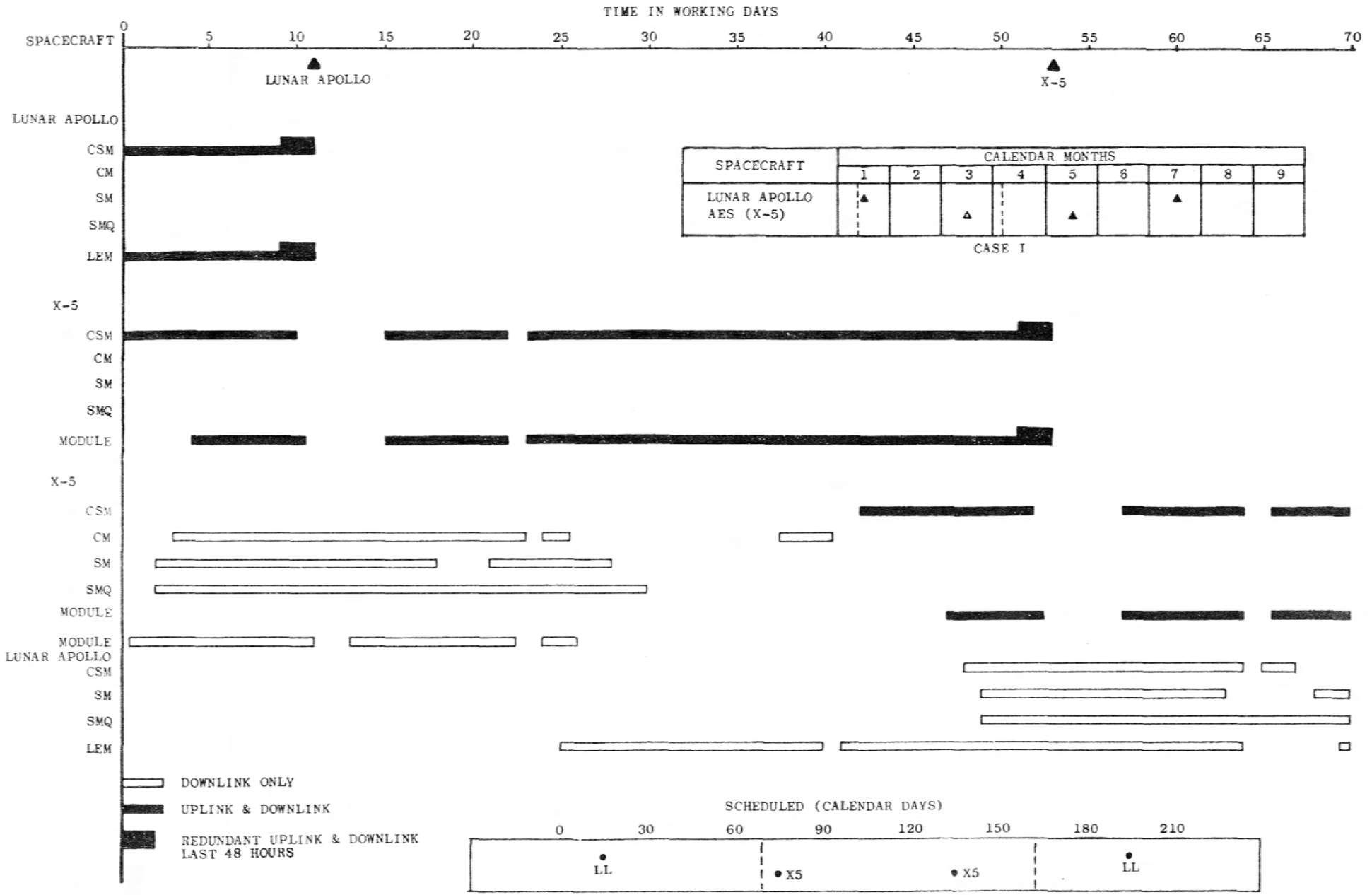
EXPERIMENT TEST SEQUENCE

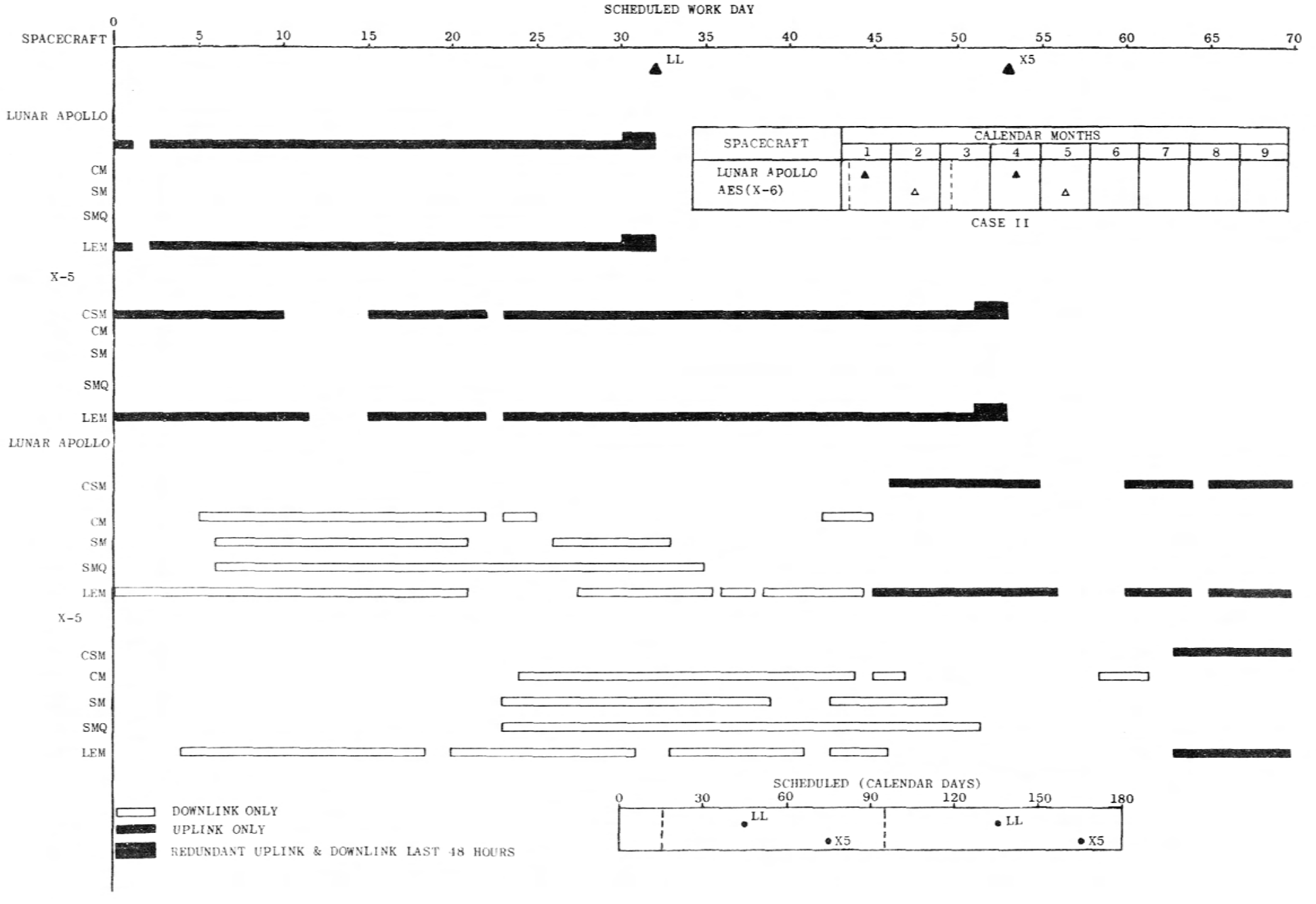
ACE ASSUMPTIONS

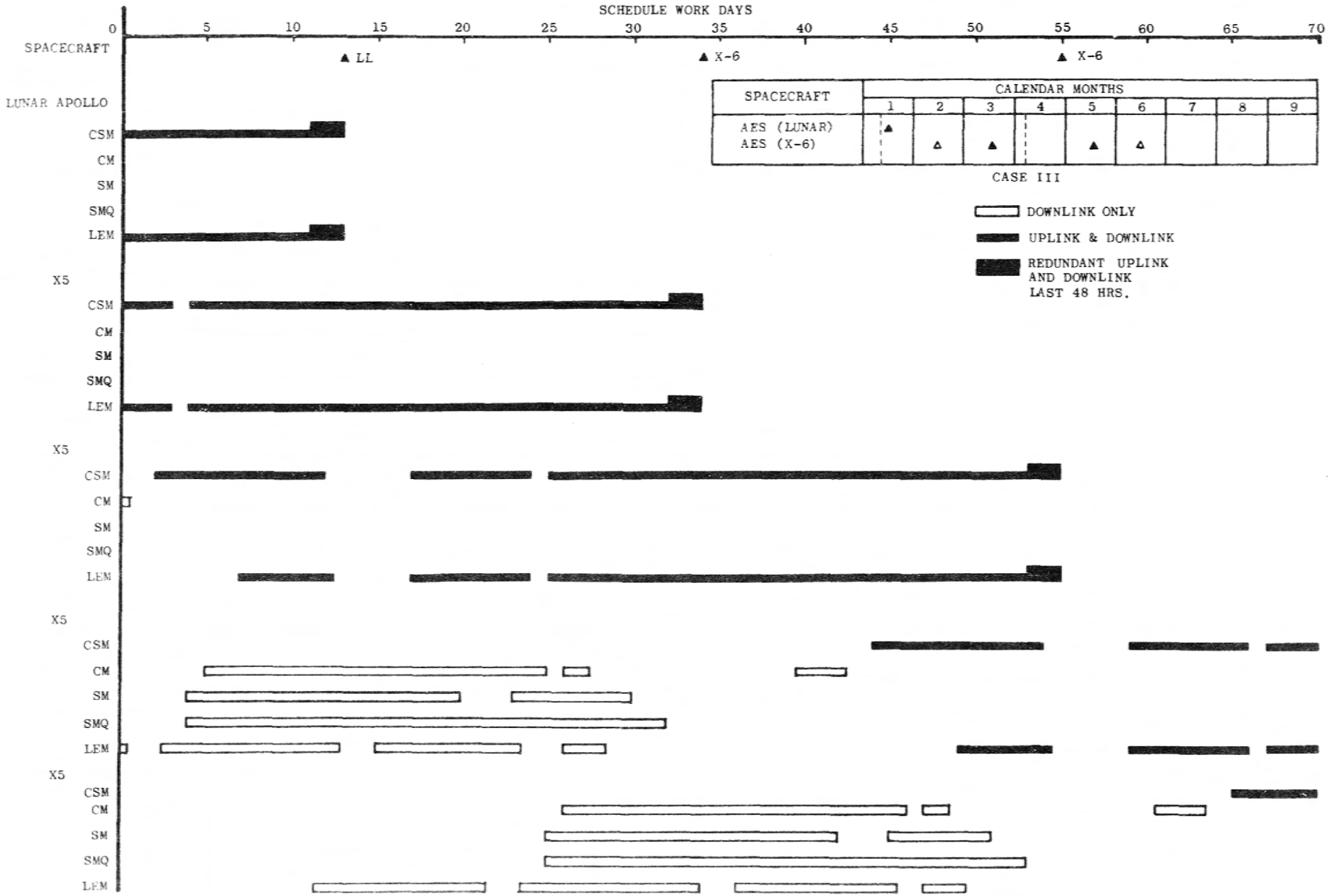
- Non-interference of Lunar Apollo operations by ORL operations.
- No contingency time is considered.
- Four (4) ACE stations are presently planned, two (2) for spacecraft support and two (2) for LEM support.
- The four (4) ACE stations could easily be modified to support spacecraft subsequent to Lunar Apollo requirements.
- ACE monitoring (downlink only) is required for system level tests.
- Contractor supplied GSE will be used to control the system level tests.
- Complete ACE stations (uplink and downlink) will be used for all tests starting with altitude chamber tests.
- Redundant ACE stations are used during the last 48 hours of the launch area operations.
- An ACE station will be committed to support a specific spacecraft from a specified time subsequent to altitude chamber tests.
- There is no ACE requirement subsequent to launch.
- Post recovery tests and mockup support have not been taken into consideration.
- The instrumentation of all configurations will be compatible with ACE equipment.

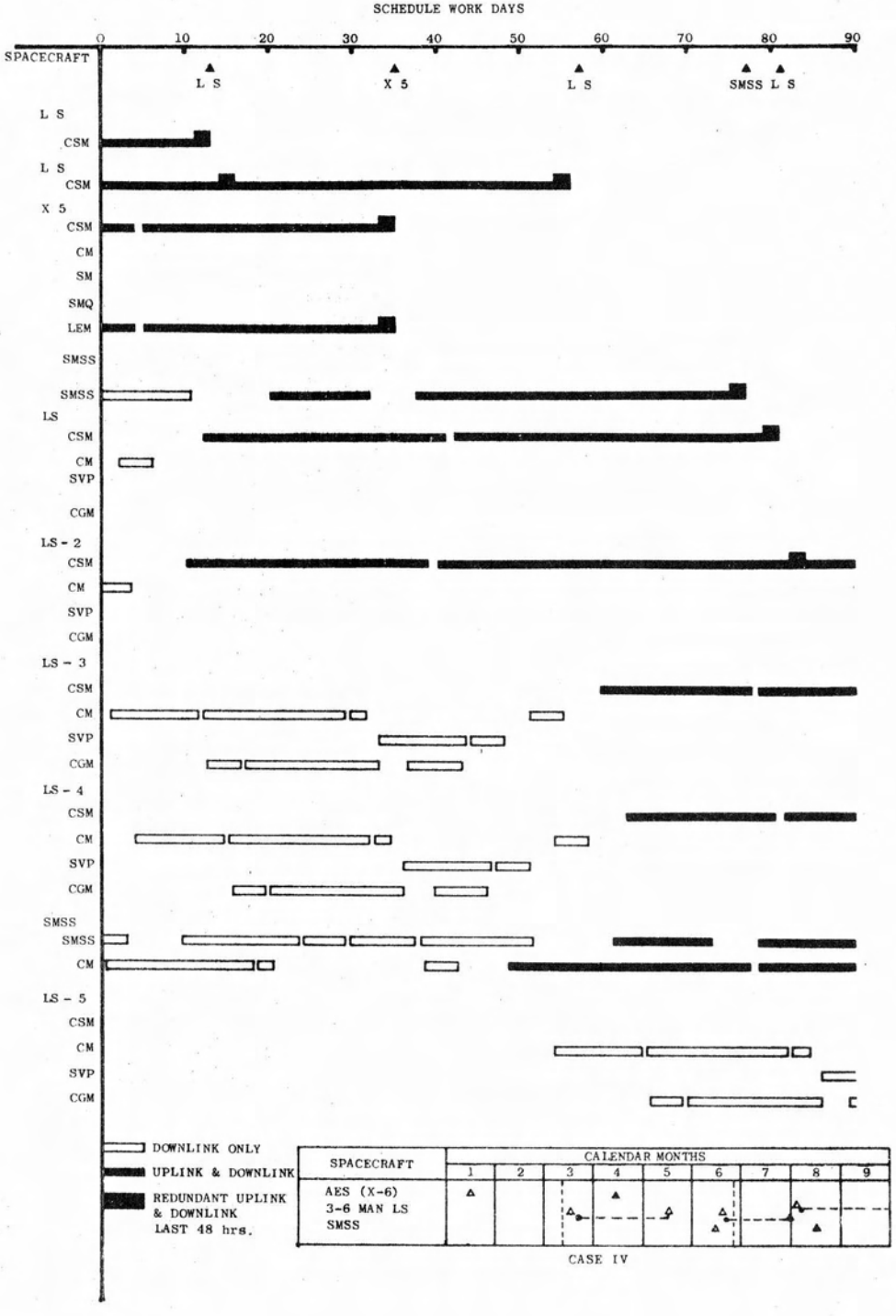
SMSS
ACE UTILIZATION FLOW



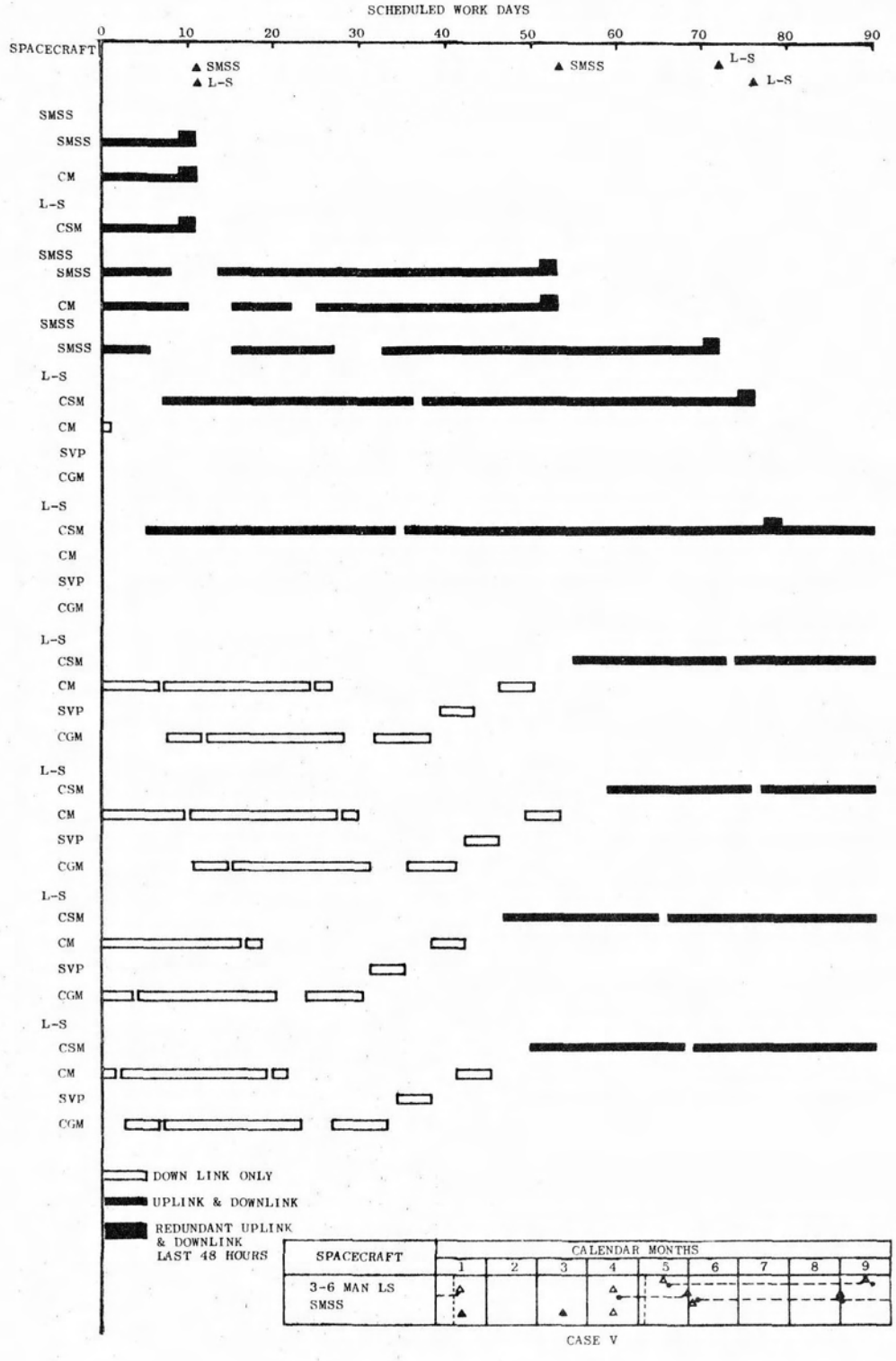

TIME IN WORKING DAYS
SPACECRAFT
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
LUNAR APOLLO
X-5
LUNAR APOLLO
CSM
CM
SM
SMQ
LEM
X-5
CSM
CM
SM
SMQ
MODULE
X-5
CSM
CM
SM
SMQ
MODULE
MODULE
LUNAR APOLLO
CSM
SM
SMQ
LEM
SPACECRAFT
CALENDAR MONTHS
1
2
3
4
5
6
7
8
9
LUNAR APOLLO AES (X-5)
CASE I
DOWNLINK ONLY
UPLINK & DOWNLINK
REDUNDANT UPLINK & DOWNLINK LAST 48 HOURS
SCHEDULED (CALENDAR DAYS)
0
30
60
90
120
150
180
210
LL
X5
X5
LL


SCHEDULED WORK DAY
0
SPACECRAFT
5
10
15
20
25
30
35
40
45
50
55
60
65
70
LL
X5
LUNAR APOLLO
CM
SM
SMQ
LEM
X-5
CSM
CM
SM
SMQ
LEM
LUNAR APOLLO
CSM
CM
SM
SMQ
LEM
X-5
CSM
CM
SM
SMQ
LEM
SPACECRAFT
CALENDAR MONTHS
1
2
3
4
5
6
7
8
9
LUNAR APOLLO AES(X-6)
CASE II
DOWNLINK ONLY
UPLINK ONLY
REDUNDANT UPLINK & DOWNLINK LAST 48 HOURS
SCHEDULED (CALENDAR DAYS)
0
30
60
90
120
150
180
LL
X5
LL
X5


SCHEDULE WORK DAYS
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
SPACECRAFT
▲ LL
▲ X-6
▲ X-6
LUNAR APOLLO
CSM
CM
SM
SMQ
LEM
X5
CSM
CM
SM
SMQ
LEM
X5
CSM
CM
SM
SMQ
LEM
X5
CSM
CM
SM
SMQ
LEM
X5
CSM
CM
SM
SMQ
LEM
SPACECRAFT
CALENDAR MONTHS
1
2
3
4
5
6
7
8
9
AES (LUNAR)
AES (X-6)
▲
△
▲
▲
△
CASE III
DOWNLINK ONLY
UPLINK & DOWNLINK
REDUNDANT UPLINK AND DOWNLINK LAST 48 HRS.


SCHEDULE WORK DAYS
0
10
20
30
40
50
60
70
80
90
SPACECRAFT
L S
X 5
L S
SMSS L S
L S
CSM
L S
CSM
X 5
CSM
CM
SM
SMQ
LEM
SMSS
SMSS
LS
CSM
CM
SVP
CGM
LS - 2
CSM
CM
SVP
CGM
LS - 3
CSM
CM
SVP
CGM
LS - 4
CSM
CM
SVP
CGM
SMSS
SMSS
CM
LS - 5
CSM
CM
SVP
CGM
DOWNLINK ONLY
UPLINK & DOWNLINK
REDUNDANT UPLINK & DOWNLINK LAST 48 hrs.
SPACECRAFT
CALENDAR MONTHS
1
2
3
4
5
6
7
8
9
AES (X-6)
3-6 MAN LS
SMSS

CASE IV


SCHEDULED WORK DAYS
0
10
20
30
40
50
60
70
80
90
SPACECRAFT
▲ SMSS
▲ L-S
▲ SMSS
▲ L-S
▲ L-S
SMSS
SMSS
CM
L-S
CSM
SMSS
SMSS
CM
SMSS
SMSS
L-S
CSM
CM
SVP
CGM
L-S
CSM
CM
SVP
CGM
L-S
CSM
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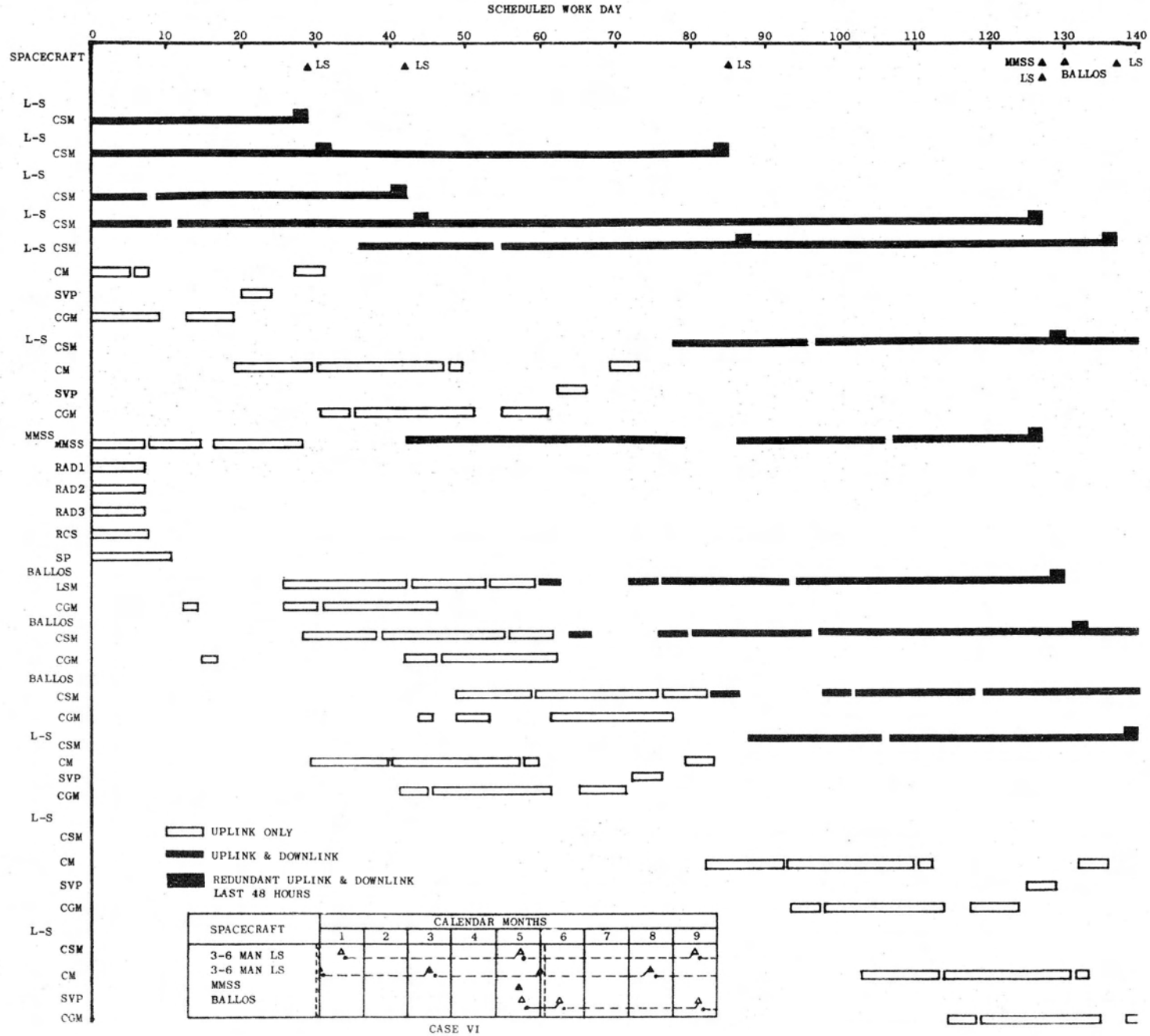
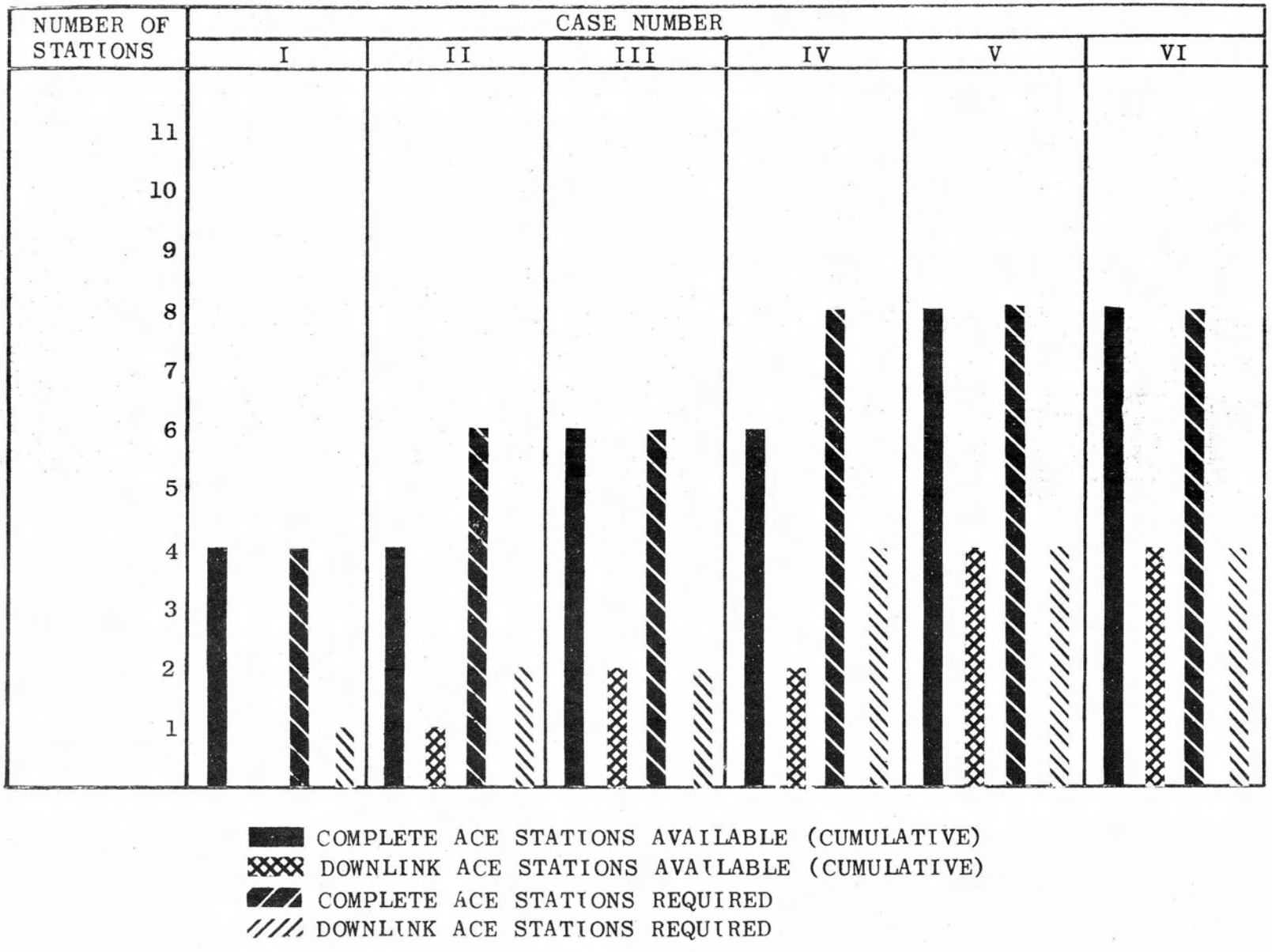
SVP
CGM
L-S
CSM
CM
SVP
CGM
L-S
CSM
CM
SVP
CGM
L-S
CSM
CM
SVP
CGM
DOWN LINK ONLY
UPLINK & DOWNLINK
REDUNDANT UPLINK & DOWNLINK LAST 48 HOURS
SPACECRAFT
CALENDAR MONTHS
1
2
3
4
5
6
7
8
9
3-6 MAN LS
SMSS

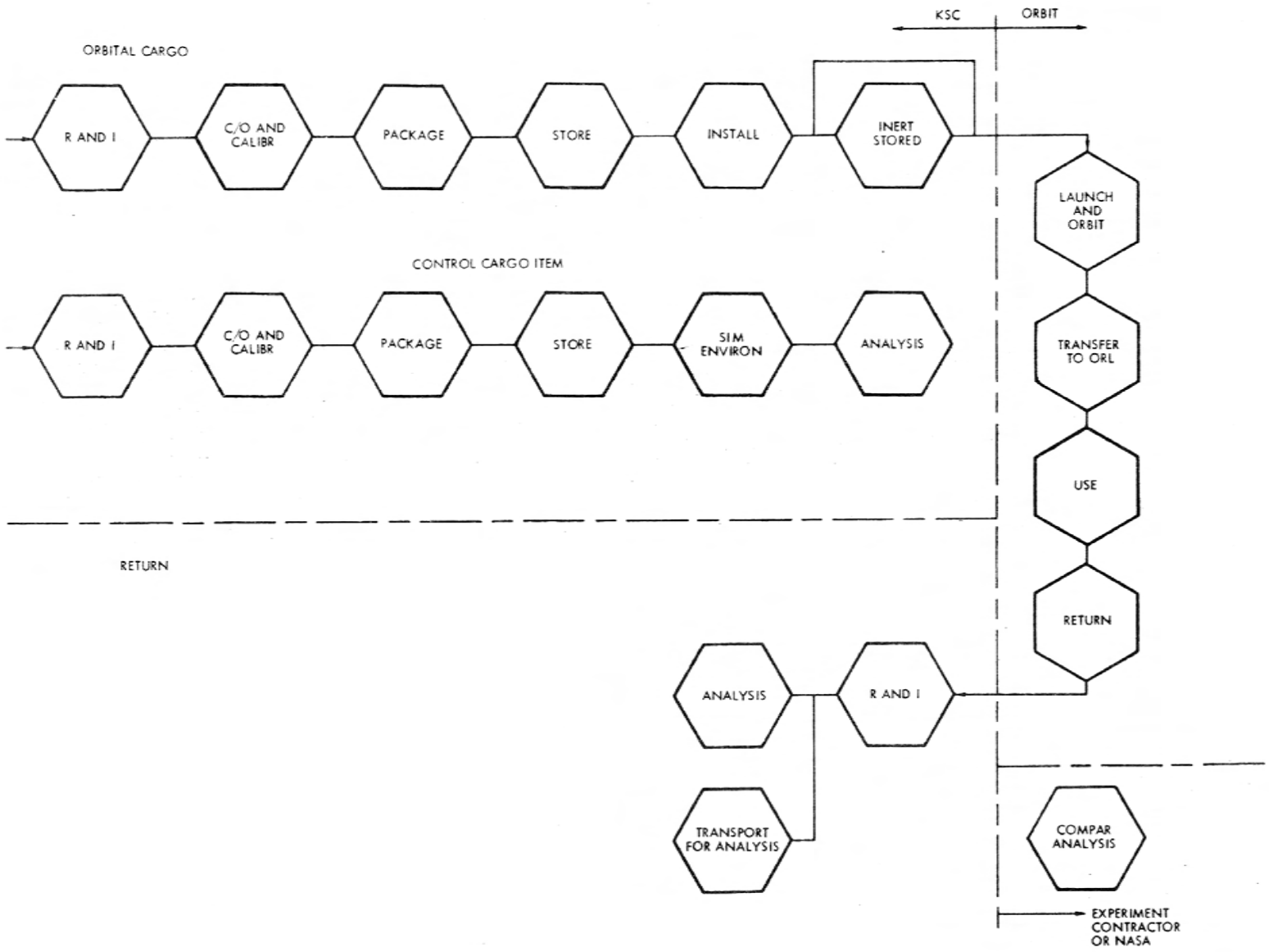
CASE V


SCHEDULED WORK DAY
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
SPACECRAFT
LS
LS
LS
MMSS
LS
BALLOS
LS
L-S
CSM
L-S
CSM
L-S
CSM
L-S
CSM
L-S
CSM
CM
SVP
CGM
L-S
CSM
CM
SVP
CGM
MMSS
MMSS
RAD1
RAD2
RAD3
RCS
SP
BALLOS
LSM
CGM
BALLOS
CSM
CGM
BALLOS
CSM
CGM
L-S
CSM
CM
SVP
CGM
L-S
CSM
CM
SVP
CGM
UPLINK ONLY
UPLINK & DOWNLINK
REDUNDANT UPLINK & DOWNLINK
LAST 48 HOURS
SPACECRAFT
CALENDAR MONTHS
1
2
3
4
5
6
7
8
9
3-6 MAN LS
3-6 MAN LS
MMSS
BALLOS

CASE VI

ACE REQUIREMENTS



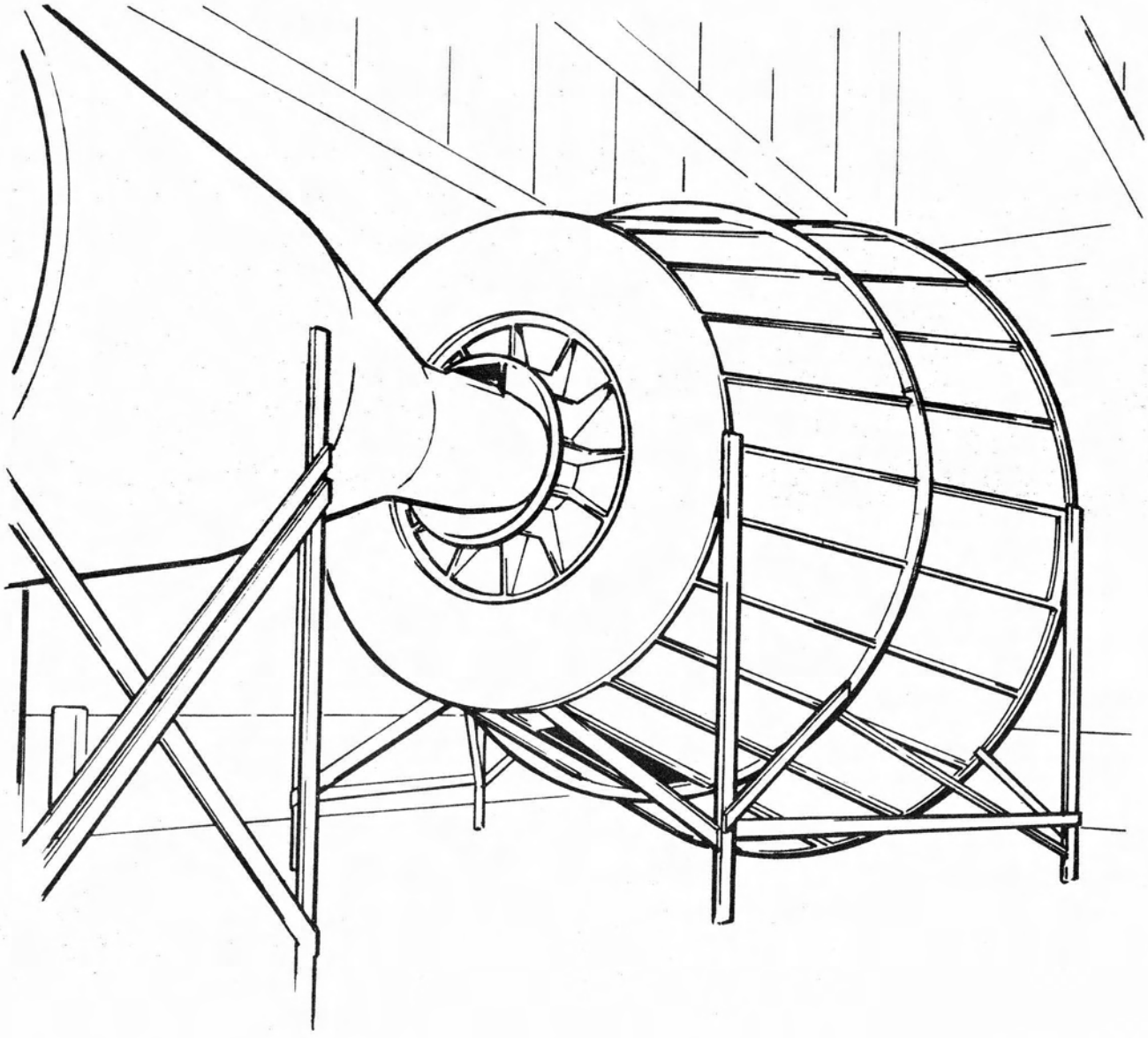


ORL Control Cargo

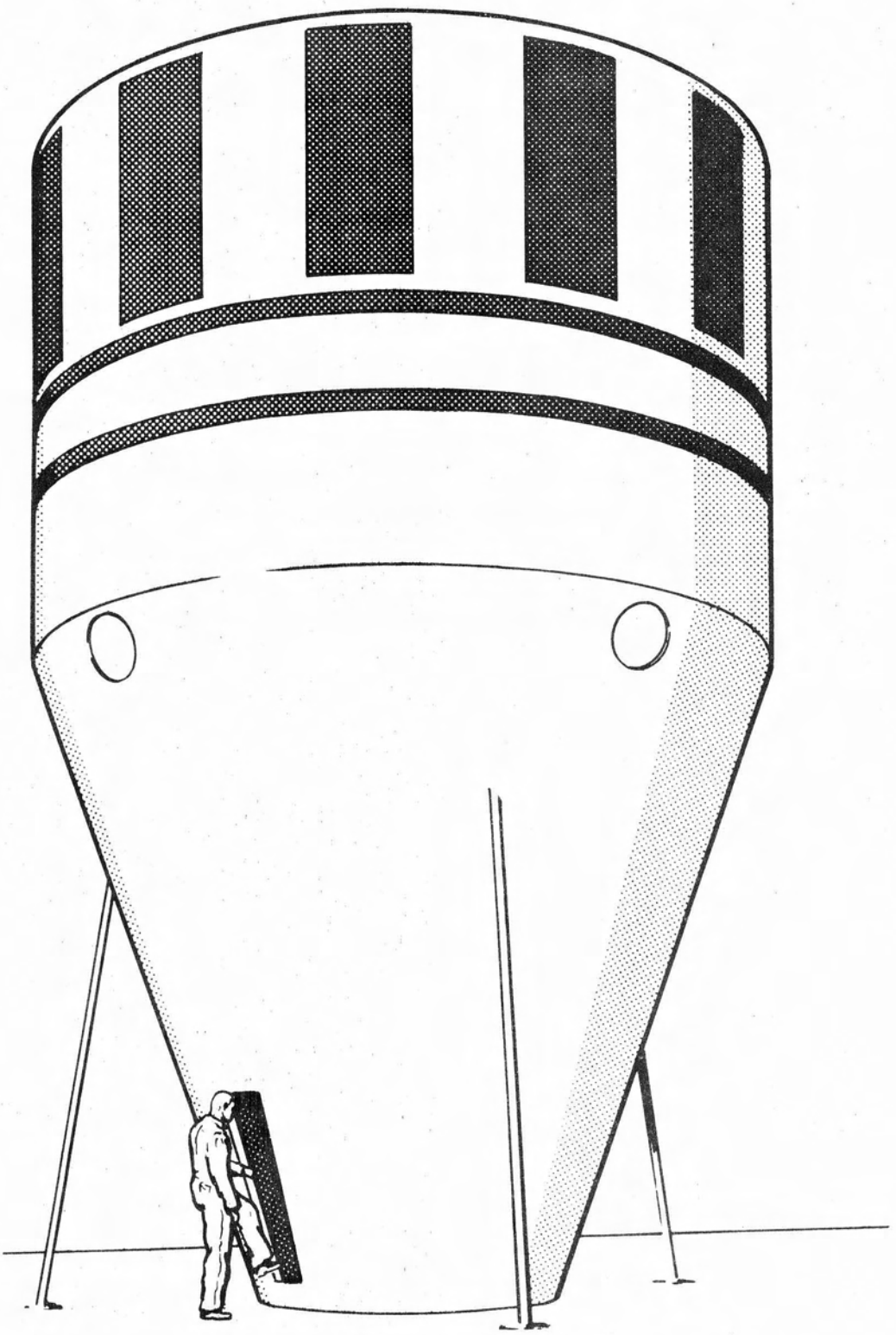
TRW

USE OF ORL/LS MOCKUPS AS TRAINING DEVICES

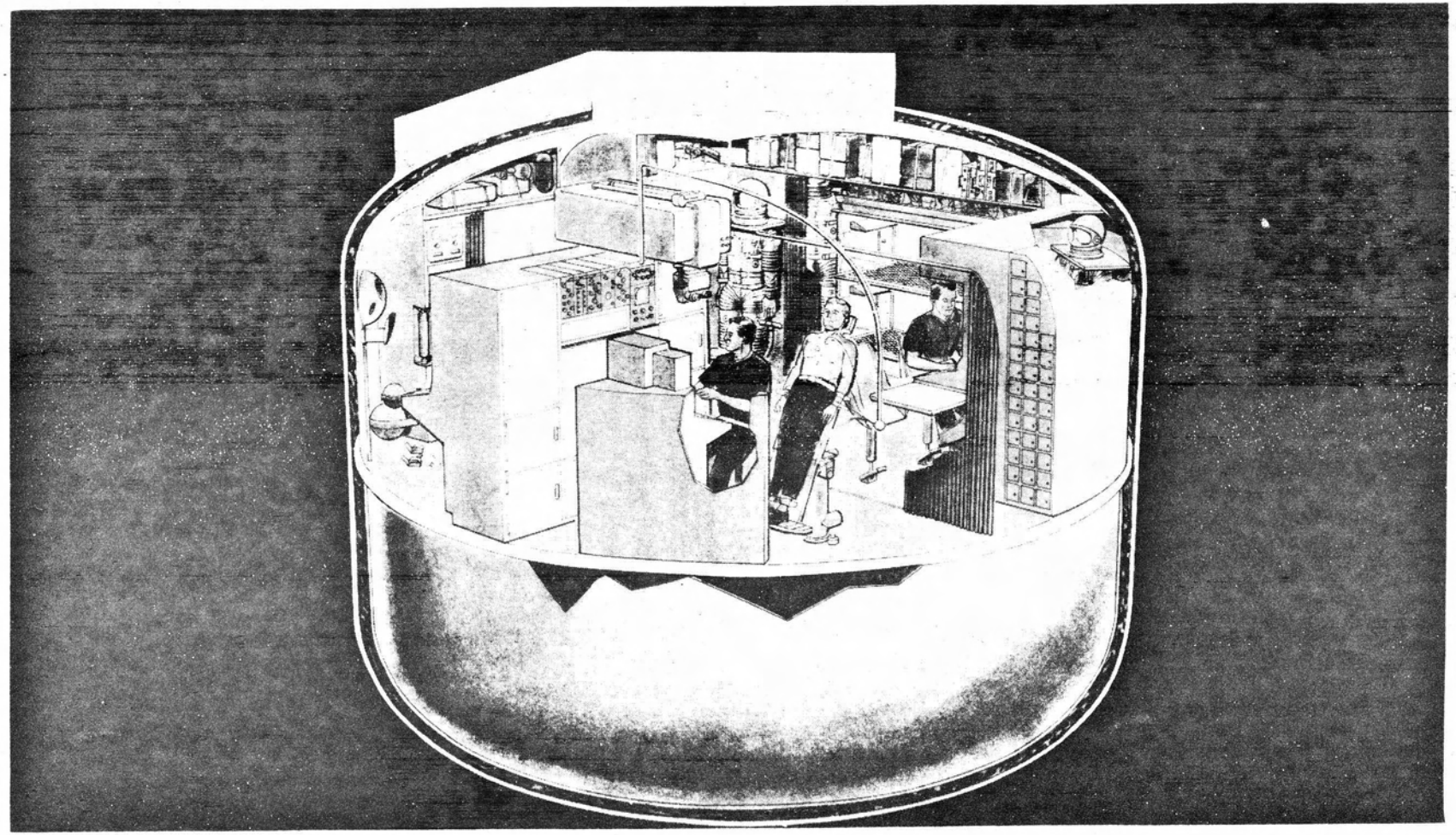
1. LABORATORY MODULE MOCKUP
2. CREW/CARGO TRANSFER MOCKUP
3. CREW MODULE MOCKUP
4. SPARE ORL/LS
5. APOLLO EXTENSIONS
6. SINGLE MODULE SPACE STATION (MORL)
7. APOLLO LOGISTICS SPACECRAFT
8. MODAP LOGISTICS SPACECRAFT



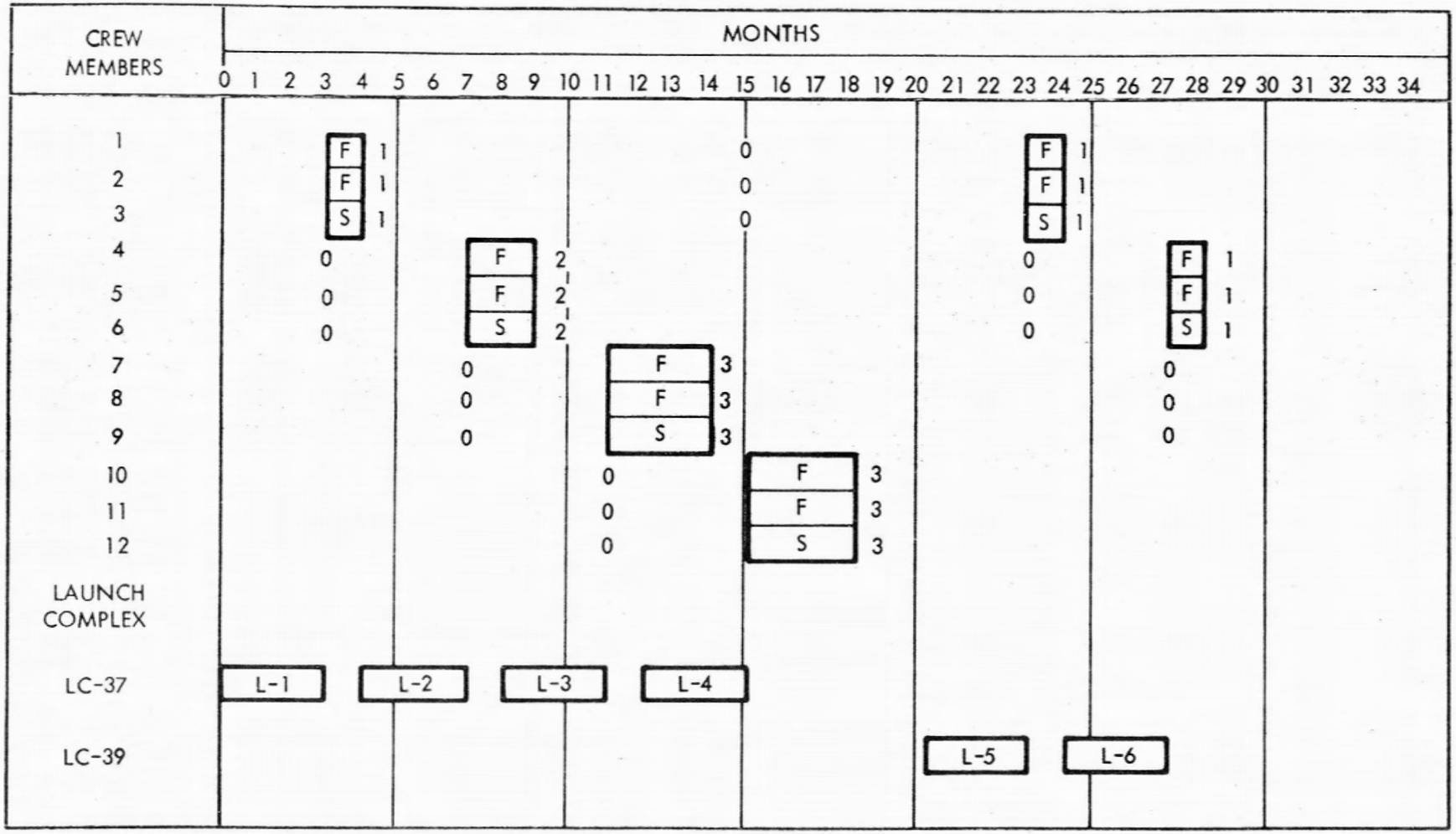
Crew/Cargo Transfer Mockup



MORL Full Scale Mockup

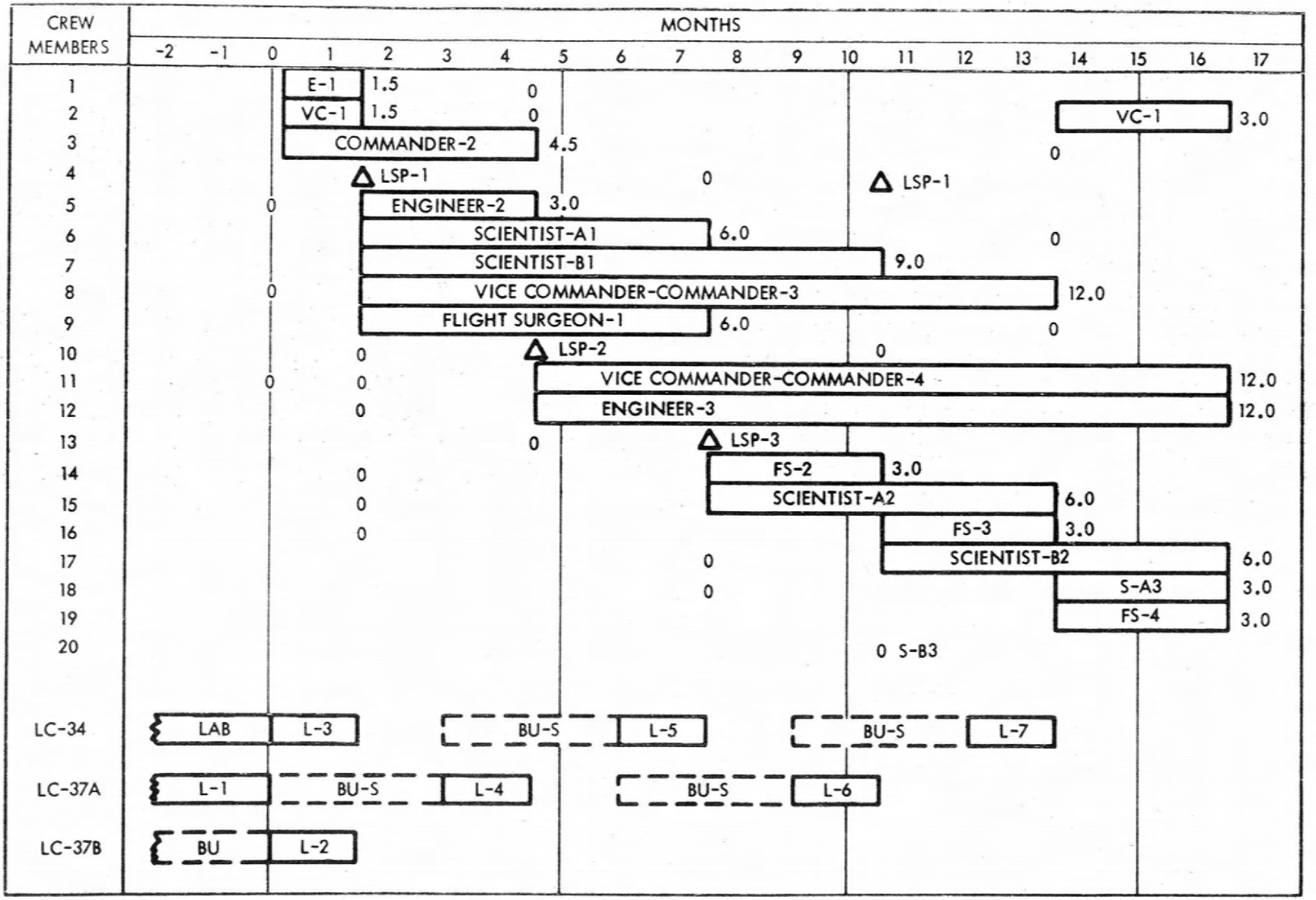


MMSS Zero-G Laboratory Upper Level Mockup



0 - BACKUP CREW
F - FLIGHT OPERATIONS SKILL
S - FLIGHT SURGEON

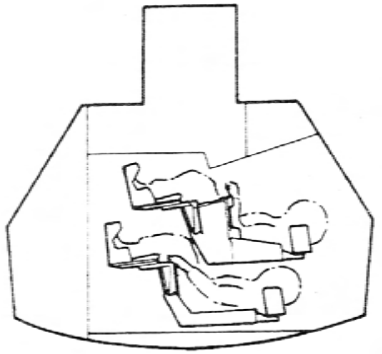
Typical Apollo Extensions Mission and Backup Crew Provisions
Apollo X-2 through X-6



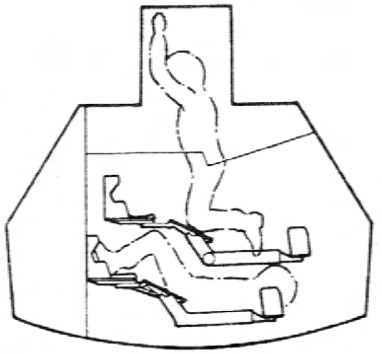
S - A3 - SCIENTIST SKILL A NUMBER 3
0 - BACKUP
L - LOGISTICS SPACECRAFT

△ LSP - LOGISTICS SPACECRAFT PILOT
BU-S - BACKUP - STANDBY

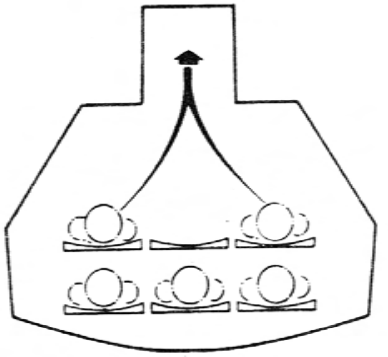
Typical SMSS/Apollo-LS Mission and Backup Crew Provisions



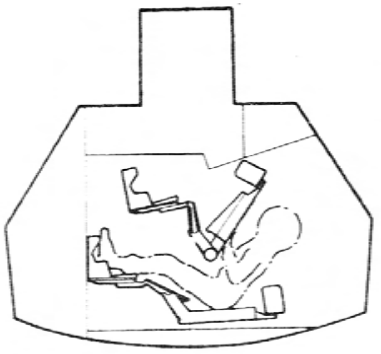
1. ALL OCCUPANTS LOWER SEATS



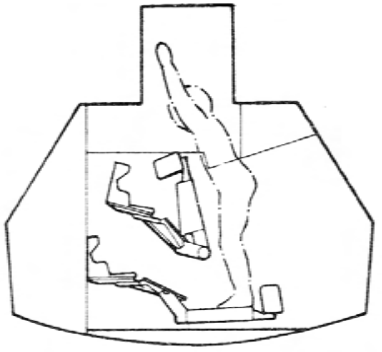
2. UPPER CENTER REMOVES & STOWS DOCKING HATCH - MAKES EXIT



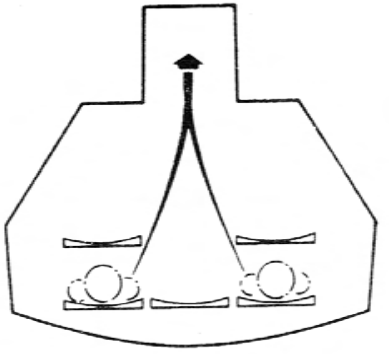
3. UPPER OUTSIDE ROLL TO CENTER & EXIT



4. LOWER CENTER FOLD UPPER CENTER SEAT

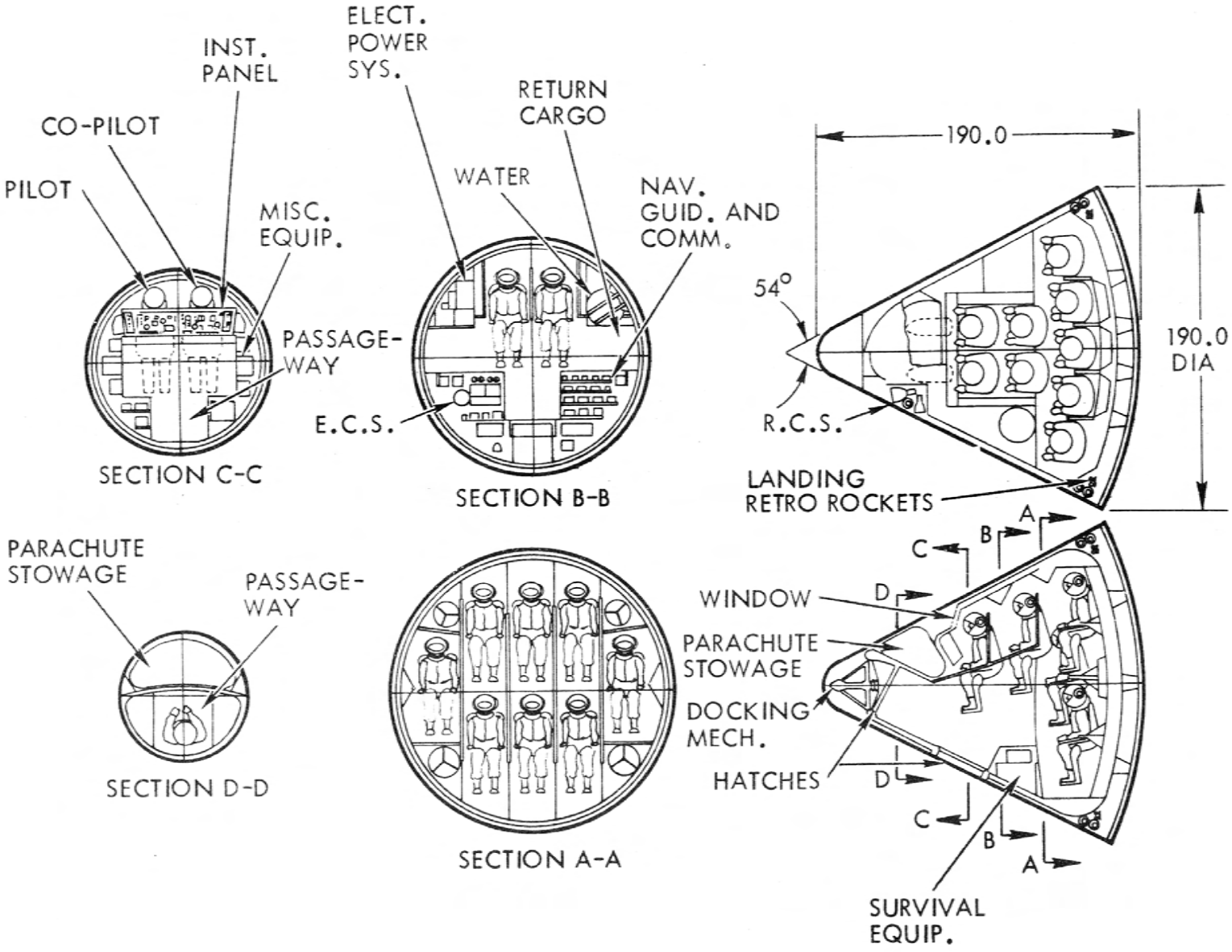


5. LOWER CENTER EXITS

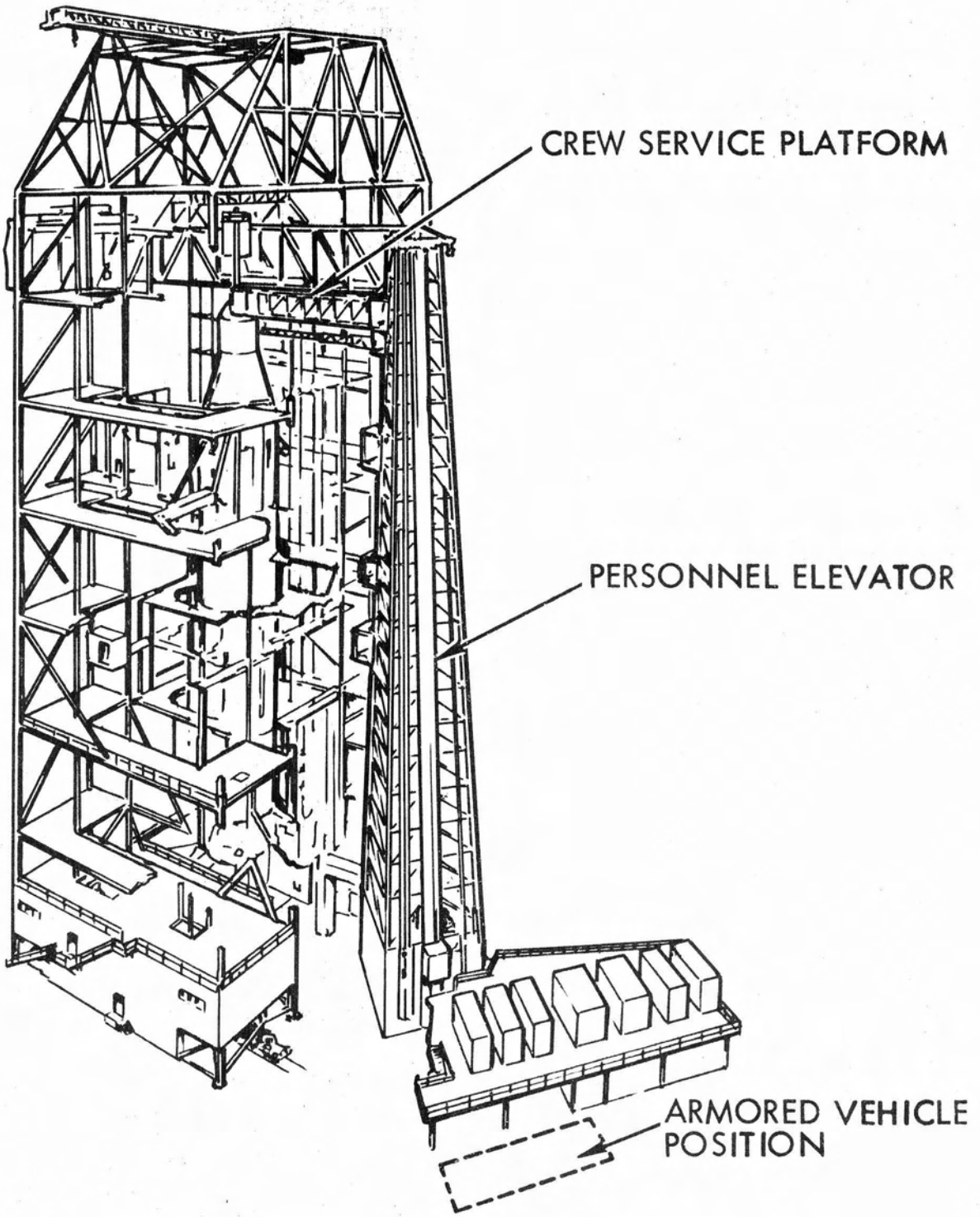


6. LOWER OUTSIDE SLIDE TO CENTER & EXIT

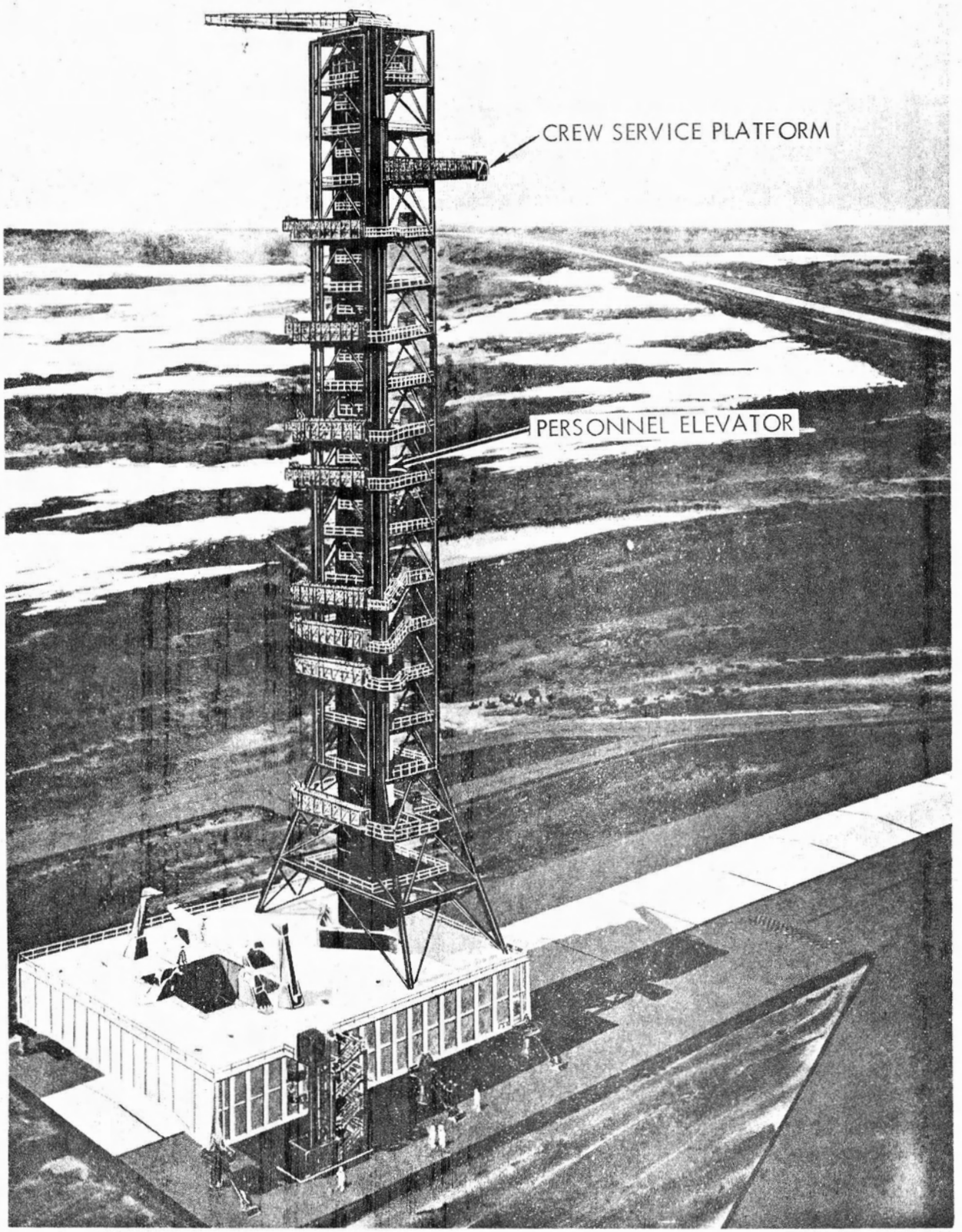
MODAP Exit Procedure



Crew Module Details



Launch Complex 34 Emergency Removal Provisions



Launch Complex 39 Emergency Removal Provisions

BUDGET IMPACT SUMMARY
(MILLIONS OF DOLLARS)

ITEM	CASE					
	I	II	III	IV	V	VI
FACILITIES	0.4	3.4	0.1	7.6	0.1	6.1
EQUIPMENT	2.8	14.2	——	17.4	——	1.5
TOTAL	3.2	17.6	0.1	25.0	0.1	7.6

BUDGET IMPACT SUMMARY
(MILLIONS OF DOLLARS)

ITEM	CASE					
	I	II	III	IV	V	VI
FACILITIES	0.4	3.4	0.1	7.6	0.1	6.1
EQUIPMENT	2.8	14.2	——	17.4	——	1.5
TOTAL	3.2	17.6	0.1	25.0	0.1	7.6

CONCLUSIONS

- Cryogenic and hypergolic test cells are adequate in size and function to support AE study configurations.
- Additional cryogenic and hypergolic test cells required to support AE study program baseline schedule.
- Larger cryogenic and hypergolic test cells required to support SMSS & [illegible] may be combined with above).
- Modification to ECS test cell required to support SMSS and MMSS study configurations.
- [illegible] adequate in function to support ORL/LS study configurations.
- Additional ACE stations required to support ORL/LS study program [illegible] schedule.

CONCLUSIONS

- Experiment integration and test capability required to support ORL/LS study experiment program.
- Cargo checkout and packaging facility required to support SMSS study program resupply.
- Integrated checkout facility required to support SMSS study configuration.
- Assembly and checkout facility required to support MMSS study configuration.
- Altitude chambers not large enough for MMSS study configuration.
- Additional crew quarters, training facilities and mission simulators required to support ORL/LS study configurations and study program baseline schedule.

CONCLUSIONS

- Detailed configuration control required for resupply cargo and S/C mockups.
- Hazardous checkout operations result from SMSS and MMSS study configurations.
- Proximity of Ordnance Storage Facility to Pyrotechnic Installation Building requires protection from inadvertent ignition of LES motor study configuration.
- Clearance survey of S/C transport routes required by SMSS and MMSS study configurations.
- Refurbishment of BALLOS CM is feasible; new facility required to support refurbishment.

RECOMMENDATIONS

- Provide two additional larger hypergolic cells and one additional larger cryogenic cell to support the ORL/LS study configurations and program baseline schedule.
- Provide 4 down link ACE stations and 4 additional complete ACE stations to support the ORL/LS study program baseline schedule.
- Modify one existing ECS cell to support SMSS and MMSS study configurations.
- Provide experiment integration and test capability to support ORL/LS study experiment program.
- Provide cargo checkout and packaging facility to support SMSS study program resupply requirements.
- Provide integrated checkout facility to support SMSS study configuration.

RECOMMENDATIONS

- Provide assembly and checkout facility to support MMSS study configuration.
- Provide future study of requirement for altitude chamber testing of MMSS study configuration.
- Provide crew quarters, training facilities, and mission simulators to support ORL/LS study configurations and study program baseline schedule.
- Provide detailed configuration control procedures for resupply cargo and spacecraft mockups.
- Redesign SMSS and MMSS spacecraft and associated logistic spacecraft to preclude introduction of hazardous ordnance into normally non-hazardous areas.
- Provide revetment between ordnance support facility and pyrotechnic installation building.

RECOMMENDATIONS

- Survey SMSS and MMSS transport routes for adequate clearance.
- Provide refurbishment facility for BALLOS command module.
- Use operational modes for ORL/LS checkout, experiment integration and test, and crew and cargo operations as a basis for further planning and program definition.
- Integrate requirements of other spacecraft programs with requirements for ORL/LS and lunar Apollo programs to determine total requirements to be placed on MILA resources.
- Study launch vehicle-spacecraft interface and space vehicle-facility and equipment interface to determine additional requirements on MILA resources.
- Study tradeoffs between program baseline schedules and MILA resources utilization, as an input to overall program planning.